Topics offered to students by other master's programs

TARGET PROGRAM

EM – Mechatronic Engineering

Analysis of Heat and Mass Transport During Hydrogen Bubble Growth in Water Electrolysis

Program : Chemical & Materials engineering - M-IRMAE

Description

Hydrogen can be produced by splitting water through electrochemical reactions in electrolysis. Although the process is overall endothermic, additional heat can be generated locally, most notably through Joule heating at the electrode surface. This localized heating modifies the temperature field near the growing hydrogen bubble, creating temperature gradients that induce thermocapillary (Marangoni) flows along the bubble interface.

In addition to thermal effects, concentration gradients of surface active species such as ions or dissolved gases can also alter surface tension, resulting in solutal Marangoni convection. These interfacial flows strongly affect bubble growth, shape, and detachment dynamics. Understanding these coupled effects requires the ability to accurately resolve the local temperature and concentration fields around the bubble. However, measuring both fields at the same time remains a significant experimental challenge.

Previous studies have demonstrated that at high applied potentials, Joule heating dominates, and thermocapillary effects become the primary drivers of interfacial motion, while solutal effects can often be neglected. Various optical techniques such as Schlieren imaging, laser induced fluorescence, and interferometry have been used to study these fields.

Mach Zehnder interferometry stands out as a noninvasive and calibration free technique for resolving instantaneous temperature fields with high sensitivity.

This thesis will focus on hydrogen bubble dynamics on a microelectrode in acidic electrolysis, using two complementary experimental techniques:

• Mach Zehnder Interferometry, to quantify the temperature field near the electrode and at the base of the bubble, especially when concentration variations are negligible.

• High speed visualization, to qualitatively capture the bubble inception, growth, and detachment processes.

• Complementary Schlieren imaging may be used for qualitative validation as done in the previous study [1].

Methodology

1. Literature survey

The student will begin by familiarising themselves with the topic. A thorough review of recent literature, especially on interferometric and visualisation techniques applied to gas-evolving electrodes, will help define the research scope and objectives.

2. Experimental set-up

The student will work with the existing electrolysis cell, Mach Zehnder interferometer, and high-speed imaging system available at the TIPS laboratory. This phase will involve hands-on training with laser alignment, optical adjustments, electrode handling, and system calibration. The student will also participate in test runs to optimise measurement conditions and gain confidence in operating the setup independently.

3. Measurement campaign and data analysis

The student will conduct experiments to visualise hydrogen bubble growth on microelectrodes using high-speed imaging and Mach Zehnder interferometry. Interferometric data will be analysed to extract local temperature fields, while high-speed recordings will be used to characterise bubble shape, growth, and detachment dynamics. Post-processing and analysis will be carried out using MATLAB. If numerical simulation results are available, they will be compared with the experimental data. In parallel, the student will measure the refractive index, density, and viscosity of the electrolyte across different concentrations and temperatures, using the available facilities at the TIPs laboratory, ULB.

4. Reporting

- Weekly meetings with the supervisor(s) to define tasks and discuss outcomes and practicalities.
- Monthly meeting with the team to verify the progress and discuss follow-up
- Final presentation

References

[1]. A. Babich, A. Bashkatov, X. Yang, G. Mutschke, and K. Eckert, "In-situ measurements of temperature field and Marangoni convection at hydrogen bubbles using schlieren and PTV techniques," Int. J. Heat Mass Transf., vol. 215, p. 124466, 2023.

[2]. J. Massing, G. Mutschke, D. Baczyzmalski, S. S. Hossain, X. Yang, K. Eckert, and C. Cierpka, "Thermocapillary convection during hydrogen evolution at microelectrodes," Electrochimica Acta, vol. 297, pp. 929–940, 2019.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	2

Supervision

Supervisor : Pierre Colinet (pierre.colinet@ulb.be)

Co-supervisor : Senthil Kumar Parimalanathan (senthil.parimalanathan@ulb.be)

Design and development of advanced drones for water quality assessment.

Program : Electrical engineering - M-IRELE

Description

This thesis develops further on previous theses in which drines have been developed for water quality assessment. Two types of drones have been developed. An aerial drone and a vessel based drone. For students from EM, this thesis will be about the optimisation of the drones and the development of algorithmq for energy optimised way point planning. For students from electric engineering and computerscience the focus will be on the development of algorithms for fleet management and multi-drone co-operative measurement campaigns.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	2

Supervision

Supervisor : Abdellah Touhafi (abdellah.touhafi@gmail.com)

Modeling Electric Heating Resistance using multi-physics approach for industrial implementation

Program : EM - Aeronautics - M-IREMR-A

Description

Electric heating elements are widely used in high-temperature industrial processes because they can deliver controlled thermal energy without direct combustion. However, these components operate under severe conditions, where electrical, thermal, and mechanical phenomena are strongly coupled. Current flowing through the resistance generates Joule heating, which leads to high temperature gradients, thermal expansion, deformation, and mechanical stresses. In some configurations, electromagnetic forces may also contribute to displacement or instability. A predictive understanding of these coupled effects is therefore essential to improve performance, reliability, lifetime, and safety in industrial applications.

The objective of this master thesis is to improve an existing multiphysics model of electric heating resistances. The model will combine electromagnetic modelling, Joule heating, heat transfer, thermal expansion, and mechanical stress analysis. The aim is to simulate how operating conditions, geometrical configurations, and material properties influence the deformation and potential failure of heating elements under realistic industrial loads. Particular attention will be paid to high-temperature materials such as molybdenum or industrial resistance materials, using appropriate temperature-dependent properties when available.

The thesis will first include a literature review on multiphysics modelling strategies for electrically heated components and on the main industrial challenges associated with high-temperature electric heating. The student will then work on the improvement of the existing numerical model, using ANSYS or an equivalent simulation platform. This will involve coupling the electromagnetic problem, including current distribution and possibly Lorentz forces, with the thermal problem through Joule heat generation, and with the mechanical problem through thermal expansion and stress analysis.

The improved model will then be used to simulate representative operating scenarios. The student will analyse the effect of current intensity, resistance geometry, boundary conditions, material properties, and symmetrical or asymmetrical configurations on temperature fields, electromagnetic forces, deformation, and stress levels. These simulations will help identify critical situations that may lead to excessive deformation, contact between components, local overheating, breakage, or mechanical instability.

The expected outcome is a validated or critically assessed multiphysics modelling framework for high-temperature electric heating elements. The thesis should provide a clearer understanding of the mechanisms leading to deformation or failure, as well as practical recommendations for safer and more efficient design and operation. The deliverables will include a literature review, an improved numerical model, a parametric analysis of operating conditions, and design guidelines concerning resistance geometry, power control strategies, material selection, and industrial implementation.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Jetnis Avdijaj (jetnis.avdijaj@ulb.be)

Implementation of a Temperature Control Strategy for CFD-Based Digital Twin of an Industrial Process

Program : EM - Aeronautics - M-IREMR-A

Description

Industrial thermal processes require precise temperature regulation to ensure product quality, energy efficiency, operational stability, and safety. In the context of digitalisation and decarbonisation, digital twins are becoming important tools to predict system behaviour, evaluate operating strategies, and support process optimisation. However, high-fidelity CFD models are often used mainly for offline analysis and are rarely coupled with dynamic control strategies. Adding control capabilities to such models is therefore an important step toward predictive and controllable virtual representations of industrial systems.

The objective of this master thesis is to develop and implement a temperature regulation system for an existing CFD model of an industrial thermal process. The aim is to move from a purely predictive CFD simulation toward a controlled numerical environment, where boundary conditions or operating parameters can be adjusted dynamically in order to reach and maintain a target temperature. This work will contribute to the development of a digital twin framework by combining physics-based modelling, control algorithms, and simulation outputs that can be exploited for future real-time or near-real-time applications.

The thesis will first include a literature review on temperature control strategies for thermal systems, including PID control, advanced control approaches, and model predictive control. The student will also review digital twin architectures for industrial processes and existing methods for integrating control loops with CFD environments such as ANSYS Fluent. Particular attention will be paid to the practical constraints associated with coupling a CFD solver and an external controller, including data exchange, time stepping, numerical stability, and computational cost.

The main part of the thesis will consist of designing and implementing a control strategy for the selected CFD model. Depending on the case study, the controller may act on inlet temperature, mass flow rate, heating power, wall heat flux, or another relevant operating variable. The control algorithm will be coupled to the CFD simulation and tested under different operating scenarios, such as changes in heat demand, disturbances, set-point variations, or modified boundary conditions. The control performance will be assessed in terms of response time, overshoot, stability, robustness, and ability to maintain the desired temperature distribution.

Finally, the thesis will analyse how the controlled CFD model can support the development of a digital twin. This includes identifying which simulation outputs are relevant for monitoring and decision support, what level of model reduction or acceleration may be required, and how control parameters can be optimised for robust operation. The expected outcome is a working control-oriented CFD framework, a critical assessment of its performance and limitations, and recommendations for future integration into an industrial digital twin platform.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Jetnis Avdijaj (jetnis.avdijaj@ulb.be)

CFD Modeling of Water Injection in Hydrogen-Fueled Internal Combustion Engines and Development of a 0D Water Injection Model for CHP Applications

Program : EM - Aeronautics - M-IREMR-A

Description

Hydrogen-fuelled internal combustion engines are a promising solution for low-carbon combined heat and power applications, where both useful mechanical or electrical power and recoverable heat can be produced. However, hydrogen combustion presents several challenges, including high in-cylinder temperatures, NO_x emissions, knock, and pre-ignition risks. Water injection is a potential strategy to mitigate these issues by reducing combustion temperatures and influencing mixture formation, evaporation processes, and combustion behaviour. In a CHP context, understanding these effects is particularly important because water injection may affect not only engine efficiency and emissions, but also the thermal balance and heat recovery potential of the system.

The objective of this master thesis is to develop a CFD model to study water injection in a hydrogen spark-ignition engine. The model will be used to analyse the evaporation process, droplet behaviour, vapour distribution, and the effect of water injection on in-cylinder temperature and combustion characteristics. The thesis will first include a literature review on hydrogen combustion in spark-ignition engines, water injection strategies, spray evaporation, two-phase flow modelling, and CFD approaches relevant to hydrogen-fuelled engines.

The main part of the thesis will consist of building a numerical CFD model of the engine configuration. Depending on the available data and geometry, the model may focus on the intake system, the combustion chamber, or a simplified representative domain. It should include the hydrogen–air mixture, the water injection system, and the relevant heat and mass transfer phenomena. Particular attention will be paid to the physical state of the injected water under different operating conditions, in order to determine whether it remains as liquid droplets, evaporates into vapour, or forms a two-phase mixture. The influence of injection timing, injected mass, droplet size, pressure, temperature, and flow conditions will be analysed.

The CFD model will then be used to investigate how water injection affects hydrogen combustion. The student will study its influence on in-cylinder temperature, mixture dilution, heat-release behaviour, thermal gradients, knock tendency, and NO_x-related temperature reduction. These results will help identify the main mechanisms through which water injection can improve or degrade engine performance in CHP-relevant operating conditions.

Finally, the CFD results will support the development of a simplified zero-dimensional model of water injection for hydrogen engines. This 0D model should reproduce the main effects of evaporation, temperature reduction, mixture dilution, and combustion modification, while remaining suitable for fast parametric studies or future system-level CHP simulations. The expected outcome is a CFD-based understanding of water injection in hydrogen spark-ignition engines, together with a first reduced-order modelling approach that can be reused in further experimental or numerical work.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.be)

Investigation of Coupled CFD Modelling for Microwave Electrification of Industrial Heating

Program : EM - Aeronautics - M-IREMR-A

Description

The objective of this master thesis is to investigate coupled modelling strategies in CFD for the study of microwave electrification applied to industrial heating processes. The work is positioned in the context of the E-HEAT proposal and, more broadly, of industrial heat decarbonisation, where replacing fossil-fuel-based heating by electrified technologies requires reliable numerical tools. The focus of the thesis is therefore not to design a complete microwave heating system, but to explore how electromagnetic energy deposition can be coupled with heat transfer and fluid-flow models in a CFD environment.

The thesis will first consist of reviewing the physical phenomena and numerical approaches involved in microwave heating. The student will analyse how microwave radiation interacts with materials, how electromagnetic power is absorbed, and how this absorbed power can be represented as a volumetric heat source in a CFD model. Particular attention will be paid to the coupling between electromagnetic fields, temperature-dependent material properties, heat conduction, convection, radiation, and possible flow effects. The objective is to identify the main modelling assumptions, coupling strategies, and numerical difficulties associated with such multiphysics simulations.

The student will then develop and test one or several simplified coupled CFD models on a representative configuration. Depending on the chosen level of complexity, the electromagnetic field may be represented through an imposed power deposition profile, a simplified analytical model, or a coupling with an external electromagnetic solver. This source term will then be integrated into a CFD model solving the thermal and, where relevant, fluid-flow problem. The work should compare different coupling levels, from weak one-way coupling to more advanced approaches where the temperature field modifies the material properties and therefore the absorbed microwave power.

A parametric study will be carried out to assess the sensitivity of the coupled model to key assumptions and input parameters. These may include microwave power, spatial distribution of the heat source, dielectric properties, temperature dependence of material parameters, geometry, boundary conditions, flow rate, and thermal losses.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Pedagogical Integration of Flight Simulators for Engineering Education

Program : EM - Aeronautics - M-IREMR-A

Description

The project will focus on transforming the existing simulators into structured teaching platforms, allowing students to connect theoretical notions of flight mechanics, aircraft performance, stability, control, and aircraft design with hands-on simulation activities.

The work will first consist of analysing the current state of the simulator infrastructure. This includes the hardware configuration, cockpit interfaces, flight simulation software, available aircraft models, visualisation systems, data extraction possibilities, and operational limitations. The student will identify what remains to be completed or improved in order to obtain a robust, repeatable, and easy-to-use laboratory setup. Particular attention will be paid to usability, reliability, documentation, and the ability to run exercises with groups of students in a teaching context.

A second part of the thesis will focus on the integration of the OAD software environment. OAD presents its tools as covering the aircraft development process from conceptual design to flight-test analysis, with applications including aircraft design, UAV/aircraft optimisation, and flight performance analysis. The objective will be to investigate how such tools can be combined with the flight simulators in order to create a coherent workflow: from preliminary aircraft design and performance estimation to simulation-based evaluation of flight behaviour.

The student will then design a first set of pedagogical activities for engineering students. These activities may address topics such as take-off and landing performance, climb rate, stall behaviour, static and dynamic stability, control response, flight envelope exploration, and the influence of aircraft design parameters on flight performance. The aim is not only to provide demonstrations, but to build laboratory sessions in which students formulate hypotheses, run simulations, collect data, analyse results, and compare them with theoretical models.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@hotmail.com)

Development of a Low-Power Gas Turbine Test Bench for RC-Size Engines

Program : EM - Aeronautics - M-IREMR-A

Description

The objective of this master thesis is to carry out the preliminary study, design, and first implementation of a low-power gas turbine test bench based on RC-size turbojet engines. The bench is intended for use in engineering laboratory sessions, where students will be able to observe and analyse the operation of a real gas turbine in a safe, compact, and didactic environment. Although RC-size engines are small, they reproduce the essential features of gas turbine operation: air compression, combustion, turbine expansion, exhaust acceleration, transient behaviour, thermal constraints, and fuel consumption. They therefore provide an attractive and affordable platform for hands-on teaching in propulsion, turbomachinery, energy conversion, and experimental methods.

The thesis will first consist of a pre-study phase. The student will analyse the technical, pedagogical, and safety requirements of such a bench. This includes identifying the type and size of engine to be used, the expected thrust and thermal loads, the constraints linked to indoor or semi-indoor operation, noise levels, exhaust management, fuel storage, and safety procedures. A review of existing educational gas turbine benches and RC turbine test setups will be carried out in order to define a realistic concept adapted to university laboratory use.

Based on this analysis, the student will develop the mechanical and functional design of the test bench. This will include the design of the supporting structure, engine mounting system, thrust measurement arrangement, protective shielding, access to the engine for maintenance, fuel system integration, and space for future instrumentation. The work will involve producing technical drawings and CAD models, selecting suitable components, defining a bill of materials, and justifying the main design choices in terms of safety, robustness, cost, ease of use, and pedagogical value.

A key objective of the thesis will then be to manufacture or assemble a first version of the bench. Depending on the progress of the project, this prototype should allow the safe installation of the engine and prepare the bench for future experimental campaigns. Particular attention will be paid to modularity, so that additional sensors such as thermocouples, pressure probes, fuel flow meters, load cells, vibration sensors, or data acquisition systems can be integrated in later stages.

The expected outcome is a complete pre-design study and a first operational or partially operational prototype of a gas turbine laboratory bench. The deliverables will include the technical specifications, CAD drawings, component selection, assembly documentation, safety analysis, and recommendations for future instrumentation and laboratory exercises. This thesis is therefore mainly an engineering design and development project, with a strong practical dimension and a clear teaching objective

Language	EN (english)
Open to other master’s programs	Yes

Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Development of a Low-Power Gas Turbine Test Bench for RC-Size Engines Feasibility Study of ULB as an Energy Hub within a Local Energy Community Feasibility Study for the Decarbonisation of Heat Supply on ULB Campuses Pedagogical Integration of Flight Simulators for Engineering Education Development of a dynamic thermal energy storage model as a digital twin in a decentralized energy system Investigation of Coupled CFD Modelling for Microwave Electrification of Industrial Heating Experimental and 0D Modelling Study of Water Injection in Hydrogen Spark-Ignition Engines for CHP Applications Development of a Hydrogen–Diesel Dual-Fuel Engine Test Bench and 0D Combustion Model for CHP Applications CFD Modeling of Water Injection in Hydrogen-Fueled Internal Combustion Engines and Development of a 0D Water Injection Model for CHP Applications   Implementation of a Temperature Control Strategy for CFD-Based Digital Twin of an Industrial Process Modeling Electric Heating Resistance using multi-physics approach for industrial implementation Adapted Chemical Reactor Networks for Fast Combustion Modelling under Variable Operating Conditions

Program : EM - Energy - M-IREMR-E

Description

Combustion modelling is a central challenge in energy and chemical engineering. Industrial systems such as gas turbines, furnaces, and engines involve strong interactions between fluid dynamics, chemical kinetics, turbulence, and heat transfer. High-fidelity CFD simulations coupled with detailed chemical mechanisms are powerful tools to analyse these systems, but they remain computationally expensive, especially when large reaction mechanisms are considered. This limits their use for parametric studies, design exploration, optimisation, or real-time applications. Reduced-order modelling approaches are therefore needed to retain the main physical and chemical behaviour of reacting flows at a much lower computational cost.

The objective of this master thesis is to investigate adapted Chemical Reactor Networks (CRN) as reduced-order models for combustion systems. A Chemical Reactor Network approximates a complex reacting flow by a set of interconnected ideal reactors, each representing a region of the flow with similar thermochemical properties. In conventional approaches, the network is generated from CFD data for one specific operating condition. When the operating conditions change, a new CFD simulation is often required to build a new network. This thesis will explore an alternative strategy: reusing a CRN structure obtained from a reference CFD case while modifying only the inlet conditions and operating parameters.

The work will first include a literature review on CRN methods, CFD-based reactor network generation, clustering techniques, and reduced-order modelling for combustion. The student will then generate a CRN from existing CFD data by grouping computational cells into regions with similar thermochemical properties, such as temperature, mixture fraction, residence time, or species concentrations. Each region will be represented as an ideal reactor, and the mass exchanges between regions will define the reactor connectivity. The resulting network will be solved using a chemical kinetics tool such as Cantera.

The main part of the thesis will consist of assessing the robustness of the adapted CRN approach. The student will apply the same reactor network structure to operating conditions different from the reference case, by changing inlet temperature, equivalence ratio, mass flow rate, fuel composition, or other relevant parameters. The CRN predictions will then be compared with reference CFD simulations or experimental data when available. Key quantities may include temperature fields, major species, pollutant formation, heat release, and global combustion efficiency.

The expected outcome is a critical assessment of whether a CRN generated from one CFD case can be reused as a fast predictive tool over a range of operating conditions. The thesis will deliver a literature review, a CFD-to-CRN workflow, a set of adapted CRN simulations, and recommendations on the validity limits and possible improvements of the method. The project requires knowledge of fluid mechanics and thermodynamics, programming skills in Python, and an interest in combustion, CFD, and numerical modelling.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Alessandro Parente (alessandro.parente@ulb.be)

Co-supervisor : Asija Inciardi (asija.inciardi@ulb.be)

Development of a Hydrogen–Diesel Dual-Fuel Engine Test Bench and 0D Combustion Model for CHP Applications

Program : EM - Energy - M-IREMR-E

Description

Hydrogen–diesel dual-fuel engines are a promising solution for improving the efficiency and reducing the carbon intensity of combined heat and power systems. By introducing hydrogen into a conventional diesel engine, it becomes possible to partially substitute fossil fuel while maintaining the robustness, high efficiency, and ignition reliability of diesel combustion. Such systems are particularly relevant for CHP applications, where both mechanical or electrical power and useful heat recovery must be considered. However, hydrogen–diesel operation involves specific combustion challenges, including ignition delay, heat-release control, knock or abnormal combustion risks, NO_x emissions, and the interaction between diesel pilot injection and hydrogen–air combustion.

The objective of this master thesis is to design and implement a dedicated hydrogen–diesel dual-fuel engine test bench within the ULB-ATM laboratory, and to complement this experimental work with the development of a zero-dimensional combustion model. The test bench should enable controlled investigations of combustion behaviour, engine performance, emissions, and heat recovery potential under different operating conditions. The student will first carry out a literature review on hydrogen–diesel dual-fuel combustion, existing experimental setups, safety constraints linked to hydrogen use, and 0D modelling approaches for internal combustion engines.

The main part of the thesis will focus on the design and implementation of the experimental test bench. This will include the definition of the fuel supply architecture, hydrogen injection strategy, diesel operation mode, instrumentation, data acquisition system, safety procedures, and operating protocols. The bench should allow the measurement of relevant quantities such as engine speed, torque or load, fuel consumption, hydrogen flow rate, temperatures, pressures, exhaust composition, and recoverable heat. Particular attention will be paid to safe hydrogen handling, ventilation, leak detection, emergency shutdown, and compatibility with laboratory constraints.

In parallel, the student will develop or adapt a 0D combustion model of the hydrogen–diesel dual-fuel engine. The model should reproduce the main features of the combustion process, including pressure and temperature evolution, ignition delay, heat-release rate, diesel pilot contribution, hydrogen energy fraction, and global engine performance. When experimental data are available, the model will be compared with measurements in order to assess its accuracy and limitations.

The expected outcome is a first experimental and numerical platform for studying hydrogen–diesel dual-fuel engines in CHP conditions. The deliverables will include a literature review, the design and implementation of the test bench, initial experimental results, a validated or partially validated 0D model, and a preliminary analysis of operating conditions favourable to efficient heat recovery. The thesis will require knowledge of thermodynamics, combustion, heat transfer, and piston engines, as well as programming skills in Python, MATLAB, or a similar environment. Practical skills and the ability to work with the ATM technical team will be important assets.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.be)

Experimental and 0D Modelling Study of Water Injection in Hydrogen Spark-Ignition Engines for CHP Applications

Program : EM - Energy - M-IREMR-E

Description

Hydrogen spark-ignition engines are a promising solution for low-carbon combined heat and power applications, where both mechanical or electrical power and useful heat can be produced. However, hydrogen combustion remains challenging because of high combustion temperatures, NO_x emissions, knock, and pre-ignition risks. Water injection is a potential strategy to mitigate these limitations by reducing in-cylinder temperatures and modifying the combustion process. In a CHP context, this temperature control is also important because it affects not only engine efficiency and emissions, but also the amount and quality of recoverable heat.

The objective of this master thesis is to design and implement an experimental setup to study water injection under conditions representative of hydrogen spark-ignition engines. A key question will be to determine whether the injected water enters the engine as liquid droplets, vapour, or a two-phase mixture, depending on injection pressure, temperature, timing, injected quantity, and operating conditions. The student will therefore first carry out a literature review on hydrogen engine combustion, abnormal combustion phenomena, NO_x formation, and water injection strategies in internal combustion engines.

The main part of the thesis will consist of developing a dedicated experimental setup for water injection characterisation. This setup should make it possible to study the evaporation behaviour, droplet dynamics, temperature evolution, and resulting phase of the injected water before its introduction into the engine. Once the methodology has been characterised, the system will be implemented on a real hydrogen spark-ignition engine. Experimental tests will then be used to assess the impact of water injection on combustion behaviour, performance, efficiency, knock tendency, thermal behaviour, and NO_x emissions.

In parallel, the student will develop or adapt a zero-dimensional combustion model of a hydrogen spark-ignition engine including the effects of water injection. The model should account for injected water quantity, evaporation, mixture dilution, temperature reduction, heat-release behaviour, engine performance, and CHP efficiency. When experimental results are available, the model will be compared with measurements in order to assess its validity and limitations.

The expected outcome is a first experimental and numerical framework for analysing water injection in hydrogen spark-ignition engines. The main deliverables will be a literature review, the design and implementation of the water-injection test setup, a first implementation on the hydrogen engine test bench, and a validated or partially validated 0D model. The thesis will require good knowledge of thermodynamics, heat transfer, and piston engines, as well as programming skills in Python, MATLAB, or a similar environment. Practical skills and the ability to work with the ATM technical team will be important assets.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.b)

Development of a dynamic thermal energy storage model as a digital twin in a decentralized energy system

Program : EM - Energy - M-IREMR-E

Description

In an attempt to reduce the impact of climate change on our planet, we are shifting away from fossil fuels toward more renewable energy sources. However, integrating more renewable energy sources, such as solar and wind, comes with its challenges. To maximize the use of energy produced by renewable sources, storage will become increasingly important in energy systems. This makes it possible to use excess energy at later times when necessary and to balance the energy production and demand curves more efficiently. When analyzing energy consumption, after electricity and transportation, heating for
space heating and hot water production is a substantial part of our energy needs. An efficient way to meet our electricity and heating needs is to use combined heat and power (CHP) units, such as micro gas turbines (MGT) or internal combustion engines (ICE), where the excess heat from the exhaust gas can be used to heat water for district heating networks (DHN). Oftentimes, electricity production is the
main driver in the CHP units, so reliable heat storage is necessary to benefit later.
The thesis will focus on developing a dynamic model of thermal energy storage (TES) that accounts for thermal inertia. This model can then be used as a digital twin, an accurate but fast model that receives
information from the physical system and can be used for real-time optimization. The TES can be implemented in an energy system that needs to be optimized to ensure that the available power and heat match demand, and it can also be used to reduce fossil fuel emissions or utilization costs. The modeling, optimization, and control of the energy system can be used to predict our ideal energy generation mix and also allow us to adapt our plan in case of disturbances, e.g., more clouds than expected, which reduces available solar energy.

First, the student conducts an extensive literature review on thermal energy storage and examines how it is modeled to balance accuracy and computational speed. Once the student has developed an idea for this model, it will be implemented in Python. During this phase, different methods can be explored and compared to results in the literature. The thermal energy storage model will be integrated into an available district heating network model. The control system will be developed to demonstrate its use in optimizing the heating network.

The student does not need any prior knowledge of energy systems or thermal energy storage, but should be interested in learning. As this project will mainly consist of programming, basic knowledge of Python is required.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Zoraida Nti (zoraida.nti@ulb.be)

Feasibility Study for the Decarbonisation of Heat Supply on ULB Campuses

Program : EM - Energy - M-IREMR-E

Description

The objective of this master thesis is to perform a first feasibility study on the decarbonisation of heat supply on ULB campuses, in close collaboration with the ULB cellule énergie. At present, the university's heat demand is mainly covered by natural gas boilers using CH_4. The aim of the thesis is to assess possible pathways to reduce or eliminate fossil fuel use for heating, while taking into account the technical, economic, operational, and spatial constraints of university campuses.

The work will first consist of characterising the current heat demand and heat production infrastructure. The student will analyse available data on gas consumption, heating networks, boiler rooms, building uses, occupancy patterns, temperature levels, and seasonal demand profiles. Particular attention will be paid to the distinction between peak heat demand, annual heat consumption, supply temperatures, and the flexibility of the buildings, since these elements strongly influence the feasibility of low-carbon heating solutions.

The student will then identify and compare a broad range of decarbonisation options. These may include heat pumps, geothermal energy, shallow geothermal storage, connection to existing or future district heating networks, heat recovery from local sources, solar thermal systems, biomass where relevant, hybrid systems combining gas and low-carbon technologies, and progressive electrification strategies. The analysis should also consider demand-side measures, such as reducing supply temperatures, improving control strategies, exploiting thermal inertia, and prioritising building-level efficiency improvements when they enable more efficient low-carbon heat production.

A simplified modelling framework will then be developed to compare several transition scenarios. These may include a reference scenario based on the current CH_4 supply, partial electrification through heat pumps, geothermal-assisted heating, hybrid systems for peak demand, and more integrated campus-scale solutions combining storage, heat recovery, and demand management. The comparison should estimate key indicators such as energy consumption, fossil fuel reduction, CO_2 emissions, peak electrical power, seasonal performance, investment cost, operating cost, spatial requirements, implementation complexity, and robustness of supply.

Finally, the thesis will address practical aspects in collaboration with the ULB cellule énergie. This includes data availability, technical constraints in existing buildings, compatibility with current heating networks, regulatory aspects, phasing of investments, and the identification of priority sites or pilot projects. The expected outcome is a structured feasibility report assessing which decarbonisation pathways are most promising for ULB campuses, under which conditions they could be implemented, and what further studies would be required. The work will provide quantitative first estimates and a roadmap toward a progressive reduction of CH_4-based heating on campus.

Language	EN (english)

Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Feasibility Study of ULB as an Energy Hub within a Local Energy Community

Program : EM - Energy - M-IREMR-E

Description

The objective of this master thesis is to perform a first feasibility study on the potential role of ULB as an energy hub within a local energy community, at the scale of the urban block or neighbourhood surrounding the university campus. The project will be carried out in close interaction with the ULB cellule énergie, with the aim of evaluating how the university's buildings, energy infrastructure, consumption profiles, and potential local production assets could contribute to a collective energy strategy.

The work will focus on identifying the technical potential for ULB to act as a local energy hub. This includes assessing opportunities for photovoltaic production, demand-side management, heat recovery, battery or thermal storage, electric vehicle charging, and possible interactions with neighbouring buildings or users. The analysis should consider both electrical and thermal energy flows, and evaluate whether coupling these vectors could bring additional value at neighbourhood scale.

The student will then develop a simplified modelling framework to compare several energy-community scenarios. These may include a reference case without energy sharing, a scenario with increased local renewable production, a scenario including flexible loads or storage, and a more integrated energy-hub scenario. The model should estimate key indicators such as self-consumption, self-sufficiency, peak power reduction, CO_2 emissions, energy costs, and possible benefits for participating users. The level of modelling will remain compatible with a first feasibility study, while being sufficiently detailed to support concrete recommendations.

Finally, the thesis will address practical and organisational aspects in collaboration with the ULB cellule énergie. This may include data availability, regulatory constraints, metering requirements, governance models, and the identification of priority actions for a future demonstrator. The expected outcome is a structured feasibility report assessing whether, and under which conditions, ULB could become a central actor in a local energy community. The work will provide both quantitative first estimates and a roadmap for further technical, economic, and institutional development.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Learn a Robot Arm to Manipulate Objects through Qualitative Modeling.

Program : Computer science and engineering - M-IRIFS

Description

We can program robots perfectly to perform tasks, but only in known environments. Pre-programmed robots struggle to handle new situations. To enable robots to operate in uncontrolled environments, they must be capable of learning. This is where the scientific field of self-learning robots comes into play. In this master's thesis, you will apply this concept to a robotic arm that must learn to manipulate objects: moving, stacking, cleaning up, and more. Our innovative approach, based on qualitative models, will lead to improved manipulation compared to the current state of the art.

The robotic arm (see figure) will be controlled based on camera images. The objects are identified and analyzed within these images, from which the important properties are extracted. During the exploration phase, the robot will try out various actions ("play"), using the observed data to learn a qualitative model that it can then use to perform tasks (the exploitation phase).

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-M
Number of topics	1

Supervision

Supervisor : Jan Lemeire (jan.lemeire@vub.be)

Learn a Robot to Tackle a Gymnasium Robotic Challenge with Qualitative models.

Program : Computer science and engineering - M-IRIFS

Description

Autonomous robots must be able to solve problems on their own. For this purpose, OpenAI has standardized a set of challenges in a benchmark: https://gymnasium.farama.org/. For example, a car must reach the top of the mountain (by “swinging”), a cart must keep a pole upright, and a lunar lander must land between the flags. To solve such a challenge, a learning model is used. This model uses information from the task environment— in the second case, the angle of the pole— to then propose an action: changing the speed. The model must then learn a strategy to move the cart in such a way that it can keep the pole upright for as long as possible. This can be tested in simulation via Gymnasium.

The default approach is reinforcement learning, which trains a neural network by trial-and-error. This , however, has several drawbacks: a lot of training, no explanation is given (a neural network is a black box), and it just works in the environment it was trained in (no generalization or abstraction).

We propose an alternative method based on qualitative models describing relationships in a more abstract and general form:

“Turning the steering wheel clockwise makes the car turn right.”

“Pressing the gas pedal increases the car’s speed.”

“Picking up an object allows it to be moved elsewhere.”

These models can be learned with fewer interactions than traditional reinforcement learning techniques and are typically more transferable across tasks and domains.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-M
Number of topics	2

Supervision

Supervisor : Jan Lemeire (jan.lemeire@vub.be)

Topics offered to students by other master's programs

TARGET PROGRAM

EM – Mechatronic Engineering

Can machine learning methods approximate the optimal power flow solution for electric transmission systems?

Program : EM - Energy - M-IREMR-E

Description

Context

Optimal Power Flow (OPF) determines the optimal operating point of a power system satisfying its physical and operational constraints. This problem already being non-linear, non-convex and computationally expensive, gets increasingly more complex with the increasing penetration of Renewable Energy Sources (RES). This evergrowing complexity motivates the growing interest in machine learning (ML) as a way to produce fast approximate solutions. However, applying ML to the operation of power systems is not straightforward as the problem is high-dimensional, physics imposes hard constraints, and model relevance depends on the operating regime of each power system case. This thesis takes the Power Grid Library for OPF Benchmarking (PGLib-OPF) as its experimental playground. This open dataset is a collection of AC transmission test cases curated for OPF, ranging from small pedagogical networks to realistic grids with thousands of buses.

Research question
How well do machine learning methods approximate OPF on the cases from the PGLib dataset, and what insights can be extracted on why they succeed or fail across cases and operating conditions?

Approach
The student will (i) familiarise with the provided OPF solvers and the PGLib dataset, (ii) generate labelled train/test data by perturbing case loads and re-solving, (iii) apply standard ML techniques (e.g. regression, random forests, MLPs…) to predict OPF outputs, (iv) evaluate prediction accuracy, optimality gap, constraint violations, and computational speed-up against the solver, and (v) analyse which case characteristics (size, congestion regime, topology…) correlate with model performance. An optional extension, time permitting, would explore graph-aware model architecture.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-M
Number of topics	1

Material Screening for Laser-Ablation Micropropulsion Using a Torsional Pendulum Thrust Balance

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally compare candidate materials for laser-ablation micropropulsion using a torsional pendulum thrust or impulse balance. Laser propulsion refers to concepts in which laser radiation transfers momentum to a spacecraft or target. In laser-ablation propulsion, laser energy is absorbed by a material surface, causing rapid heating, vaporization, plasma formation, or material ejection. The recoil from the ejected material produces a small impulse, making this approach relevant for micropropulsion, attitude control, precision positioning, and possibly remote momentum transfer to small objects or debris.

The work will build on an existing torsional pendulum setup previously developed for laser-propulsion studies. The main objective is to determine how material properties such as composition, rigidity, porosity, optical absorption, surface roughness, and internal structure influence the impulse generated by pulsed laser ablation. The student will first review the principles of laser propulsion, pulsed laser ablation, micropropulsion, and impulse measurement, with attention to key quantities such as impulse bit, momentum coupling coefficient, laser fluence, ablation threshold, repeatability, and surface degradation.

Experimentally, small material samples will be mounted on the torsional pendulum and irradiated by a laser under controlled conditions. The recoil impulse produced by each laser pulse will induce an angular displacement or oscillation, from which the impulse can be estimated using the pendulum calibration, geometry, torsional stiffness, damping, and moment of inertia. The first phase will focus on calibration and validation of the measurement system, including sensitivity, noise floor, repeatability, damping behaviour, and uncertainty.

The second phase will test standard reference materials such as aluminium, copper, graphite, polymers, black coatings, adhesive tapes, or commercial absorptive films. These results will provide baseline data on how optical absorption, thermal conductivity, melting or vaporization behaviour, and surface morphology affect impulse generation. A third phase will investigate custom or engineered materials, such as porous materials, composites with carbon or metallic fillers, multilayer coatings, polymer matrices, foams, aerogels, or surface-treated samples. Laser parameters such as pulse energy, spot size, repetition rate, incidence angle, number of pulses, and target position will be controlled as carefully as possible.

The analysis will compare impulse bit, impulse as a function of laser energy or fluence, estimated momentum coupling coefficient, repeatability over multiple shots, and surface degradation after irradiation. The expected outcome is a calibrated comparative assessment of materials for laser-ablation micropropulsion. The thesis should rank candidate materials according to propulsion-relevant performance metrics and provide recommendations for future vacuum-compatible laser-propulsion experiments.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervisor

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Co-supervisor

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Calibration of colour-changing hygroscopic materials for water detection in lunar-regolith simulants

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally assess whether colour-changing hygroscopic materials can be used as simple indicators for detecting and semi-quantifying water in sand or lunar-regolith simulants. The detection of water on the Moon is a major challenge for future exploration, as water may occur as adsorbed molecules, hydroxyl groups, frost, ice grains, or concentrated deposits in permanently shadowed regions. While advanced instruments such as infrared spectrometers, neutron detectors, mass spectrometers, and thermal analysis systems can provide detailed measurements, there is also interest in developing simple, low-cost, robust indicators capable of giving rapid evidence of water or humidity in contact with granular materials.

The work will focus on humidity-sensitive materials that change colour when they absorb or adsorb water, such as silica-gel-based indicators, cobalt-free humidity cards, functional salts, porous films, or humidity-sensitive polymers. The student will first review lunar water detection, regolith properties, hygroscopic materials, and colourimetric sensing. Particular attention will be paid to clarifying what such indicators can detect, since colour-change materials are mainly sensitive to available molecular water or vapour-phase humidity, and not necessarily to chemically bound hydroxyl groups.

The experimental work will consist in preparing sand or lunar-regolith simulant samples with controlled water contents, introduced gravimetrically by adding known masses of water to dry granular material. Candidate indicator materials will then be exposed to these samples under reproducible conditions, for example in direct contact with the grains, partially buried in the medium, placed in the headspace of a sealed vial, or separated by a porous membrane. These configurations will help determine whether the response is driven by liquid contact, vapour-phase humidity, or local moisture gradients.

Colour changes will be recorded over time using photography, scanning, or a simple optical imaging setup under controlled lighting. Quantitative image analysis will be used to extract RGB, HSV, or CIELAB colour parameters and generate calibration curves relating colour response to known water content. The analysis will also evaluate response time, sensitivity, repeatability, reversibility after drying, and detection limit. Additional tests may examine the influence of grain size, porosity, mineral composition, sample geometry, temperature, and equilibration time.

The expected outcome is a calibrated proof-of-concept assessment of colour-changing hygroscopic materials for water detection in regolith-like media. The thesis should determine whether this approach is suitable for qualitative detection, semi-quantitative estimation, or only laboratory screening, and provide recommendations for future development of simple regolith-contact water indicators for lunar exploration.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor

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Co-supervisor

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Electromagnetic Shielding Properties of Standard and Custom Materials from 100 MHz to 10 GHz

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to develop and validate a practical experimental methodology for comparing the electromagnetic shielding performance of standard and custom materials in the 100 MHz–10 GHz frequency range. Electromagnetic shielding is increasingly important in aerospace systems, electronics, telecommunications, biomedical devices, sensor platforms, and space instrumentation, where sensitive components must be protected from external electromagnetic interference while limiting unwanted emissions. Classical metallic shielding solutions can be highly effective, but they are often heavy, rigid, or difficult to integrate into multifunctional structures.

The work will explore alternative shielding materials whose performance can be tuned through composition, thickness, porosity, rigidity, conductivity, magnetic response, or internal structure. Examples include conductive polymer composites, carbon-loaded elastomers, metallized textiles, porous conductive foams, graphene- or carbon-black-based films, magnetic particle composites, and multilayer hybrid materials. The laboratory has access to a vector network analyser and two probes covering approximately 100 MHz to 10 GHz, which will be used to establish a comparative testing platform.

The student will first review the principles of electromagnetic shielding, including reflection, absorption, multiple internal reflections, conductivity, magnetic permeability, skin depth, and frequency-dependent attenuation. The experimental work will then focus on defining a repeatable measurement protocol in which a material sample is placed between or near transmitting and receiving probes. Measurements with and without the sample will be used to estimate attenuation as a function of frequency, for example through relative changes in transmission parameters such as S21. Particular attention will be paid to calibration, probe positioning, sample size, edge leakage, distance between probes, background noise, environmental reflections, and repeatability.

Reference materials such as aluminium foil, copper foil, stainless-steel mesh, conductive tape, metallized films, carbon-loaded sheets, ferrite-containing materials, or commercial EMI shielding fabrics will first be tested to establish baseline behaviour. Custom materials will then be fabricated or selected with controlled variations in composition, filler content, thickness, porosity, rigidity, and multilayer structure. The analysis will compare frequency-dependent attenuation curves and assess how material parameters influence shielding performance. Where possible, results may also be normalized by thickness or areal density to evaluate lightweight shielding efficiency.

The expected outcome is a validated laboratory-scale methodology for screening electromagnetic shielding materials. The thesis should identify promising material families, quantify the influence of composition and structure on attenuation, and clarify the limitations of the probe-based setup compared with standardized certification methods. It should also provide recommendations for improving the platform, for example through a dedicated sample holder, shielding box, coaxial fixture, absorber-lined enclosure, or free-space measurement geometry.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor

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Torsional Pendulum Micro-Thrust Balance for Electrospray Propulsion Preparation

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to adapt and validate a torsional pendulum thrust-balance setup for the measurement of very small forces relevant to electrospray propulsion. Electrospray propulsion is a promising micropropulsion technology for CubeSats, small satellites, precision attitude control, drag compensation, and formation flying. It relies on the electrostatic acceleration of charged droplets, ions, or ion–droplet mixtures emitted from a conductive liquid under a strong electric field. Although the resulting thrust is typically in the micro-newton or sub-micro-newton range, it can be highly controllable and efficient, making it attractive for precision space applications.

A key experimental challenge is the reliable measurement of such small forces. Before developing a complete electrospray thruster, the laboratory needs a calibrated micro-thrust measurement platform. The work will therefore build on an existing torsional pendulum previously developed for laser propulsion studies and assess whether it can be adapted to electrospray-relevant force ranges. The thesis will focus on the measurement principle, calibration strategy, sensitivity, noise sources, and compatibility with future high-voltage operation.

The student will first review electrospray propulsion, Taylor cone formation, electrohydrodynamic emission, charged-particle acceleration, and micro-thrust measurement techniques. The experimental work will then consist in analysing the existing pendulum design and identifying the required modifications in terms of arm length, torsional stiffness, moment of inertia, damping, mechanical stability, displacement readout, electrical isolation, and future integration of a high-voltage emitter.

The first experimental phase will focus on calibration without electrospray operation. Known small forces may be applied using calibrated masses, electrostatic or magnetic forces, controlled mechanical displacement, or another suitable method. The system will be characterized in terms of linearity, sensitivity, minimum detectable force, response time, noise floor, drift, and repeatability. A second phase will investigate artefacts such as air currents, vibrations, acoustic noise, cable stiffness, electrostatic coupling, thermal drift, and mechanical hysteresis, with possible mitigation through shielding, damping, improved mounting, optical readout, or signal filtering.

The expected outcome is a calibrated and experimentally characterized torsional pendulum micro-thrust balance suitable as a foundation for future electrospray propulsion experiments. The thesis should determine whether the setup can reach electrospray-relevant force levels, identify the dominant limitations, and provide design recommendations for later integration with a high-voltage electrospray emitter and, eventually, a vacuum-compatible thrust-measurement platform.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor

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Co-supervisor

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Visibility of quantum dots under solar excitation

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to assess whether quantum dot fluorescence can be detected or visually observed under solar or solar-like excitation. Quantum dots are semiconductor nanocrystals with size-dependent optical properties. They can absorb light over a broad spectral range and emit fluorescence at specific wavelengths, making them attractive for optical sensing, imaging, security marking, diagnostics, photonics, and space-related detection concepts. However, while quantum dots are often clearly visible under UV lamps or controlled laboratory excitation, their visibility under sunlight is less straightforward because fluorescence must compete with broadband background illumination, reflection, scattering, and ambient light.

The objective of the thesis is to evaluate which optical parameters control the detectability of quantum dots under realistic illumination conditions. The student will first review the basic photophysics of quantum dots, including absorption, emission, quantum yield, Stokes shift, photobleaching, and surface passivation, together with basic concepts related to solar spectral irradiance, atmospheric filtering, and optical visibility. Selected quantum dot samples, provided as liquid dispersions, coated substrates, polymer films, or dried spots, will then be characterized experimentally.

The experimental work will include absorption and emission measurements using available techniques such as UV–Vis spectroscopy, fluorescence spectroscopy, reflectance measurements, and optical imaging. The student will investigate how the fluorescence signal depends on concentration, substrate, emission wavelength, excitation source, and viewing conditions. Where available, tests may be performed using a solar simulator, broadband lamp, UV source, or controlled illumination setup in order to compare laboratory excitation with more realistic solar-like conditions.

In parallel, the student will develop a simplified predictive model to estimate the fluorescence signal generated under Earth-surface and space-relevant illumination scenarios. This model may combine incident spectral irradiance, sample absorbance, emission efficiency, emission spectrum, and background reflectance. The analysis will compare the expected fluorescence signal with the optical background in order to determine whether visual detection is realistic or whether instrumental detection would be required.

The expected outcome is a quantitative proof-of-concept assessment of quantum dot visibility under solar excitation. The thesis should identify the key parameters controlling detectability, including quantum yield, absorption spectrum, emission wavelength, sample loading, substrate contrast, and illumination spectrum, and provide recommendations for future applications in sensing, marking, or space-related optical detection.

Language	EN (english)

Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M- IRPH
Number of topics	1

Supervision

Supervisor

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Co-supervisor

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Influence of non-Newtonian fluids on droplet coalescence and interfacial behaviour

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally investigate how the rheology of a non-Newtonian subphase influences droplet coalescence and interfacial behaviour. Droplet coalescence, the process by which two droplets or interfaces merge into a single liquid body, is central to many applications, including emulsions, coatings, spraying, inkjet printing, microfluidics, oil–water separation, pharmaceutical formulations, and food processing. Although often described using Newtonian fluids, many practical systems involve complex fluids such as polymer solutions, biological fluids, gels, suspensions, or surfactant-rich mixtures. Their rheological properties may strongly affect interface deformation, thin-film drainage, surface stability, and merging dynamics.

The objective of the thesis is to compare Newtonian and non-Newtonian systems under controlled experimental conditions, with particular attention to surface tension, surface pressure, surfactant effects, and coalescence behaviour. The student will first review the literature on droplet coalescence, interfacial tension, surfactant transport, and non-Newtonian rheology. Model fluids will then be selected, including a Newtonian reference fluid and one or more non-Newtonian systems, such as polymer-containing solutions or weakly structured fluids.

Experiments will be carried out using a Langmuir trough or another available interfacial measurement setup. The student will vary parameters such as surfactant concentration, subphase composition, and fluid rheology in order to evaluate their influence on the interface. Depending on the available configuration, the work may include surface pressure–area measurements, imaging of droplet approach and coalescence, measurement of coalescence time, observation of interface deformation, or indirect assessment of interface stability.

The analysis will focus on comparing surface tension or surface pressure data, characteristic response times, concentration-dependent trends, and coalescence behaviour between Newtonian and non-Newtonian systems. Where available, rheological information such as viscosity or shear-rate dependence will be used to interpret the results. The observations will be compared with simplified models from capillarity, viscous flow, interfacial rheology, and surfactant transport.

The expected outcome is an improved experimental understanding of how non-Newtonian fluid properties influence interface stability and droplet coalescence. The thesis should identify the dominant physical parameters, assess the role of surfactants and subphase composition, and provide guidance for future studies of coalescence in complex fluids.

Language	FR
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor

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Electrochromic Coatings for Active Thermal Control in Space : Experimental Assessment

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally assess the potential of electrochromic coatings as active thermal-control materials. Electrochromic materials reversibly change their optical properties when an electrical voltage is applied. While they are mainly known for smart-window applications, where they regulate light transmission and solar heat gain, the same principle could be used to control the thermal behaviour of a surface. By switching between coloured and bleached states, an electrochromic coating may modify the amount of radiation absorbed by a surface and therefore influence its temperature under illumination.

The main objective of the thesis is to determine whether electrical switching of an electrochromic coating can produce a measurable and controllable change in thermal behaviour under laboratory conditions. The student will first review the basic principles of electrochromic materials, optical switching mechanisms, smart-window technologies, and possible applications in thermal management. A safe and reproducible experimental protocol will then be defined for testing electrochromic samples.

Experiments will involve activating the coating using a DC power supply, potentiostat, or equivalent voltage-control system, depending on the available materials. The samples will be tested in different optical states under identical heating conditions, using a lamp, heated stage, hot plate, or solar-simulator-like source if available. Surface temperature will be monitored using thermocouples, contact sensors, or infrared imaging. The same sample will be compared in its coloured and bleached states, and repeated switching cycles will be performed to assess reversibility, hysteresis, degradation, and repeatability.

The analysis will focus on temperature–time curves, heating and cooling rates, maximum temperature differences, switching time, and stability over multiple cycles. Where possible, a simple energy-balance interpretation may be used to relate the observed thermal response to changes in optical properties.

The expected outcome is a proof-of-concept validation of electrochromic coatings for active thermal control. The thesis should determine whether voltage-induced optical switching produces a significant temperature modulation, identify the main limiting factors, and provide recommendations for future active thermal-control coating experiments.

Language	FR
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor
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Co-supervisor
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Experimental assessment of thermochromic coatings for passive thermal regulation in space

Program : EM - Aeronautics - M-IREMR-A

Description

This thesis aims to experimentally assess the potential of thermochromic coatings as passive thermal-regulation materials. Such coatings modify their optical properties with temperature, typically switching between a darker, more absorbing state and a lighter, more reflective state. This behaviour could be exploited to regulate surface temperature without active control, by increasing heat absorption when the surface is cold and reducing absorption when it becomes warm. The concept is relevant for systems exposed to alternating heating and cooling conditions, such as outdoor devices, building surfaces, spacecraft components, scientific payloads, or autonomous sensors.

The work will focus on determining whether the colour change of thermochromic coatings produces a measurable and repeatable thermal effect under controlled day–night-like cycling. The student will first conduct a short literature review on thermochromic materials, passive thermal control, and radiative heat transfer. Coated samples and reference surfaces, such as black, white, metallic, or uncoated substrates, will then be tested under identical cyclic heating and cooling conditions. Experiments may use laboratory equipment such as lamps, hot plates, Peltier elements, heated stages, or environmental chambers. Surface temperatures will be monitored using thermocouples, contact probes, infrared measurements, or a combination of these methods, while colour changes may be documented visually.

The analysis will compare temperature–time curves for the thermochromic and reference samples. Key quantities will include the switching temperature range, maximum and minimum temperatures, heating and cooling rates, hysteresis, reversibility, and cycle-to-cycle repeatability. Where relevant, a simple energy-balance model may be used to interpret the results and relate the observed thermal response to absorbed radiation and surface properties.

The expected outcome is a proof-of-concept evaluation of thermochromic coatings for passive thermal regulation. The thesis should determine whether the selected coating provides a significant thermal benefit, under which conditions this effect is most visible, and what parameters should be improved for future applications.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor

Axel Coussement (axel.coussement@ulb.be)

Co-supervisor

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Analysis of Heat and Mass Transport During Hydrogen Bubble Growth in Water Electrolysis

Program : Chemical & Materials engineering - M-IRMAE

Description

Hydrogen can be produced by splitting water through electrochemical reactions in electrolysis. Although the process is overall endothermic, additional heat can be generated locally, most notably through Joule heating at the electrode surface. This localized heating modifies the temperature field near the growing hydrogen bubble, creating temperature gradients that induce thermocapillary (Marangoni) flows along the bubble interface.
In addition to thermal effects, concentration gradients of surface active species such as ions or dissolved gases can also alter surface tension, resulting in solutal Marangoni convection. These interfacial flows strongly affect bubble growth, shape, and detachment dynamics. Understanding these coupled effects requires the ability to accurately resolve the local temperature and concentration fields around the bubble. However, measuring both fields at the same time remains a significant experimental challenge.
Previous studies have demonstrated that at high applied potentials, Joule heating dominates, and thermocapillary effects become the primary drivers of interfacial motion, while solutal effects can often be neglected. Various optical techniques such as Schlieren imaging, laser induced fluorescence, and interferometry have been used to study these fields.
Mach Zehnder interferometry stands out as a noninvasive and calibration free technique for resolving instantaneous temperature fields with high sensitivity.
This thesis will focus on hydrogen bubble dynamics on a microelectrode in acidic electrolysis, using two complementary experimental techniques:
• Mach Zehnder Interferometry, to quantify the temperature field near the electrode and at the base of the bubble, especially when concentration variations are negligible.
• High speed visualization, to qualitatively capture the bubble inception, growth, and detachment processes.
• Complementary Schlieren imaging may be used for qualitative validation as done in the previous study [1].
Methodology
1. Literature survey
The student will begin by familiarising themselves with the topic. A thorough review of recent literature, especially on interferometric and visualisation techniques applied to gas-evolving electrodes, will help define the research scope and objectives.
2. Experimental set-up
The student will work with the existing electrolysis cell, Mach Zehnder interferometer, and high-speed imaging system available at the TIPS laboratory. This phase will involve hands-on training with laser alignment, optical adjustments, electrode handling, and system calibration. The student will also participate in test runs to optimise measurement conditions and gain confidence in operating the setup independently.
3. Measurement campaign and data analysis

The student will conduct experiments to visualise hydrogen bubble growth on microelectrodes using high-speed imaging and Mach Zehnder interferometry. Interferometric data will be analysed to extract local temperature fields, while high-speed recordings will be used to characterise bubble shape, growth, and detachment dynamics. Post-processing and analysis will be carried out using MATLAB. If numerical simulation results are available, they will be compared with the experimental data. In parallel, the student will measure the refractive index, density, and viscosity of the electrolyte across different concentrations and temperatures, using the available facilities at the TIPs laboratory, ULB.

4. Reporting

- Weekly meetings with the supervisor(s) to define tasks and discuss outcomes and practicalities.
- Monthly meeting with the team to verify the progress and discuss follow-up
- Final presentation

References

[1]. A. Babich, A. Bashkatov, X. Yang, G. Mutschke, and K. Eckert, "In-situ measurements of temperature field and Marangoni convection at hydrogen bubbles using schlieren and PTV techniques," Int. J. Heat Mass Transf., vol. 215, p. 124466, 2023.

[2]. J. Massing, G. Mutschke, D. Baczyzmalski, S. S. Hossain, X. Yang, K. Eckert, and C. Cierpka, "Thermocapillary convection during hydrogen evolution at microelectrodes," Electrochimica Acta, vol. 297, pp. 929–940, 2019.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	2

Supervision

Supervisor : Pierre Colinet (pierre.colinet@ulb.be)

Co-supervisor : Senthil Kumar Parimalanathan (senthil.parimalanathan@ulb.be)

Design and development of advanced drones for water quality assessment.

Program : Electrical engineering - M-IRELE

Description

This thesis develops further on previous theses in which drines have been developed for water quality assessment. Two types of drones have been developed. An aerial drone and a vessel based drone. For students from EM, this thesis will be about the optimisation of the drones and the development of algorithmq for energy optimised way point planning. For students from electric engineering and computerscience the focus will be on the development of algorithms for fleet management and multi-drone co-operative measurement campaigns.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	2

Supervision

Supervisor : Abdellah Touhafi (abdellah.touhafi@gmail.com)

Modeling Electric Heating Resistance using multi-physics approach for industrial implementation

Program : EM - Aeronautics - M-IREMR-A

Description

Electric heating elements are widely used in high-temperature industrial processes because they can deliver controlled thermal energy without direct combustion. However, these components operate under severe conditions, where electrical, thermal, and mechanical phenomena are strongly coupled. Current flowing through the resistance generates Joule heating, which leads to high temperature gradients, thermal expansion, deformation, and mechanical stresses. In some configurations, electromagnetic forces may also contribute to displacement or instability. A predictive understanding of these coupled effects is therefore essential to improve performance, reliability, lifetime, and safety in industrial applications.

The objective of this master thesis is to improve an existing multiphysics model of electric heating resistances. The model will combine electromagnetic modelling, Joule heating, heat transfer, thermal expansion, and mechanical stress analysis. The aim is to simulate how operating conditions, geometrical configurations, and material properties influence the deformation and potential failure of heating elements under realistic industrial loads. Particular attention will be paid to high-temperature materials such as molybdenum or industrial resistance materials, using appropriate temperature-dependent properties when available.

The thesis will first include a literature review on multiphysics modelling strategies for electrically heated components and on the main industrial challenges associated with high-temperature electric heating. The student will then work on the improvement of the existing numerical model, using ANSYS or an equivalent simulation platform. This will involve coupling the electromagnetic problem, including current distribution and possibly Lorentz forces, with the thermal problem through Joule heat generation, and with the mechanical problem through thermal expansion and stress analysis.

The improved model will then be used to simulate representative operating scenarios. The student will analyse the effect of current intensity, resistance geometry, boundary conditions, material properties, and symmetrical or asymmetrical configurations on temperature fields, electromagnetic forces, deformation, and stress levels. These simulations will help identify critical situations that may lead to excessive deformation, contact between components, local overheating, breakage, or mechanical instability.

The expected outcome is a validated or critically assessed multiphysics modelling framework for high-temperature electric heating elements. The thesis should provide a clearer understanding of the mechanisms leading to deformation or failure, as well as practical recommendations for safer and more efficient design and operation. The deliverables will include a literature review, an improved numerical model, a parametric analysis of operating conditions, and design guidelines concerning resistance geometry, power control strategies, material selection, and industrial implementation.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Jetnis Avdijaj (jetnis.avdijaj@ulb.be)

Implementation of a Temperature Control Strategy for CFD-Based Digital Twin of an Industrial Process

Program : EM - Aeronautics - M-IREMR-A

Description

Industrial thermal processes require precise temperature regulation to ensure product quality, energy efficiency, operational stability, and safety. In the context of digitalisation and decarbonisation, digital twins are becoming important tools to predict system behaviour, evaluate operating strategies, and support process optimisation. However, high-fidelity CFD models are often used mainly for offline analysis and are rarely coupled with dynamic control strategies. Adding control capabilities to such models is therefore an important step toward predictive and controllable virtual representations of industrial systems.

The objective of this master thesis is to develop and implement a temperature regulation system for an existing CFD model of an industrial thermal process. The aim is to move from a purely predictive CFD simulation toward a controlled numerical environment, where boundary conditions or operating parameters can be adjusted dynamically in order to reach and maintain a target temperature. This work will contribute to the development of a digital twin framework by combining physics-based modelling, control algorithms, and simulation outputs that can be exploited for future real-time or near-real-time applications.

The thesis will first include a literature review on temperature control strategies for thermal systems, including PID control, advanced control approaches, and model predictive control. The student will also review digital twin architectures for industrial processes and existing methods for integrating control loops with CFD environments such as ANSYS Fluent. Particular attention will be paid to the practical constraints associated with coupling a CFD solver and an external controller, including data exchange, time stepping, numerical stability, and computational cost.

The main part of the thesis will consist of designing and implementing a control strategy for the selected CFD model. Depending on the case study, the controller may act on inlet temperature, mass flow rate, heating power, wall heat flux, or another relevant operating variable. The control algorithm will be coupled to the CFD simulation and tested under different operating scenarios, such as changes in heat demand, disturbances, set-point variations, or modified boundary conditions. The control performance will be assessed in terms of response time, overshoot, stability, robustness, and ability to maintain the desired temperature distribution.

Finally, the thesis will analyse how the controlled CFD model can support the development of a digital twin. This includes identifying which simulation outputs are relevant for monitoring and decision support, what level of model reduction or acceleration may be required, and how control parameters can be optimised for robust operation. The expected outcome is a working control-oriented CFD framework, a critical assessment of its performance and limitations, and recommendations for future integration into an industrial digital twin platform.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Jetnis Avdijaj (jetnis.avdijaj@ulb.be)

CFD Modeling of Water Injection in Hydrogen-Fueled Internal Combustion Engines and Development of a 0D Water Injection Model for CHP Applications

Program : EM - Aeronautics - M-IREMR-A

Description

Hydrogen-fuelled internal combustion engines are a promising solution for low-carbon combined heat and power applications, where both useful mechanical or electrical power and recoverable heat can be produced. However, hydrogen combustion presents several challenges, including high in-cylinder temperatures, NO_x emissions, knock, and pre-ignition risks. Water injection is a potential strategy to mitigate these issues by reducing combustion temperatures and influencing mixture formation, evaporation processes, and combustion behaviour. In a CHP context, understanding these effects is particularly important because water injection may affect not only engine efficiency and emissions, but also the thermal balance and heat recovery potential of the system.

The objective of this master thesis is to develop a CFD model to study water injection in a hydrogen spark-ignition engine. The model will be used to analyse the evaporation process, droplet behaviour, vapour distribution, and the effect of water injection on in-cylinder temperature and combustion characteristics. The thesis will first include a literature review on hydrogen combustion in spark-ignition engines, water injection strategies, spray evaporation, two-phase flow modelling, and CFD approaches relevant to hydrogen-fuelled engines.

The main part of the thesis will consist of building a numerical CFD model of the engine configuration. Depending on the available data and geometry, the model may focus on the intake system, the combustion chamber, or a simplified representative domain. It should include the hydrogen–air mixture, the water injection system, and the relevant heat and mass transfer phenomena. Particular attention will be paid to the physical state of the injected water under different operating conditions, in order to determine whether it remains as liquid droplets, evaporates into vapour, or forms a two-phase mixture. The influence of injection timing, injected mass, droplet size, pressure, temperature, and flow conditions will be analysed.

The CFD model will then be used to investigate how water injection affects hydrogen combustion. The student will study its influence on in-cylinder temperature, mixture dilution, heat-release behaviour, thermal gradients, knock tendency, and NO_x-related temperature reduction. These results will help identify the main mechanisms through which water injection can improve or degrade engine performance in CHP-relevant operating conditions.

Finally, the CFD results will support the development of a simplified zero-dimensional model of water injection for hydrogen engines. This 0D model should reproduce the main effects of evaporation, temperature reduction, mixture dilution, and combustion modification, while remaining suitable for fast parametric studies or future system-level CHP simulations. The expected outcome is a CFD-based understanding of water injection in hydrogen spark-ignition engines, together with a first reduced-order modelling approach that can be reused in further experimental or numerical work.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.be)

Investigation of Coupled CFD Modelling for Microwave Electrification of Industrial Heating

Program : EM - Aeronautics - M-IREMR-A

Description

The objective of this master thesis is to investigate coupled modelling strategies in CFD for the study of microwave electrification applied to industrial heating processes. The work is positioned in the context of the E-HEAT proposal and, more broadly, of industrial heat decarbonisation, where replacing fossil-fuel-based heating by electrified technologies requires reliable numerical tools. The focus of the thesis is therefore not to design a complete microwave heating system, but to explore how electromagnetic energy deposition can be coupled with heat transfer and fluid-flow models in a CFD environment.

The thesis will first consist of reviewing the physical phenomena and numerical approaches involved in microwave heating. The student will analyse how microwave radiation interacts with materials, how electromagnetic power is absorbed, and how this absorbed power can be represented as a volumetric heat source in a CFD model. Particular attention will be paid to the coupling between electromagnetic fields, temperature-dependent material properties, heat conduction, convection, radiation, and possible flow effects. The objective is to identify the main modelling assumptions, coupling strategies, and numerical difficulties associated with such multiphysics simulations.

The student will then develop and test one or several simplified coupled CFD models on a representative configuration. Depending on the chosen level of complexity, the electromagnetic field may be represented through an imposed power deposition profile, a simplified analytical model, or a coupling with an external electromagnetic solver. This source term will then be integrated into a CFD model solving the thermal and, where relevant, fluid-flow problem. The work should compare different coupling levels, from weak one-way coupling to more advanced approaches where the temperature field modifies the material properties and therefore the absorbed microwave power.

A parametric study will be carried out to assess the sensitivity of the coupled model to key assumptions and input parameters. These may include microwave power, spatial distribution of the heat source, dielectric properties, temperature dependence of material parameters, geometry, boundary conditions, flow rate, and thermal losses.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Pedagogical Integration of Flight Simulators for Engineering Education

Program : EM - Aeronautics - M-IREMR-A

Description

The project will focus on transforming the existing simulators into structured teaching platforms, allowing students to connect theoretical notions of flight mechanics, aircraft performance, stability, control, and aircraft design with hands-on simulation activities.

The work will first consist of analysing the current state of the simulator infrastructure. This includes the hardware configuration, cockpit interfaces, flight simulation software, available aircraft models, visualisation systems, data extraction possibilities, and operational limitations. The student will identify what remains to be completed or improved in order to obtain a robust, repeatable, and easy-to-use laboratory setup. Particular attention will be paid to usability, reliability, documentation, and the ability to run exercises with groups of students in a teaching context.

A second part of the thesis will focus on the integration of the OAD software environment. OAD presents its tools as covering the aircraft development process from conceptual design to flight-test analysis, with applications including aircraft design, UAV/aircraft optimisation, and flight performance analysis. The objective will be to investigate how such tools can be combined with the flight simulators in order to create a coherent workflow: from preliminary aircraft design and performance estimation to simulation-based evaluation of flight behaviour.

The student will then design a first set of pedagogical activities for engineering students. These activities may address topics such as take-off and landing performance, climb rate, stall behaviour, static and dynamic stability, control response, flight envelope exploration, and the influence of aircraft design parameters on flight performance. The aim is not only to provide demonstrations, but to build laboratory sessions in which students formulate hypotheses, run simulations, collect data, analyse results, and compare them with theoretical models.

Language	EN (english)
Open to other master’s programs	Yes
Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@hotmail.com)

Development of a Low-Power Gas Turbine Test Bench for RC-Size Engines

Program : EM - Aeronautics - M-IREMR-A

Description

The objective of this master thesis is to carry out the preliminary study, design, and first implementation of a low-power gas turbine test bench based on RC-size turbojet engines. The bench is intended for use in engineering laboratory sessions, where students will be able to observe and analyse the operation of a real gas turbine in a safe, compact, and didactic environment. Although RC-size engines are small, they reproduce the essential features of gas turbine operation: air compression, combustion, turbine expansion, exhaust acceleration, transient behaviour, thermal constraints, and fuel consumption. They therefore provide an attractive and affordable platform for hands-on teaching in propulsion, turbomachinery, energy conversion, and experimental methods.

The thesis will first consist of a pre-study phase. The student will analyse the technical, pedagogical, and safety requirements of such a bench. This includes identifying the type and size of engine to be used, the expected thrust and thermal loads, the constraints linked to indoor or semi-indoor operation, noise levels, exhaust management, fuel storage, and safety procedures. A review of existing educational gas turbine benches and RC turbine test setups will be carried out in order to define a realistic concept adapted to university laboratory use.

Based on this analysis, the student will develop the mechanical and functional design of the test bench. This will include the design of the supporting structure, engine mounting system, thrust measurement arrangement, protective shielding, access to the engine for maintenance, fuel system integration, and space for future instrumentation. The work will involve producing technical drawings and CAD models, selecting suitable components, defining a bill of materials, and justifying the main design choices in terms of safety, robustness, cost, ease of use, and pedagogical value.

A key objective of the thesis will then be to manufacture or assemble a first version of the bench. Depending on the progress of the project, this prototype should allow the safe installation of the engine and prepare the bench for future experimental campaigns. Particular attention will be paid to modularity, so that additional sensors such as thermocouples, pressure probes, fuel flow meters, load cells, vibration sensors, or data acquisition systems can be integrated in later stages.

The expected outcome is a complete pre-design study and a first operational or partially operational prototype of a gas turbine laboratory bench. The deliverables will include the technical specifications, CAD drawings, component selection, assembly documentation, safety analysis, and recommendations for future instrumentation and laboratory exercises. This thesis is therefore mainly an engineering design and development project, with a strong practical dimension and a clear teaching objective

Language	EN (english)
Open to other master’s programs	Yes

Eligible master’s programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Development of a Low-Power Gas Turbine Test Bench for RC-Size Engines Feasibility Study of ULB as an Energy Hub within a Local Energy Community Feasibility Study for the Decarbonisation of Heat Supply on ULB Campuses Pedagogical Integration of Flight Simulators for Engineering Education Development of a dynamic thermal energy storage model as a digital twin in a decentralized energy system Investigation of Coupled CFD Modelling for Microwave Electrification of Industrial Heating Experimental and 0D Modelling Study of Water Injection in Hydrogen Spark-Ignition Engines for CHP Applications Development of a Hydrogen–Diesel Dual-Fuel Engine Test Bench and 0D Combustion Model for CHP Applications CFD Modeling of Water Injection in Hydrogen-Fueled Internal Combustion Engines and Development of a 0D Water Injection Model for CHP Applications   Implementation of a Temperature Control Strategy for CFD-Based Digital Twin of an Industrial Process Modeling Electric Heating Resistance using multi-physics approach for industrial implementation Adapted Chemical Reactor Networks for Fast Combustion Modelling under Variable Operating Conditions

Program : EM - Energy - M-IREMR-E

Description

Combustion modelling is a central challenge in energy and chemical engineering. Industrial systems such as gas turbines, furnaces, and engines involve strong interactions between fluid dynamics, chemical kinetics, turbulence, and heat transfer. High-fidelity CFD simulations coupled with detailed chemical mechanisms are powerful tools to analyse these systems, but they remain computationally expensive, especially when large reaction mechanisms are considered. This limits their use for parametric studies, design exploration, optimisation, or real-time applications. Reduced-order modelling approaches are therefore needed to retain the main physical and chemical behaviour of reacting flows at a much lower computational cost.

The objective of this master thesis is to investigate adapted Chemical Reactor Networks (CRN) as reduced-order models for combustion systems. A Chemical Reactor Network approximates a complex reacting flow by a set of interconnected ideal reactors, each representing a region of the flow with similar thermochemical properties. In conventional approaches, the network is generated from CFD data for one specific operating condition. When the operating conditions change, a new CFD simulation is often required to build a new network. This thesis will explore an alternative strategy: reusing a CRN structure obtained from a reference CFD case while modifying only the inlet conditions and operating parameters.

The work will first include a literature review on CRN methods, CFD-based reactor network generation, clustering techniques, and reduced-order modelling for combustion. The student will then generate a CRN from existing CFD data by grouping computational cells into regions with similar thermochemical properties, such as temperature, mixture fraction, residence time, or species concentrations. Each region will be represented as an ideal reactor, and the mass exchanges between regions will define the reactor connectivity. The resulting network will be solved using a chemical kinetics tool such as Cantera.

The main part of the thesis will consist of assessing the robustness of the adapted CRN approach. The student will apply the same reactor network structure to operating conditions different from the reference case, by changing inlet temperature, equivalence ratio, mass flow rate, fuel composition, or other relevant parameters. The CRN predictions will then be compared with reference CFD simulations or experimental data when available. Key quantities may include temperature fields, major species, pollutant formation, heat release, and global combustion efficiency.

The expected outcome is a critical assessment of whether a CRN generated from one CFD case can be reused as a fast predictive tool over a range of operating conditions. The thesis will deliver a literature review, a CFD-to-CRN workflow, a set of adapted CRN simulations, and recommendations on the validity limits and possible improvements of the method. The project requires knowledge of fluid mechanics and thermodynamics, programming skills in Python, and an interest in combustion, CFD, and numerical modelling.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Alessandro Parente (alessandro.parente@ulb.be)

Co-supervisor : Asija Inciardi (asija.inciardi@ulb.be)

Development of a Hydrogen–Diesel Dual-Fuel Engine Test Bench and 0D Combustion Model for CHP Applications

Program : EM - Energy - M-IREMR-E

Description

Hydrogen–diesel dual-fuel engines are a promising solution for improving the efficiency and reducing the carbon intensity of combined heat and power systems. By introducing hydrogen into a conventional diesel engine, it becomes possible to partially substitute fossil fuel while maintaining the robustness, high efficiency, and ignition reliability of diesel combustion. Such systems are particularly relevant for CHP applications, where both mechanical or electrical power and useful heat recovery must be considered. However, hydrogen–diesel operation involves specific combustion challenges, including ignition delay, heat-release control, knock or abnormal combustion risks, NO_x emissions, and the interaction between diesel pilot injection and hydrogen–air combustion.

The objective of this master thesis is to design and implement a dedicated hydrogen–diesel dual-fuel engine test bench within the ULB-ATM laboratory, and to complement this experimental work with the development of a zero-dimensional combustion model. The test bench should enable controlled investigations of combustion behaviour, engine performance, emissions, and heat recovery potential under different operating conditions. The student will first carry out a literature review on hydrogen–diesel dual-fuel combustion, existing experimental setups, safety constraints linked to hydrogen use, and 0D modelling approaches for internal combustion engines.

The main part of the thesis will focus on the design and implementation of the experimental test bench. This will include the definition of the fuel supply architecture, hydrogen injection strategy, diesel operation mode, instrumentation, data acquisition system, safety procedures, and operating protocols. The bench should allow the measurement of relevant quantities such as engine speed, torque or load, fuel consumption, hydrogen flow rate, temperatures, pressures, exhaust composition, and recoverable heat. Particular attention will be paid to safe hydrogen handling, ventilation, leak detection, emergency shutdown, and compatibility with laboratory constraints.

In parallel, the student will develop or adapt a 0D combustion model of the hydrogen–diesel dual-fuel engine. The model should reproduce the main features of the combustion process, including pressure and temperature evolution, ignition delay, heat-release rate, diesel pilot contribution, hydrogen energy fraction, and global engine performance. When experimental data are available, the model will be compared with measurements in order to assess its accuracy and limitations.

The expected outcome is a first experimental and numerical platform for studying hydrogen–diesel dual-fuel engines in CHP conditions. The deliverables will include a literature review, the design and implementation of the test bench, initial experimental results, a validated or partially validated 0D model, and a preliminary analysis of operating conditions favourable to efficient heat recovery. The thesis will require knowledge of thermodynamics, combustion, heat transfer, and piston engines, as well as programming skills in Python, MATLAB, or a similar environment. Practical skills and the ability to work with the ATM technical team will be important assets.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.be)

Experimental and 0D Modelling Study of Water Injection in Hydrogen Spark-Ignition Engines for CHP Applications

Program : EM - Energy - M-IREMR-E

Description

Hydrogen spark-ignition engines are a promising solution for low-carbon combined heat and power applications, where both mechanical or electrical power and useful heat can be produced. However, hydrogen combustion remains challenging because of high combustion temperatures, NO_x emissions, knock, and pre-ignition risks. Water injection is a potential strategy to mitigate these limitations by reducing in-cylinder temperatures and modifying the combustion process. In a CHP context, this temperature control is also important because it affects not only engine efficiency and emissions, but also the amount and quality of recoverable heat.

The objective of this master thesis is to design and implement an experimental setup to study water injection under conditions representative of hydrogen spark-ignition engines. A key question will be to determine whether the injected water enters the engine as liquid droplets, vapour, or a two-phase mixture, depending on injection pressure, temperature, timing, injected quantity, and operating conditions. The student will therefore first carry out a literature review on hydrogen engine combustion, abnormal combustion phenomena, NO_x formation, and water injection strategies in internal combustion engines.

The main part of the thesis will consist of developing a dedicated experimental setup for water injection characterisation. This setup should make it possible to study the evaporation behaviour, droplet dynamics, temperature evolution, and resulting phase of the injected water before its introduction into the engine. Once the methodology has been characterised, the system will be implemented on a real hydrogen spark-ignition engine. Experimental tests will then be used to assess the impact of water injection on combustion behaviour, performance, efficiency, knock tendency, thermal behaviour, and NO_x emissions.

In parallel, the student will develop or adapt a zero-dimensional combustion model of a hydrogen spark-ignition engine including the effects of water injection. The model should account for injected water quantity, evaporation, mixture dilution, temperature reduction, heat-release behaviour, engine performance, and CHP efficiency. When experimental results are available, the model will be compared with measurements in order to assess its validity and limitations.

The expected outcome is a first experimental and numerical framework for analysing water injection in hydrogen spark-ignition engines. The main deliverables will be a literature review, the design and implementation of the water-injection test setup, a first implementation on the hydrogen engine test bench, and a validated or partially validated 0D model. The thesis will require good knowledge of thermodynamics, heat transfer, and piston engines, as well as programming skills in Python, MATLAB, or a similar environment. Practical skills and the ability to work with the ATM technical team will be important assets.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Cyril Freyling (cyril.freyling@ulb.b)

Development of a dynamic thermal energy storage model as a digital twin in a decentralized energy system

Program : EM - Energy - M-IREMR-E

Description

In an attempt to reduce the impact of climate change on our planet, we are shifting away from fossil fuels toward more renewable energy sources. However, integrating more renewable energy sources, such as solar and wind, comes with its challenges. To maximize the use of energy produced by renewable sources, storage will become increasingly important in energy systems. This makes it possible to use excess energy at later times when necessary and to balance the energy production and demand curves more efficiently. When analyzing energy consumption, after electricity and transportation, heating for
space heating and hot water production is a substantial part of our energy needs. An efficient way to meet our electricity and heating needs is to use combined heat and power (CHP) units, such as micro gas turbines (MGT) or internal combustion engines (ICE), where the excess heat from the exhaust gas can be used to heat water for district heating networks (DHN). Oftentimes, electricity production is the
main driver in the CHP units, so reliable heat storage is necessary to benefit later.
The thesis will focus on developing a dynamic model of thermal energy storage (TES) that accounts for thermal inertia. This model can then be used as a digital twin, an accurate but fast model that receives
information from the physical system and can be used for real-time optimization. The TES can be implemented in an energy system that needs to be optimized to ensure that the available power and heat match demand, and it can also be used to reduce fossil fuel emissions or utilization costs. The modeling, optimization, and control of the energy system can be used to predict our ideal energy generation mix and also allow us to adapt our plan in case of disturbances, e.g., more clouds than expected, which reduces available solar energy.

First, the student conducts an extensive literature review on thermal energy storage and examines how it is modeled to balance accuracy and computational speed. Once the student has developed an idea for this model, it will be implemented in Python. During this phase, different methods can be explored and compared to results in the literature. The thermal energy storage model will be integrated into an available district heating network model. The control system will be developed to demonstrate its use in optimizing the heating network.

The student does not need any prior knowledge of energy systems or thermal energy storage, but should be interested in learning. As this project will mainly consist of programming, basic knowledge of Python is required.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Co-supervisor : Zoraida Nti (zoraida.nti@ulb.be)

Feasibility Study for the Decarbonisation of Heat Supply on ULB Campuses

Program : EM - Energy - M-IREMR-E

Description

The objective of this master thesis is to perform a first feasibility study on the decarbonisation of heat supply on ULB campuses, in close collaboration with the ULB cellule énergie. At present, the university's heat demand is mainly covered by natural gas boilers using CH_4. The aim of the thesis is to assess possible pathways to reduce or eliminate fossil fuel use for heating, while taking into account the technical, economic, operational, and spatial constraints of university campuses.

The work will first consist of characterising the current heat demand and heat production infrastructure. The student will analyse available data on gas consumption, heating networks, boiler rooms, building uses, occupancy patterns, temperature levels, and seasonal demand profiles. Particular attention will be paid to the distinction between peak heat demand, annual heat consumption, supply temperatures, and the flexibility of the buildings, since these elements strongly influence the feasibility of low-carbon heating solutions.

The student will then identify and compare a broad range of decarbonisation options. These may include heat pumps, geothermal energy, shallow geothermal storage, connection to existing or future district heating networks, heat recovery from local sources, solar thermal systems, biomass where relevant, hybrid systems combining gas and low-carbon technologies, and progressive electrification strategies. The analysis should also consider demand-side measures, such as reducing supply temperatures, improving control strategies, exploiting thermal inertia, and prioritising building-level efficiency improvements when they enable more efficient low-carbon heat production.

A simplified modelling framework will then be developed to compare several transition scenarios. These may include a reference scenario based on the current CH_4 supply, partial electrification through heat pumps, geothermal-assisted heating, hybrid systems for peak demand, and more integrated campus-scale solutions combining storage, heat recovery, and demand management. The comparison should estimate key indicators such as energy consumption, fossil fuel reduction, CO_2 emissions, peak electrical power, seasonal performance, investment cost, operating cost, spatial requirements, implementation complexity, and robustness of supply.

Finally, the thesis will address practical aspects in collaboration with the ULB cellule énergie. This includes data availability, technical constraints in existing buildings, compatibility with current heating networks, regulatory aspects, phasing of investments, and the identification of priority sites or pilot projects. The expected outcome is a structured feasibility report assessing which decarbonisation pathways are most promising for ULB campuses, under which conditions they could be implemented, and what further studies would be required. The work will provide quantitative first estimates and a roadmap toward a progressive reduction of CH_4-based heating on campus.

Language	EN (english)

Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Feasibility Study of ULB as an Energy Hub within a Local Energy Community

Program : EM - Energy - M-IREMR-E

Description

The objective of this master thesis is to perform a first feasibility study on the potential role of ULB as an energy hub within a local energy community, at the scale of the urban block or neighbourhood surrounding the university campus. The project will be carried out in close interaction with the ULB cellule énergie, with the aim of evaluating how the university's buildings, energy infrastructure, consumption profiles, and potential local production assets could contribute to a collective energy strategy.

The work will focus on identifying the technical potential for ULB to act as a local energy hub. This includes assessing opportunities for photovoltaic production, demand-side management, heat recovery, battery or thermal storage, electric vehicle charging, and possible interactions with neighbouring buildings or users. The analysis should consider both electrical and thermal energy flows, and evaluate whether coupling these vectors could bring additional value at neighbourhood scale.

The student will then develop a simplified modelling framework to compare several energy-community scenarios. These may include a reference case without energy sharing, a scenario with increased local renewable production, a scenario including flexible loads or storage, and a more integrated energy-hub scenario. The model should estimate key indicators such as self-consumption, self-sufficiency, peak power reduction, CO_2 emissions, energy costs, and possible benefits for participating users. The level of modelling will remain compatible with a first feasibility study, while being sufficiently detailed to support concrete recommendations.

Finally, the thesis will address practical and organisational aspects in collaboration with the ULB cellule énergie. This may include data availability, regulatory constraints, metering requirements, governance models, and the identification of priority actions for a future demonstrator. The expected outcome is a structured feasibility report assessing whether, and under which conditions, ULB could become a central actor in a local energy community. The work will provide both quantitative first estimates and a roadmap for further technical, economic, and institutional development.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Axel Coussement (axel.coussement@ulb.be)

Learn a Robot Arm to Manipulate Objects through Qualitative Modeling.

Program : Computer science and engineering - M-IRIFS

Description

We can program robots perfectly to perform tasks, but only in known environments. Pre-programmed robots struggle to handle new situations. To enable robots to operate in uncontrolled environments, they must be capable of learning. This is where the scientific field of self-learning robots comes into play. In this master's thesis, you will apply this concept to a robotic arm that must learn to manipulate objects: moving, stacking, cleaning up, and more. Our innovative approach, based on qualitative models, will lead to improved manipulation compared to the current state of the art.

The robotic arm (see figure) will be controlled based on camera images. The objects are identified and analyzed within these images, from which the important properties are extracted. During the exploration phase, the robot will try out various actions ("play"), using the observed data to learn a qualitative model that it can then use to perform tasks (the exploitation phase).

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-M
Number of topics	1

Supervision

Supervisor : Jan Lemeire (jan.lemeire@vub.be)

Learn a Robot to Tackle a Gymnasium Robotic Challenge with Qualitative models.

Program : Computer science and engineering - M-IRIFS

Description

Autonomous robots must be able to solve problems on their own. For this purpose, OpenAI has standardized a set of challenges in a benchmark: https://gymnasium.farama.org/. For example, a car must reach the top of the mountain (by "swinging"), a cart must keep a pole upright, and a lunar lander must land between the flags. To solve such a challenge, a learning model is used. This model uses information from the task environment— in the second case, the angle of the pole— to then propose an action: changing the speed. The model must then learn a strategy to move the cart in such a way that it can keep the pole upright for as long as possible. This can be tested in simulation via Gymnasium.

The default approach is reinforcement learning, which trains a neural network by trial-and-error. This , however, has several drawbacks: a lot of training, no explanation is given (a neural network is a black box), and it just works in the environment it was trained in (no generalization or abstraction).

We propose an alternative method based on qualitative models describing relationships in a more abstract and general form:

"Turning the steering wheel clockwise makes the car turn right."

"Pressing the gas pedal increases the car's speed."

"Picking up an object allows it to be moved elsewhere."

These models can be learned with fewer interactions than traditional reinforcement learning techniques and are typically more transferable across tasks and domains.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-M
Number of topics	2

Supervision

Supervisor : Jan Lemeire (jan.lemeire@vub.be)

Electro-Mechanical Engineering – Robotics & Mechatronics

Master Thesis Topics (M-IREMR-M)

Academic year 2026–2027

Speed adaptive control of an active lower-limb prosthesis

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Robotic prostheses aim to restore mobility after amputation, with the goal of enabling safe, comfortable, and efficient walking in everyday life. While active prosthetic knees can generate mechanical power and improve mobility, their clinical adoption remains limited by complex control strategies that require time-consuming, user-specific tuning. In parallel, current personalization approaches are typically restricted to a single walking speed, even though gait naturally varies with speed, fatigue, and environment. This gap highlights the need for more adaptive and user-centered control frameworks.

This thesis offers the opportunity to contribute to the development of next-generation control strategies for active lower-limb prostheses. Building on existing work in the lab, you will design and implement a tunable, speed-adaptive controller and evaluate its performance experimentally. The project combines control design, programming (LabVIEW/Python), and hands-on experimentation with a robotic prosthesis. A key objective will be to identify control strategies that are both easy to tune in practice and adaptable to individual user needs.

This project is ideal for students interested in robotics, biomechanics, and human-centered design, and offers the chance to work at the intersection of engineering and healthcare, with direct impact on assistive technologies.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRIFS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Louis Flynn

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Lien : Video of the lab's participation at the CYBATHLON 2024 competition: https://youtu.be/zXyVNl7PXw0?si=p9pF0jb7lWeM7U6W

Implementation of a controller for a lower-limb exoskeleton

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context

Age-related mobility impairment is a major challenge for older adults and is strongly associated with reductions in muscle mass and muscle quality. Lower limb exoskeletons have been proposed as a promising strategy to help this population. They can serve as rehabilitation tools that facilitate repetitive, task-specific training and promote muscle strengthening. On the other hand, when used as assistive devices, exoskeletons may enable older adults with mobility impairments to remain physically active in daily life. One of the major challenges in exoskeletons is providing the correct amount of assistance throughout the different activities of daily life. The exoskeleton should be aware of the activity the user is performing (e.g. walking, stair ascent/descent), but also understand when and how much to provide assistance withing this specific activity. Many methods exist for controlling these devices, but each have different drawbacks that should be considered.

Objective

In this thesis the student will develop a controller for a lower-limb exoskeleton (hip-knee). Two control strategies are proposed, but the student can also choose to come up with their own control strategy.

Methods

The student can choose from one of following implementations of a controller:

- Previous work in the lab implemented an AFO algorithm that can synchronize to the joints' trajectories for different tasks of daily living. Furthermore, when switching to a new activity of daily living, we can determine the phase shift of this AFO to predict the next activity of living. The student will integrate the found AFO algorithms into a lower-limb exoskeleton and validate whether the algorithm works in real-life scenario. This real-life scenario will introduce new difficulties such as noise and slight changes in gait. Furthermore, an important part of this work will be to adjust this algorithm to be generalizable for different individuals. The student will therefore have to come up with solutions for occurring problems due to the transfer from simulation to a real-life exoskeleton.
- you will build a neuromuscular controller and tune its parameters based on earlier recorded Muscular Voluntary Contractions (MVC's) of older adults. Neuromuscular controllers are based on formulations of a set of muscles using the Hill-type muscle model. These Hill-type muscles will receive kinematic data (i.e. joint angles) and output a specific joint torque. To link these joint angles to output torques, muscle reflexes are used. However, this tuning of the reflexes is done manually and takes a long time for each individual. We believe that by having MVC data, we can adjust the muscle properties used in this controller in a more guided approach and as such improve its tuning process and therefore the performance of the controller. To understand how these MVCs can be used for this tuning, biomechanical models can be used. In these models, an optimization between simulated

joint torques and measured joint torques can be performed for different kinematic conditions to find muscle parameters for older adults.

- A control strategy proposed by the student with guidance of the supervisor(s)

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A
Number of topics	3

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Louis Flynn

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Mechanical characterization of polymeric soft materials to be used as miniaturized actuators

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context: Soft matter is used as an actuator in microrobotics. It can deform under an external stimu-lus (light, heat, or pH...) to generate a mechanical output (force and displacement). In the lab, we utilize the two-photon polymerization method (2PP) to shape 50µm soft actuators from a thermo-responsive polymer (pNIPAM = poly(N-isopropylacrylamide)). These active cubes demonstrate bending, contraction, twist, or shear deformation in a heated water bath [1]. Their mechanical performances must be characterized statically, to determine the elastic properties (Young modulus, Poisson coefficients) and/or dynamically, to determine the viscoelastic properties.
Objective: The aim of this thesis is to develop a setup to measure the force-displacement character-istics of such actuators. Inspired by Micro-Electro-Mechanical Systems (MEMS) force sen-sors [2] and/or atomic force microscopy (AFM) [3], this set-up will be fabricated in using glass microstructures (to be produced with the FemtoPrint machine) or with other materi-als deemed relevant by the candidate.
Methods: Literature review on characterizing the mechanical performance of soft material at microscale. Design the set-up considering the following criteria: 1) samples are character-ized in water to allow them to swell and shrink, 2) a heating system (conventional or laser) will be used to drive the actuators, and 3) the sensor must be in contact with small samples (50 to 200 µm). Eventually, the results obtained may be supplemented and compared with data obtained with an environmental AFM, at UMons, and/or a nanoindentation system [4], at EMPA (Thun, Switzerland).
Prerequisites: Mechanics (to determine the device shape and develop the different part of the set-up using CAD software), coding (to automatically control the setup), and materials (to un-derstand the material model obtained from experimental measurements).

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	M-IRCBS, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	2

Supervision

Supervisor : Pierre Lambert

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Lien : https://plambert.ulb.be/wp-content/uploads/2026/03/2026-03-31_LAMBERT.pdf

Aerial Robot Perching to a Wide Range of Surfaces with Tactile Sensing

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

Supervisor : Bram Vanderborght

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Co-supervisor: Bryan Convens

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Lien : https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg

Optimized topologies of an actuator and arm for a humanoid robot

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Humanoid robots could revolutionize many sectors, but their progress is limited by the challenge of designing compact, efficient, and powerful joint actuators.
This project aims to develop an optimized humanoid arm and actuator topology that improves performance, range of motion, and weight efficiency.
It involves comparing existing designs and creating a CAD model of an improved solution, ideal for students interested in mechanical design and robotics.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : PABLO LOPEZ GARCIA

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Unified Range-Multispectral-Inertial Odometry (R-VTIO) for Autonomous Drone Navigation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Background:
Standard Visual-Inertial Odometry (VIO) pipelines fuse RGB imagery with IMU data but degrade in two distinct failure modes: visual degradation (fog, smoke, low light) and scale/altitude ambiguity in featureless terrain. Existing work has addressed these failure modes independently. Multispectral VIO (VTIO) introduces thermal-infrared (TIR) imagery as an alternative visual channel, while Range-Visual-Inertial Odometry (RVIO) incorporates LiDAR altimeter range constraints and coarse-to-fine map registration. No published system currently fuses all four modalities (RGB, Thermal, Range, IMU) in a single tightly-coupled estimation framework for UAV navigation. This thesis fills that gap by designing a unified factor-graph-based odometry system: Range-Visual-Thermal-Inertial Odometry (R-VTIO).
Research Questions:

- Does a unified R-VTIO framework outperform the individual VTIO and RVIO baselines in trajectory accuracy and robustness across degraded environments?
- What is the marginal contribution of each sensor modality (RGB, Thermal, Range) to overall odometry accuracy, as measured by an ablation study?

Objectives:

- Implement a unified factor graph (GTSAM or Ceres) that jointly optimises over RGB features, thermal features, IMU pre-integration, and altimeter range factors
- Run a full ablation study: RGB-only, RGB+IMU, RGB+Thermal+IMU (VTIO), RGB+Range+IMU (RVIO), and full R-VTIO
- Collect flight data in at least two degraded scenarios: night flight and high-altitude featureless terrain
- Benchmark against GNSS RTK ground truth and compare with VINS-Fusion and ROVIO baselines

[1] T. Qin, P. Li, and S. Shen, “VINS-Mono: A Robust and Versatile Monocular Visual-Inertial State Estimator,” IEEE Transactions on Robotics, vol. 34, no. 4, pp. 1004–1020, 2018.
[2] T. Qin, S. Cao, J. Pan, P. Li, and S. Shen, “A General Optimization-based Framework for Global Pose Estimation with Multiple Sensors,” arXiv preprint arXiv:1901.03642, 2019.
[3] M. Bloesch, S. Omari, M. Hutter, and R. Siegwart, “Robust Visual Inertial Odometry Using a Direct EKF-Based Approach,” in Proc. IEEE/RSJ IROS, pp. 298–304, 2015.
[4] M. Bloesch, M. Burri, S. Omari, M. Hutter, and R. Siegwart, “Iterated Extended Kalman Filter Based Visual-Inertial Odometry Using Direct Photometric Feedback,” IJRR, vol. 36, no. 10, pp. 1053–1072, 2017.
[5] N. Khedekar, M. Kulkarni, and K. Alexis, “MIMOSA: A Multi-Modal SLAM Framework for Resilient Autonomy against Sensor Degradation,” in Proc. IEEE/RSJ IROS, pp. 7153–7159, 2022.
[6] J. Michalczyk, R. Jung, and S. Weiss, “Radar Visual Inertial Odometry and Radar Thermal

Inertial Odometry: Robust Navigation even in Challenging Visual Conditions," in Proc. IEEE/RSJ IROS, 2021.
[7] M. Nissov, N. Khedekar, and K. Alexis, "Degradation Resilient LiDAR-Radar-Inertial Odometry," in Proc. IEEE ICRA, pp. 8587–8594, 2024.
[8] F. Dellaert and GTSAM Contributors, "borglab/gtsam," Georgia Tech Borg Lab, 2022. Available: https://github.com/borglab/gtsam

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	M-IRIFS, M-IRELE, M-IREMR-M
Number of topics	2

Supervision

Supervisor : Adrian Munteanu

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Optimizing spatiotemporal pressure control of actuated cuffs for wearable robots

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
One of the most critical challenges for development of exoskeletons and exosuits is the design of physical attachments – mechanical braces, cuffs, and straps – that connect the robot to the human user. In addition to securing the device to the human body, the attachments transmit mechanical energy from the robot to the body. Higher pressure at the interface between the attachment and the body improves energy transmission but also results in worse human comfort and soft-tissue injury risk. Recent work from our group suggests that dynamically modulating interface pressure location and timing via pneumatically-actuated straps can overcome this tradeoff between energy transmission and comfort/safety. However, the optimal spatiotemporal distribution for different postures, tasks, and humans users is unknown.
Objective
The objective of the thesis is to optimize control of pressure in soft robotic straps to maximize energy transmission and human comfort/safety.
Methods
The student will develop an optimization procedure for controlling pressure of robotic straps on the human arm during common movement tasks. This involves implementing human-in-the-loop or other optimization methods for efficiently and accurately converging on an optimal set of control parameters for each user and use case. The student will perform experiments with human participants to measure energy transmission and human comfort/safety achieved by different pressure patterns. Energy transmission and tissue safety will be assessed via force and motion data and human comfort via self-reports.
The hardware and low-level controls for three pneumatically-actuated straps are currently usable for testing but can also be further modified to explore different spatiotemporal patterns. A six-dof commercial robot arm is available for measuring interaction force and relative motion, or the student can implement embedded sensors in the straps as an alternative measurement method.
Prerequisites
-Arduino programming for real-time mechatronic systems
-ROS for control of a commercial robotic arm
-Experience in or willingness to learn human-subject testing
-Matlab or other software for data analysis

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IREMR-M
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Mengnan Wu

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Lien : https://iopscience.iop.org/article/10.1088/1361-665X/ae2555#supplDataLink

Adaptive Dynamic Safety Margin Design for Force-Regulated Explicit Reference Governors

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis investigates the design of adaptive safety margins for Explicit Reference Governors (ERG) applied to robotic manipulators operating under external forces and contact constraints.

Explicit Reference Governors ensure constraint satisfaction by predicting future system behavior and evaluating a Dynamic Safety Margin (DSM) that quantifies the distance to constraint violation. In current implementations, safety margins are typically defined using fixed worst-case bounds on modeling uncertainty and force-estimation errors. While this guarantees safety, it often leads to conservative robot behavior and reduced performance.

The objective of this thesis is to develop an adaptive tightening mechanism that adjusts the safety margin online based on measurable uncertainty indicators such as force-estimation residuals, prediction error, or disturbance dynamics. The proposed method will be integrated into an existing force-regulated ERG framework for robotic manipulators.

The student will:

Analyze the baseline ERG and DSM formulation
Design an adaptive uncertainty bound for force and motion prediction
Integrate the adaptive margin into the ERG safety mechanism
Validate the approach through simulation and experimental evaluation
Compare performance against fixed-bound safety margins

The expected outcome is a safer and less conservative ERG controller capable of maintaining constraint satisfaction while improving responsiveness and task efficiency.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Git repository and documentation of the force-regulated ERG framework (to be provided to the student)

Expansion of gearbox test bench for NVH testing

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Human-centered robots like humanoids and cobots require not only efficient actuators but also low noise and vibration for user comfort and acceptance.
This project expands a VUB gearbox test bench, in collaboration with AILOS, to include Noise, Vibration, and Harshness (NVH) analysis using specialized sensors and data processing methods.
The goal is to evaluate and compare gearbox performance and acoustic behavior, ensuring quieter and smoother operation for robotic applications.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	2

Supervision

Supervisor : PABLO LOPEZ GARCIA

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Commissioning of a robotics actuator for a humanoid robot

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Humanoid robots can transform sectors like healthcare and manufacturing, but their deployment is limited by the challenge of designing compact, powerful, and safe joint actuators.
This project focuses on integrating and testing an actuator for a humanoid arm using existing components, with evaluation based on torque, efficiency, and controllability under realistic conditions.
The goal is to build a functional, well-characterized actuator, suited for students interested in robotics, control systems, and mechanical design.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : PABLO LOPEZ GARCIA

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Adaptive robotic grippers for fruit harvesting

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

1) Objectives of the project

Soft robotic grippers have shown strong potential in agricultural harvesting due to their inherent adaptability and gentle interaction with delicate objects. A common approach is the use of suction cups to pick fruits directly from branches. However, conventional suction-based grippers require precise alignment and orientation to form a proper seal, which limits their robustness in unstructured environments.

To address this limitation, we have developed self-closing suction cups and universal vacuum grippers that can conformably grasp objects with varying shapes, sizes, and quantities, without requiring precise alignment. These technologies introduce embodied intelligence at the hardware level, enabling more robust and versatile grasping.

The main challenge in applying these systems to fruit harvesting lies in the limited actuation force of current vacuum-driven bending actuators, which is often insufficient to reliably detach fruits from branches.

This project aims to develop high-force, flexible vacuum actuators and integrate them with self-closing suction cups to create adaptive robotic grippers for fruit harvesting. By combining vacuum actuation with cable-driven mechanisms, the gripper will achieve stronger and more controllable bending. The final goal is to develop an efficient, adaptable gripper capable of handling a wide variety of fruits in realistic harvesting scenarios.

2) Methodology

This project focuses on enhancing actuation force and integrating multiple actuation principles into a single gripper system. The main steps include:

i) Literature study on vacuum actuators and cable-driven soft actuators.
ii) Design and numerical analysis of high-force vacuum bending actuators, including pleated or structured geometries to increase effective pressure area.
iii) Integration of cable-driven mechanisms with vacuum actuation to enhance force output and controllability.
iv) Fabrication of prototypes using molding or additive manufacturing, such as FFF and SLA 3D printing.
v) Experimental characterization and demonstration of fruit gripping and detachment performance.

To support this project, we already have working prototypes of vacuum actuators and self-closing suction cups that can be further developed. The student will benefit from a research team with strong expertise in soft robotics, as well as collaboration with the FYSC group at VUB for materials and fabrication.

3) the prerequisites needed to succeed in this project

We are looking for students with interests in:

i) CAD design and mechanical design
ii) 3D printing and prototyping
iii) Basic electronics and Arduino
iv) Hands-on experimentation and robotics

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	M-IRCNE, M-IRELE
Number of topics	1

Supervision

Supervisor : Zhanwei Wang

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Co-supervisor: Seppe Terryn

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Lien : https://www.youtube.com/watch?v=ZAHmhGE_f-M)

Comparative study of physics-enhanced graph neural network approaches for multiple degrees-of-freedom system response estimation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

- Context of the master thesis

Wind turbines are the biggest dynamic, mass-produced, man-made structures. Their structural response to environmental and operational variations is highly complex and non-linear. As such, both physical modelling and data-driven inference have difficulties in accurately estimating the response. The former require simplifications which, along with unknown quantities (e.g. blade geometry), undermine accuracy. The latter may achieve high performance, but are limited to their training space, and extrapolation isn't trustworthy. This is also the case for virtual sensing, where limited instrumentation limits the ability to capture the full dynamics of the system, leading to uncertain predictions at unsensed locations, especially outside observed operational conditions.

In this context, physics-enhanced or hybrid modelling has come to the foreground. The philosophy behind it is straightforward: data-driven algorithms have problem-specific physical knowledge embedded into their architectures (loss function, differentiable equations, etc.) which improve generalization and performance. In this thesis, a comparative study of different approaches into embedding physical knowledge into a data-driven algorithm will be research by analyzing performance over multiple degrees-of-freedom systems (MDOF). These (MDOF), represent idealized reductions of real-world structures (e.g. wind turbines, bridges, etc.) and are extremely convenient, as they have low computational costs and their parametrization enables varied response simulation. The baseline algorithm will be a graph neural network.

- References

§ Haywood-Alexander, Marcus, et al. "Discussing the spectrum of physics-enhanced machine learning: a survey on structural mechanics applications." Data-Centric Engineering 5 (2024): e30.
§ Cicirello, Alice. "Physics-Enhanced Machine Learning: a position paper for dynamical systems investigations." Journal of Physics: Conference Series. Vol. 2909. No. 1. IOP Publishing, 2024.
§ Mehrjoo, Azin, Eleonora M. Tronci, and Babak Moaveni. "A Physics-Informed Framework for Input Load Estimation in Offshore Wind Turbines." International Conference on Experimental Vibration Analysis for Civil Engineering Structures. Cham: Springer Nature Switzerland, 2025.

- Objectives

§ Review virtual sensing in offshore wind turbines.
§ Identify and review physics-enhanced/hybrid modelling approaches.
§ Generate MDOF systems with varying numbers of degrees and exciting load [both intensity and location] in a Python script.
§ Encode MDOF as a graph, including stiffness, damping and mass matrices.
§ Implement a Graph Neural Network (GNN) virtual senser baseline in Python.
§ Assess and compare the addition of physics knowledge into the baseline with relation to: performance over unseen numbers of nodes [extrapolation and interpolation] and unseen excitations [intensity and location].

- Prerequisites/special skills
· Basic python programming.
· Knowledge of fundamentals of structural mechanics (e.g. equations of motion, etc.).
· Attendance of Prof. Deraemaker's Dynamics of Structures or Mechanical Vibrations course (https://structuraldynamics.ulb.be/dynamics-of-structures-2025-2026/)

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH
Number of topics	1

Supervision

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Geometric and structural design of flexible joints for deployable scissor grids

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Note: if interested, come and discuss the topics with us, to refine the research question based on your skills and interests.

Context:

Deployable structures are fascinating structural mechanisms: they have the ability to transform themselves from a small, closed or stowed configuration to a much larger, open or deployed configuration. Mobile deployable structures have the great advantage of speed and ease of erection and dismantling compared to conventional building forms. They have a wide field of application, from space antennas to festival structures, to adaptable furniture and toys.

At VUB there is 20 years of expertise on these fascinating systems and recently a spin-off company called KONLIGO was created to design and build zero-waste event structures based on our scissor technology.

Because these deployable structures can be used and reused over and over again they are well-suited to support the transition to a zero-waste event industry, where currently the waste problem is huge. Because of the modular construction and high component uniformity, and easy repair and maintenance, they are well-suited for a 'circular business model'.

Topic:
Many new shapes have been developed by us in recent years. Digital models have been made, new shapes have been patented and small-scale models have been realised to test these concepts.
But every new shape has its specific detailing issues to be solved: e new joint that allows the required movement, a new material for the joint or the beams, a modular design that allows reconfiguration, adding stiffening cables or not, etc…

To be able to build our vast library of new and promising shapes for scissor structures, one possible strategy is to develop new joints that are flexible in one direction and stiff in the other. This requires 3D-printing/prototyping and some material engineering. This could potentially unlock very interesting new shapes for expanding the application potential of scissor grids.
Depending on the interest and the profile of the student(s) involved, different accents/directions can be identified, collaboration between students with a different profile is also accepted:

• Emphasis on the exploration of various configurations based on a range of design criteria and application contexts, through scale models and 2D-3D prototyping
• Parametric modelling of scissor geometry in Rhino/Grasshopper and 3D-models/rendered images
• Prototyping a scissor structure at full scale
The aim of this project is the successful experimental exploration and realisation of deployable scissor structures, based on realistic design criteria. Digital and physical design and fabrication tools can be explored and used for the successful realisation of these new shapes.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	2

Supervision

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Practical demonstration of a bidirectional converter topology for a hybrid energy storage system in mobile robotics

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context:
Mobile robots are subject to highly dynamic load conditions, with repeated peak power demands during acceleration and opportunities for energy recovery during braking. A Hybrid Energy Storage System (HESS) can improve performance by combining storage units with different characteristics and interfacing them to a common DC bus through bidirectional power converters.
Objective:
The objective of this thesis is to identify, implement, and evaluate the most suitable bidirectional converter topology for connecting multiple battery modules to a common DC bus that feeds a robot power profile emulator.
This includes the development of a control and energy management strategy for stable bus operation, controlled power sharing, and handling of dynamic robotic load profiles.
The thesis will address the following questions:
1. Which bidirectional converter topology is the most suitable for interfacing multiple battery modules with different voltage or state-of-charge levels to a common DC bus in a mobile robotic application?
2. Can a control and energy management strategy maintain stable DC bus voltage and appropriate power sharing under representative robot load cycles, including peak power events?
Methodology:
The student will first perform a short literature review on Hybrid Energy Storage Systems (HESS) and bidirectional converter topologies for mobile robotic applications. Based on this review, a small number of candidate topologies will be selected and compared in terms of efficiency, controllability, complexity, and suitability for representative robotic load profiles. The selected topologies will then be modelled and simulated using a robot power profile emulator as the load. In parallel, the student will design a control and energy management strategy for DC bus regulation and coordinated power flow between the connected storage elements. Finally, a simple demonstrator will be built using the converter and battery-related modules provided by the group, and the simulation results will be compared with experimental observations in order to identify and recommend the most suitable topology.
Requirements:
Preferred student qualifications include experience in power electronics, electrical systems, and their simulation tools such as MATLAB/Simulink. Interest in battery integration, control, and robotic applications is expected.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-E
Number of topics	2

Supervision

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AI-enabled robotics for precision farming

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

The SAAS (Service d'Automatique et Analyse des Systèmes) department at the École polytechnique de Bruxelles (ULB) conducts advanced research in precision agriculture, with a particular focus on modeling, control, and robotics. In this context, we invite applications for a master's thesis project in AI-enabled robotics for precision farming.
This project aims to develop a mobile robotic system capable of autonomously inspecting crop fields to support the early detection of plant diseases and enable efficient, sustainable treatment strategies. Building on a knowledge base composed of annotated images of disease symptoms and semantic descriptions of their locations on plants, the student will design motion planning and control algorithms for a robotic manipulator. A camera mounted on the end-effector will be used to perform detailed plant inspections.
The proposed algorithms will be implemented and validated on a KUKA LBR iiwa 14 R820 available at the department. The primary application will focus on detecting common tomato diseases, such as The SAAS (Service d'Automatique et Analyse des Systèmes) department at the École polytechnique de Bruxelles (ULB) conducts advanced research in precision agriculture, with a particular focus on modeling, control, and robotics. In this context, we invite applications for a master's thesis project in AI-enabled robotics for precision farming.
This project aims to develop a mobile robotic system capable of autonomously inspecting crop fields to support the early detection of plant diseases and enable efficient, sustainable treatment strategies. Building on a knowledge base composed of annotated images of disease symptoms and semantic descriptions of their locations on plants, the student will design motion planning and control algorithms for a robotic manipulator. A camera mounted on the end-effector will be used to perform detailed plant inspections.
The proposed algorithms will be implemented and validated on a KUKA LBR iiwa 14 R820 available at the department. The primary application will focus on detecting common tomato diseases, such as grey mold, alternaria solani, powdery mildew, necrosis, chlorosis. The project will leverage an image database developed in collaboration with the Laboratoire de Production et de Biostimulation des Plantes cultivées (LPBP) at ULB.Early Blight. The project will leverage an image database developed in collaboration with the Laboratoire de Production et de Biostimulation des Plantes cultivées (LPBP) at ULB.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE
Number of topics	2

Supervision

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Visualizing the Droplet Size and Droplet Distribution of Oil Atomizers for oil injected screw compressors.

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis is in collaboration with Atlas Copco Airpower and will be under NDA.
To improve efficiency of the compression phase in a screw compressor, oil is often injected in the compression chamber to cool the compressed air as well as seal the gaps between the different components to minimize leakages. The very short time-constrain of the heat-transfer between the injected oil droplets and the compressed air, makes the cooling aspect extremely challenging in fast-turning machines. Therefore, the contact area between the air and oil should be as large as possible. Oil atomizers can be used to create a huge number of very small droplets to increase the heat-transfer surface. In the evaluation process of these atomizers the droplet size and break-up behavior should be visualized. Especially in an intermittent environment of passing lobes of the screw rotor.
This thesis is about the visualization of these droplets using two techniques: Laser Doppler Anemometry (LDA) and High-speed Camera measurements. Both equipment and measuring experience are already available as well as two fundamental setups: nozzle spray box and a 2D intermeshing rotor setup.
The thesis mainly includes:

- Managing/exploiting the experimental setups (controlling the nozzles, measuring/controlling the oil pressure and flows, …)
- Data acquisition and Data post-processing (e.g. image processing in matlab)

Before selecting this topic, please contact:
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Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	
Number of topics	1

Supervision

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Co-supervisor: jarl beckers

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Autonomous Counter-Drone System

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the MA proposal on https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested in one of these 5 topics, please contact bryan.convens@vub.be for more information given during a Microsoft Teams meeting.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

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World Model for Drone Navigation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Background:
Current VIO pipelines are reactive: they estimate pose from the most recent sensor observations. When those observations suddenly degrade, flying from sunlight into dense fog, or from textured terrain over a featureless lake, the pipeline experiences an abrupt loss of features, often causing tracking failure before any recovery mechanism can act. A predictive approach, inspired by recent advances in world models for robotics (JEPA, Dreamer-V3, diffusion-based latent dynamics), offers a fundamentally different strategy: learn a compressed latent representation of the drone's multispectral environment and use it to anticipate future sensor states. If the world model predicts that visual features will vanish in 2 seconds (e.g., approaching fog), the navigation system can pre-emptively increase reliance on thermal or IMU channels, or adjust the flight trajectory to stay in feature-rich regions. A multispectral drone platform carrying RGB cameras, a thermal core, an IMU, and a range sensor provides a rich, multi-modal data source for training such a model. This thesis investigates whether a learned world model, trained on multispectral drone data, can improve the robustness of drone state estimation and enable predictive, anticipatory navigation rather than purely reactive recovery.
Research Questions

- Can a latent world model trained on multispectral drone data (RGB, thermal, IMU) predict upcoming visual degradation events before they occur and navigate to a given location?
- What latent representation architecture (JEPA-style, VAE, diffusion) best captures the joint dynamics of RGB and thermal imagery from a drone perspective?
- Can the world model generalise across environments not seen during training?

What the Student Does

- Curate and structure flight datasets into a training corpus with synchronised RGB, thermal, IMU, and range streams
- Implement a latent dynamics model (starting with JEPA or Dreamer-V3 architecture) that learns to predict future latent states from current multi-modal observations and drone actions
- Train the world model to navigate to a given location

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE, M-IREMR-M
Number of topics	2

Supervision

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Multiphysics analysis of oil injection for screw compressors.

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis is in collaboration with Atlas Copco Airpower and will be under NDA.
To improve efficiency of the compression phase in a screw compressor, oil is often injected in the compression chamber to cool the compressed air as well as seal the gaps between the different components to minimize leakages. The time-dependency of the heat-transfer between the injected oil droplets and the compressed air, makes the cooling aspect extremely challenging in fast-turning machines. Therefore the goal of this Master Thesis would be to investigate different oil-injection strategies in a Multiphysics-simulation tool in Matlab/Simulink/Simscape to determine design rules for optimal oil-injection parameters.
A basic working model will be provided as a starting point of the thesis This model needs to be adapted and extended in function of the needs for the analysis. A specific injection strategy will also be proposed, but this will not be disclosed before the start of the thesis.
The different domains include:

- Mechanical time-of-flight calculation of oil droplets in a compression chamber with dynamic modelling using the equations of motion.
- Heat transfer modelling of an oil droplet in a compressed air environment, using a basic heat transfer model and simplified assumptions on the air flow.
- Basic thermodynamic effects on the compression (isentropic vs. isothermal)

Depending on the initial findings and parallel research, an experimental validation of the injection strategy can be performed with high-speed camera measurements of different injection nozzles. The latter is a topic for another thesis work, thus close collaboration might be relevant.

Before selecting this topic, please contact:
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Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

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Robust vision system for ophthalmic robotics with 3d tool depth estimation and eye motion tracking using stereo vision and monocular camera

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context:
In ophthalmic microsurgery, precise tool positioning is critical to avoid damaging delicate structures such as the retina. While advanced imaging systems like OCT provide accurate depth information, they are complex and costly.
Simpler approaches, such as shadow-based depth estimation, can extract depth from microscope images but lack robustness on their own . Stereo vision offers full 3D reconstruction, while eye motion tracking is essential to compensate for involuntary movements.
This project combines stereo vision, shadow-based cues, and eye tracking into a unified framework, validated through a simple experimental setup.
Objective:
The goal is to develop and validate a vision-based system for:
3D tracking of the surgical tool
Precise tracking of eye motion
Estimation of tool-to-retina distance
The system will be evaluated on a simplified prototype setup.
Methods:
Calibrate a stereo vision system and implement 3D triangulation
Detect and track the tool tip in stereo images
Implement shadow-based depth estimation as a complementary method
Track eye motion using visual features (e.g., pupil or trocar)
Fuse measurements to improve robustness
Validate accuracy using a simple experimental setup
Prerequisites:
Programming: Python or MATLAB
Basic knowledge of image processing and computer vision
Fundamentals of linear algebra and geometry

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS
Number of topics	2

Supervision

Supervisor : Tom Verstraten

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Universal vacuum gripper with self-closing suction cups for handling thin elastic films

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

1) The objectives of the project

Vacuum grippers are widely used in manufacturing and logistics due to their compactness, reliability, and high gripping force. In many industrial applications, arrays of suction cups are used to handle objects of varying sizes and shapes. However, when some suction cups are not sealed, vacuum leakage occurs, reducing gripping efficiency and increasing energy consumption.

To address this challenge, our group has developed an advanced self-closing suction cup technology. These suction cups can automatically close when they are not in contact with an object, preventing air leakage and maintaining stable vacuum pressure. This technology introduces embodied intelligence into the hardware level, reducing the need for complex control systems. Based on this concept, we have developed universal vacuum grippers that can handle objects with different shapes and sizes, and these systems have already been tested in industrial environments.

A new challenge arises in the handling of thin elastic film objects, such as plastic bags, packaging films, and flexible sheets. These materials are widely used in logistics, food packaging, recycling, and pharmaceutical industries. However, thin films are difficult to grasp because they deform easily, wrinkle, and may allow air leakage between the suction cup and the surface. Conventional suction cups often fail to reliably pick up such flexible materials.

In this project, we will further adapt our self-closing suction cup and universal gripper technologies to handle thin elastic film objects. The goal is to design and develop a specialized vacuum gripper capable of reliably picking and placing thin film materials commonly found in industrial and logistics applications.

2) Methodology

This project focuses on adapting suction cup multi-material structures, airflow, and self-closing conditions to improve the gripping reliability of thin elastic films. To achieve these goals, the project will include:

(i) A literature study on vacuum gripping of flexible materials and thin films.
(ii) Design optimization of self-closing suction cups and gripper configurations for handling thin elastic films.
(iii) Manufacturing of prototypes using molding or additive manufacturing methods such as

FFF 3D printing.
(iv) Experimental evaluation of gripping reliability, deformation behavior of thin films, and performance comparison with conventional suction cups.

To support this project, we already have working prototypes of self-closing suction cups and universal vacuum grippers. The student will build upon these existing technologies and benefit from the experience of our research team working on soft robotics, vacuum systems, and industrial grippers.

3) Prerequisites needed to succeed in this project

We are looking for students who have interests in:

(i) CAD design and mechanical design
(ii) 3D printing or prototyping
(iii) Basic knowledge of mechanics
(iv) Experimental testing and hands-on engineering
(v) Robotics, automation, or industrial applications

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCNE, M-IRELE, M- IRPH
Number of topics	1

Supervision

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Teaching Robots Skills via Human-Machine Interfaces and Imitation Learning

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

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Co-supervisor: Bryan Convens

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Design and Fabrication of an Aerial Manipulation Platform

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This project is part of a larger effort to enable aerial-ground cooperative manipulation where drones
and ground robots work together to transport objects. The drone platfrom, a X650 quadrotor
(Figure 1, left), currently lacks a suitable grasping mechanism for transporting items with handles,
such as kettlebells or beams. In prior work, a lightweight passive gripper was designed (Figure 1,
right), capable of mechanically intelligent grasping without active actuation. The next step is to
mount this gripper on the drone via a 2-DoF joint, allowing it to orient the gripper during flight for
successful object handling.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A
Number of topics	2

Supervision

Supervisor : Greet Van de Perre

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Sensor selection for ankle braces

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
For wearable devices such as orthoses, prosthetic sockets, braces, insoles and exoskeleton cuffs, user safety and comfort are paramount. Devices that cause discomfort, pain, or tissue injury are unlikely to be adopted. Yet, despite this importance, design practices for human–device interfaces remain largely empirical, relying on qualitative assessments, user feedback, or experience-based iteration.
These human-device interfaces or cuffs can also be assessed through quantitative measurements by embedding sensors, capturing the interaction at skin level while the user in moving or performing a specific task. However, there is still uncertain; the number of sensors to use, the type of sensors (FSR, magnetic or capacity based), the proper way to include them within the cuff (matrix or a stripe of sensors).
Objective
Identify a suitable sensor arrangement that provides relatable force measurements that match the baseline of torque measurement, to assess which are the most suited in an ankle brace.
Method
The student will be given an existing ankle brace (made in-house/ generic model) with space for different sensors (see picture). The testbench will consist of measuring the torque on the ankle (shown in red) while a subject does plantarflexion, at the same time the sensors (illustrated in blue) will acquire the interacting forces. The role of the student will be to systematically assess sensors and verify their accuracy with regards to the torque-sensor baseline.

Prerequisites
MA2 student with a practical experience with data acquisition, processing data. Good to have but not mandatory experience with sensors and biomechanics.

Skills you will obtain
Human data collection, Torque analysis

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision
Supervisor : Tom Verstraten

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Aerial Robot Collision-Resilient Navigation with Tactile Sensing

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

Supervisor : Bram Vanderborght

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3D printing of deployable scissor joints

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Note: if interested, come and discuss the topics with us, to refine the research question based on your skills and interests.

Context:

Deployable structures are fascinating structural mechanisms: they have the ability to transform themselves from a small, closed or stowed configuration to a much larger, open or deployed configuration. Mobile deployable structures have the great advantage of speed and ease of erection and dismantling compared to conventional building forms. They have a wide field of application, from space antennas to festival structures, to adaptable furniture and toys.

At VUB there is 20 years of expertise on these fascinating systems and recently a spin-off company called KONLIGO was created to design and build zero-waste event structures based on our scissor technology.

Because these deployable structures can be used and reused over and over again they are well-suited to support the transition to a zero-waste event industry, where currently the waste problem is huge. Because of the modular construction and high component uniformity, and easy repair and maintenance, they are well-suited for a 'circular business model'.

Topic:
The deployable bars of a scissor structure are connected by specifically designed joints, that allow the necessary movement. However, there is a specific class of structures that is left out because of the deployment is not possible, or difficult. Unless the joints are designed in such a way that they accommodate this special requirement movement. The projected outcome is an overview of the possibilities for innovative joints for deployable scissor structures that open up the possibilities for new shapes that have never been built before. Physical models (small and medium scale), digital parametric modelling, digital fabrication and potential full-scale testing belong to the possibilities, depending on the chosen focus.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	2

Supervision

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Instrumented glass gripper: Percipio Robotics' Tulip gripper revisited (+ internship – to be confirmed by the company Percipio Robotics)

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context: Percipio Robotics is a spin-off from the FEMTO-ST research institute, which has designed the Tulip gripper [1]. This compact, lightweight gripper, weighing less than 30g, is designed for micromanipulation and can grip objects from 50µm to 10mm. It solves the problems of large grippers and fragility frequently encountered in micro-robotics. Parallely, the TIPs department designs and manufactures compliant mechanisms in glass (FemtoPRINT technique), whose deformation is measured with optical/photonics techniques.
Objectives: This thesis aims to design and develop an instrumented version of the Percipio Robotics' Tulip gripper. The master thesis can be preceded by a 3 months internship in the company (Besançon, France).
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and characterization of the flexure mechanism.
Prerequisites: mechanical design, good command of French

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRCNE, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IRPH
Number of topics	2

Supervision

Supervisor : Pierre LAMBERT

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Constraint-Based Control for Multi-Contact Manipulation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Robotics manipulation tasks often involve multiple simultaneous contacts between the robot, object, and environment. These interactions are inherently coupled through shared force and motion constraints, making control significantly more complex.
Recent advances in multi-contact and reactive manipulation show that coordinating distributed contact forces while respecting friction and contact constraints is key to achieving stable and dexterous behaviors. However, ensuring safe transitions, force redistribution, and constraint satisfaction across multiple contacts remains an open challenge.

The goal of this project is to achieve safe, model-based control of multi-contact manipulation by simultaneously enforcing multiple contact constraints and coordinating distributed contact forces.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS
Number of topics	2

Supervision

Supervisor : Greet Van de Perre

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Co-supervisor: Bram Vanderborght

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Touch-sensing method for wall reconstruction in Construction

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

In wall-construction with robotic system, it is crucial to have a precise localization of the robot with respect to the target wall. However, using camera systems to achieve this under construction settings is not possible. Typically, the accuracy of such systems under lab light conditions, would be ∓5 cm of error. Since the robotic arm is very accurate due to its joint sensors, we propose to use the robotic arm for autonomous tactile surface mapping of partially constructed walls to correctly estimate the target pose for the placement of the next block.

Objectives:

Develop a tactile exploration strategy for wall reconstruction;
Improve localization using a touch probe;
Correct and refine point cloud and camera-based measurements;
Enable accurate target pose estimation for autonomous construction.

Methodology:
The robot explores the wall using a touch probe to collect precise contact measurements, which are fused with camera-based point cloud data. A correction framework aligns and refines noisy visual measurements using tactile feedback. The resulting model enables accurate estimation of wall geometry and target poses for block placement as well as wall re-construction.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRIFS
Number of topics	2

Supervision

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Co-supervisor: Bram Vanderborght

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Lien : https://vub-my.sharepoint.com/:b:/g/personal/zemerart_asani_vub_be/IQB8k8KCZ_92T7Ec8RV4OwOAAcYaVC3BxUH1r0i17xSTyow?e=Vb0Q3o

Adaptive Dynamic Safety Margin Design for Force-Regulated Explicit Reference Governors

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis investigates the design of adaptive safety margins for Explicit Reference Governors (ERG) applied to robotic manipulators operating under external forces and contact constraints.

Explicit Reference Governors ensure constraint satisfaction by predicting future system behavior and evaluating a Dynamic Safety Margin (DSM) that quantifies the distance to constraint violation. In current implementations, safety margins are typically defined using fixed worst-case bounds on modeling uncertainty and force-estimation errors. While this guarantees safety, it often leads to conservative robot behavior and reduced performance.

The objective of this thesis is to develop an adaptive tightening mechanism that adjusts the safety margin online based on measurable uncertainty indicators such as force-estimation residuals, prediction error, or disturbance dynamics. The proposed method will be integrated into an existing force-regulated ERG framework for robotic manipulators.

The student will:

Analyze the baseline ERG and DSM formulation
Design an adaptive uncertainty bound for force and motion prediction
Integrate the adaptive margin into the ERG safety mechanism
Validate the approach through simulation and experimental evaluation
Compare performance against fixed-bound safety margins

The expected outcome is a safer and less conservative ERG controller capable of maintaining constraint satisfaction while improving responsiveness and task efficiency.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Git repository and documentation of the force-regulated ERG framework (to be provided to the student)

Definition of a Transparency Index and Study of the Effects of Virtual Mass and Damping

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context

Haptic devices are used to apply virtual forces to human operators. These forces are typically modeled using a mass–spring–damper system. On one hand, the haptic system must remain stable (i.e., avoid severe or diverging oscillations); on the other hand, the reflected force should be as close as possible to the desired force to be transparent. Transparency refers to how accurately the rendered impedance matches the desired virtual impedance across frequency. The dynamics of the haptic device, sensor quantization, sampling, and time delay all affect transparency and generally degrade it.

The goal of this work is to define a reliable transparency index that can accurately quantify the level of transparency. The proposed index will be validated through simulations in MATLAB and subsequently through experiments using the Touch haptic device. The outcome of this project will be a validated transparency index and quantitative insights into the role of virtual mass and damping in haptic rendering performance.

Objective

Objectives are:

- Define relevant formulations in the Laplace domain to represent system transparency via frequency response analysis;
- Verify and compare the transparency index through MATLAB simulations;
- Validate and compare the results through experiments on the Touch haptic device.

Methods

The haptic device is modeled as a 1-DOF system with inertia and viscous friction. The virtual environment is represented as a mass–spring–damper system (formulated in the continuous-time/Laplace domain), while sampling time and time delay are explicitly considered (Fig. 1). Coulomb friction is compensated via force feedback, and sensor quantization is neglected in the theoretical analysis.

In this project, several transparency indices will first be defined to quantify transparency as a scalar measure. Then, motivated by the fact that virtual mass can, in certain conditions, enlarge the stable operating domain more effectively than virtual damping, the effects of virtual mass and damping on transparency will be systematically investigated. To this end, theoretical transparency indices will be formulated in the Laplace domain, including metrics such as: (i) the bandwidth of the closed-loop haptic device dynamics, and (ii) the bandwidth over which the ratio between the rendered impedance and the desired impedance remains close to unity.

Next, the bandwidth of the experimental setup (i.e., one joint of the Touch haptic device) will be identified using the frequency response function between the applied motor torque (input) and the resulting angular displacement at the paddle (output), thereby accounting for nonlinear effects present in the real system.

Prerequisites

- Programming: MATLAB, Simulink
- Basic knowledge of control systems
- Interest in haptics and mechanical design

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Ahmad Mashayekhi

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Actuation and control of a clutchable-elastic lower-limb exoskeleton

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context

Many people who have limited mobility (due to age or medical conditions) for example when trying to stand from a seated position, ascend stairs,.... This can heavily limit the quality of life for these people and even result in injuries from falling or other complications that can arise from poor posture and fatigue. These issues can be solved by providing assistance with wearable robotics such as exoskeletons. One of the main challenges with exoskeletons is to limit their weight to allow the user to still perform tasks. To reduce the weight of exoskeletons, we study the use of springs and clutches to capture and store energy during some parts of the motion and release it later when beneficial, thus removing the need for heavy motors and actuators and allowing assistance for motions such as sit-to-stand without external power. This system has already shown its ability to assist tasks such as sit-to-stand, reducing the effort made by the user; however, it requires manual control of the system by the user.

Goal of the thesis

In this thesis, you will improve a clutch and spring-based knee exoskeleton that is currently manually controlled. You will incorporate a semi-active actuation and control system allowing the clutch and spring to be connected and disconnected automatically with the right timing to provide assistance.

This project will be based on the existing exoskeleton but will require designing and building the system controlling the clutch, studying and modeling the system to build an efficient and versatile controller, and finally validating the exoskeleton with experimental results on multiple tasks.

Prerequisites:

It is recommended to have experience with the following aspect:

System identification

Controller design

Actuator design

CAD

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IREMR-A, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Lien : This thesis will be based on an exoskeleton made in a previous master thesis the result of this thesis along with video showing the exoskeleton can be found here: https://vub-my.sharepoint.com/:f:/g/personal/nathan_elie_o_de_smedt_vub_be/IgBEWoOCKBLIT6lRSDeQeTAvATsUME7j3gkUkt5ON5t8G2E?e=3ajtvX

Design of new didactic devices for teaching control engineering

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Many of the pilot processes used in the SAAS department to teach control theory were developed through master's theses. This is the case for the rotary inverted pendulum, the ring positioner, the ball in the tube process, …
The aim of this master thesis is to develop new pilot processes that are modular, evolving, and open-source to provide a better and more practical learning experience to the students. Here are a few examples of processes that SAAS would like to develop (non-exhaustive list):

- Ball in hoop or Flying ball in hoop
  - https://www.youtube.com/watch?v=8FaNk6C2ckM
  - https://www.youtube.com/watch?v=484GN4KBQnc
  - https://github.com/aa4cc/flying-ball-in-hoop
  - https://aa4cc.github.io/flying-ball-in-hoop/
- Cubli - robot that can jump up and balance on its corner
  - https://www.wevolver.com/specs/cubli
- …

Key objectives:

- selection of the sensors/actuators
- design of the signal conditioning / acquisition stages
- design of the experimental setup (SolidWorks, 3D printer …)
- design of the power supply & cable management
- modeling of the process
- implementation of a control strategy (Arduino/C programming or Matlab/data-acquisition board or Raspberry PI)
- setup of some didactic experiments & their related teaching materials

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	2

Supervision

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Virtual Assembly Validation of Complex CAD Systems with Haptic Feedback

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context

Modern mechanical systems (e.g., turbine engines, robotic manipulators) consist of many tightly packed components. While CAD tools provide geometric modeling and basic collision checks, they lack intuitive means to physically validate (dis)assembly feasibility, especially in constrained spaces and when tools (e.g., wrenches) are involved.

Purely visual inspection is often insufficient, and physical prototyping is costly. Haptic-enabled virtual environments offer a promising alternative by allowing users to feel contacts and constraints, enabling more realistic and efficient validation of (dis)assembly processes.

Objective

This thesis aims to develop a haptic-assisted virtual assembly system for:

- Interactive manipulation of CAD components in a virtual environment
- Real-time collision detection with force feedback
- Verification of assembly feasibility and tool accessibility

The system will enable users to detect collisions both visually and through touch, ensuring that parts and required tools can be assembled without interference.

Methods

3D CAD models will be converted into interactive 3D objects within a virtual environment (e.g., Unity or an OpenGL-based framework), including appropriate collision meshes.

An operator will be able to select and manipulate individual components within the assembly. During interaction, object interpenetration will be prevented in the virtual environment. Simultaneously, when collisions occur, the haptic device will generate force feedback, providing the user with a realistic sense of contact.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRIFS
Number of topics	2

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Ahmad Mashayekhi

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Lien : https://vub-my.sharepoint.com/:b:/g/personal/ahmad_mashayekhi_vub_be/IQB1d09btw48QbVW3Luj2xIFAaTC1mgr48Z_XypoarQ-Xm8?e=SETDa6

AI-based sign language recognition through EMG and Vision

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Hand gestures play a central role in sign language, but vision-based recognition often struggles with visually ambiguous poses (e.g., letters with similar handshapes) and occlusions (e.g., when the hand is partially covered). This project aims to enhance sign language recognition by combining vision-based hand tracking with surface electromyography (sEMG) signals captured from the forearm muscles. By leveraging both modalities, the system will evaluate whether EMG can provide discriminative information that complements video input and improves recognition accuracy in challenging conditions. The student will develop a pipeline for synchronized acquisition of RGB video and sEMG signals, preprocess the data, and implement machine learning models for gesture classification and multimodal fusion.

Context:
Sign language is the primary means of communication for millions of deaf and hard-of-hearing individuals worldwide. Automatic Sign Language Recognition (ASLR) has the potential to bridge communication barriers between signing and non-signing communities, enabling more inclusive human–computer interaction in domains such as healthcare, education, and assistive technology. Current state-of-the-art approaches predominantly rely on computer vision techniques, leveraging RGB cameras and hand landmark estimation frameworks such as MediaPipe, to capture the spatial configuration of the hand. While these methods have shown promising results under controlled conditions, they remain brittle in real-world scenarios where lighting variability, background clutter, self-occlusion, or visually similar handshapes introduce significant ambiguity. Surface electromyography (sEMG) offers a complementary sensing modality: by recording the electrical activity of forearm muscles during hand and finger movements, sEMG captures neuromuscular intent independently of visual conditions. Unlike cameras, sEMG is inherently robust to occlusion and can differentiate between gestures that appear visually identical but involve distinct muscular activation patterns. The integration of these two modalities, visual and myoelectric, into a unified multimodal framework represents an emerging research direction with strong potential to improve the accuracy, robustness, and generalizability of gesture recognition systems. This thesis explores that direction, contributing both a synchronized multimodal dataset and a comparative study of fusion strategies.

Objectives:

- Data acquisition: Design and record a structured dataset of sign language handshapes and/or isolated words covering approximately 10 gesture classes. The dataset will deliberately include visually similar gestures (e.g., handshapes sharing the same finger configuration but differing in muscle tension) and occluded conditions (e.g., partial hand coverage or non-frontal orientations). Data will be collected synchronously using an RGB camera and a multi-channel sEMG armband, with attention to temporal alignment, participant variability (multiple subjects), and session reproducibility. A data collection protocol and annotation scheme will be defined and documented.

- Preprocessing & feature extraction: Process raw video streams to extract hand landmarks and relevant spatial descriptors using frameworks such as MediaPipe, and apply signal conditioning to sEMG recordings (filtering, segmentation, normalization). Extract time-domain features from EMG signals (e.g., mean absolute value, root mean square, zero-crossing rate, waveform length) and, optionally, frequency-domain or time-frequency features. Ensure that both modalities are represented by consistent, well-aligned feature vectors suitable for downstream classification.
- Model development: Train and evaluate unimodal classifiers independently on vision and EMG data to establish individual performance baselines. Implement at least one multimodal fusion strategy, early fusion (concatenating feature vectors before classification) and/or late fusion (combining the outputs of independently trained classifiers). Candidate models include traditional machine learning approaches (e.g., SVM, Random Forest) as well as neural network architectures (e.g., MLP, CNN, or LSTM depending on the input representation).
- Evaluation: Assess classification performance using standard metrics including accuracy, precision, recall, and F1-score, reported per class and overall. Analyse results across gesture subgroups, particularly visually ambiguous and occluded gestures, to determine whether and to what extent EMG improves recognition where vision alone fails. Compare the performance of vision-only, EMG-only, and fused models to quantify the added value of multimodal integration.
- (Optional) Investigate more advanced fusion mechanisms (e.g., attention-based weighting of modalities) or extend the gesture vocabulary. Conduct a user study or robustness analysis under varying occlusion levels to further characterise system limitations and strengths.

Pre-requisites:

- Basic knowledge of signal processing and machine learning.
- Programming skills in Python (PyTorch/Scikit-learn, OpenCV).
- Interest in human–computer interaction or biomedical signal processing.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Optimizing spatiotemporal pressure control of actuated cuffs for wearable robots

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
One of the most critical challenges for development of exoskeletons and exosuits is the design of physical attachments – mechanical braces, cuffs, and straps – that connect the robot to the human user. In addition to securing the device to the human body, the attachments transmit mechanical energy from the robot to the body. Higher pressure at the interface between the attachment and the body improves energy transmission but also results in worse human comfort and soft-tissue injury risk. Recent work from our group suggests that dynamically modulating interface pressure location and timing via pneumatically-actuated straps can overcome this tradeoff between energy transmission and comfort/safety. However, the optimal spatiotemporal distribution for different postures, tasks, and humans users is unknown.
Objective
The objective of the thesis is to optimize control of pressure in soft robotic straps to maximize energy transmission and human comfort/safety.
Methods
The student will develop an optimization procedure for controlling pressure of robotic straps on the human arm during common movement tasks. This involves implementing human-in-the-loop or other optimization methods for efficiently and accurately converging on an optimal set of control parameters for each user and use case. The student will perform experiments with human participants to measure energy transmission and human comfort/safety achieved by different pressure patterns. Energy transmission and tissue safety will be assessed via force and motion data and human comfort via self-reports.
The hardware and low-level controls for three pneumatically-actuated straps are currently usable for testing but can also be further modified to explore different spatiotemporal patterns. A six-dof commercial robot arm is available for measuring interaction force and relative motion, or the student can implement embedded sensors in the straps as an alternative measurement method.
Prerequisites
- Arduino programming for real-time mechatronic systems
- ROS for control of a commercial robotic arm
- Experience in or willingness to learn human-subject testing
- Matlab or other software for data analysis

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Lien : https://iopscience.iop.org/article/10.1088/1361-665X/ae2555#supplDataLink

Modeling, control, and experimental validation of an eye surgery robot

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context:
In ophthalmic robotic surgery, precise and safe tool manipulation is essential due to the sensitivity of intraocular structures. A key requirement is the Remote Center of Motion (RCM), which ensures that the tool pivots around the eye entry point without causing damage.
Previous work has focused on simulation of such systems. However, moving toward real applications requires understanding not only control in simulation, but also stiffness behavior, sensor calibration, and real world implementation.
This project extends simulation toward experimental validation by integrating actuators, sensors, and control in a simplified prototype.
Objective:
The goal is to model, control, and experimentally validate a simplified eye-surgery robotic system with RCM behavior.
The student will:
Analyze stiffness and compliance of the mechanism
Implement impedance-based control strategies in simualtion
Integrate sensors and actuators in a prototype
Validate control performance through basic experiments
Methods:
Develop a Simscape Multibody model with RCM constraint
Perform stiffness and compliance analysis of the mechanism
Implement impedance and adaptive control strategies
Calibrate sensors (position/force) and integrate actuators
Implement controllers on a real setup
Validate behavior through basic experiments
Prerequisites:
Programming: MATLAB/Simulink (required)
Basic knowledge of control systems and robotics
Familiarity with modeling (Simscape or similar)

Language	EN (english)
Open to other master's programs	No
Eligible master's programs	
Number of topics	2

Supervision

Supervisor : Tom Verstraten

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Autonomous Drone Racing Using Only Onboard Sensing and Computation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

Supervisor : Bram Vanderborght

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Co-supervisor: Bryan Convens

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Lien : https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg

Safety-Aware Coordination for Collaborative Multi-Robot Systems using Explicit Reference Governors

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Collaborative robotic systems increasingly rely on multiple robots operating in shared workspaces to perform coordinated tasks such as object transfer, cooperative manipulation, and parallel assembly. While high-level planning methods can generate feasible schedules for multiple robots, ensuring safe execution during runtime remains a critical challenge, particularly when robots operate in close proximity.

This thesis investigates the design of a safety-aware coordination mechanism for multi-robot systems using Explicit Reference Governors (ERG). The ERG framework provides a predictive safety layer that adjusts the robot reference in real time to prevent constraint violations. In a multi-robot context, this mechanism can be extended to account for the motion of neighboring robots and maintain safe coordination during task execution.

The objective of this thesis is to develop and evaluate a coordination-aware ERG capable of enforcing safety constraints between multiple robots while preserving task performance. The work will build upon an existing multi-robot task and motion planning framework and focus on the execution-level safety and coordination problem.

The student will:
Study safety and coordination challenges in multi-robot systems
Implement predictive safety constraints between collaborating robots
Design a coordination-aware reference governor
Integrate the method into a multi-robot execution framework
Evaluate safety and performance in representative collaborative scenarios

The expected outcome is a robust safety mechanism for coordinated multi-robot systems that enables reliable execution of parallel tasks in shared environments.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-M
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

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Lien : Multi-robot task and motion planning and execution framework documentation (to be provided)

Adaptive Dynamic Safety Margin Design for Force-Regulated Explicit Reference Governors

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis investigates the design of adaptive safety margins for Explicit Reference Governors (ERG) applied to robotic manipulators operating under external forces and contact constraints.

Explicit Reference Governors ensure constraint satisfaction by predicting future system behavior and evaluating a Dynamic Safety Margin (DSM) that quantifies the distance to constraint violation. In current implementations, safety margins are typically defined using fixed worst-case bounds on modeling uncertainty and force-estimation errors. While this guarantees safety, it often leads to conservative robot behavior and reduced performance.

The objective of this thesis is to develop an adaptive tightening mechanism that adjusts the safety margin online based on measurable uncertainty indicators such as force-estimation residuals, prediction error, or disturbance dynamics. The proposed method will be integrated into an existing force-regulated ERG framework for robotic manipulators.

The student will:

Analyze the baseline ERG and DSM formulation
Design an adaptive uncertainty bound for force and motion prediction
Integrate the adaptive margin into the ERG safety mechanism
Validate the approach through simulation and experimental evaluation
Compare performance against fixed-bound safety margins

The expected outcome is a safer and less conservative ERG controller capable of maintaining constraint satisfaction while improving responsiveness and task efficiency.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Git repository and documentation of the force-regulated ERG framework (to be provided to the student)

Design and Construction of a Tactile and Proximity Sensing End-effector for Physical Interaction by Contact with a Drone

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

Supervisor : Bram Vanderborght

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Lien : https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg

Personalising Biomechanical Digital Twins Using Predictive Musculoskeletal Simulations

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
Digital twins are becoming increasingly more popular in healthcare, to provide personalised and efficient treatments, and overcome the need for large data collection trials, which may be challenging for vulnerable populations. Biomechanical models, also called musculoskeletal models, offer an alternative to such experiments. These simulations allow researchers to simulate the human body, its skeleton and muscles. Additionally, they allow us to gain insights into data that would be difficult or impossible to measure, like muscle or joint forces.

Currently, many studies use musculoskeletal simulations to analyse measured experimental data, like optical markers, ground reaction forces or sEMG data, together with generic models, representing the “average” human, and based typically on cadaver studies. However, in order to design personalised treatments, there is a need for models that are subject-specific, and simulations that can predict movement in unseen conditions, without relying on experimental data (also called predictive musculoskeletal simulations).

Although there are different available frameworks in the literature to personalise musculoskeletal models, these typically still require large data collection trials, or they are not adapted to predictive simulations. As such, we created a personalisation framework that aims to address these challenges, by calibrating muscle parameters of the musculoskeletal model to predict personalised joint kinematics.

Objective
The goal of this thesis is to extend the current personalisation framework to include kinematics at different speeds. To this end, you will use a dataset containing movement data at different speeds to personalise muscle parameters of the musculoskeletal models for healthy, young participants. You will use the open-source software OpenSim to scale the models to each subject’s size, and a MATLAB-based framework to predict the walking movement of the models. You will create a custom cost function to evaluate the fit of the predicted and the speed-matched recorded kinematics. Additionally, we can also consider contact parameters with the ground for a better estimation of ground reaction forces. Finally, you will validate your framework by analysing changes in muscle parameters and the generalization of the simulations to different conditions.

Your central research question will thus be whether the inclusion of data at various speeds, and the personalisation of ground contact parameters, enables a better generalization of the personal musculoskeletal models to unseen conditions.

To get an idea about the thesis topic, check out the following **video**: https://youtu.be/AEZfg9TsUgY.

A more detailed version of the **proposal** can be found here: https://vub-my.sharepoint.com/:b:/g/personal/menthy_denayer_vub_be/IQAHXobFA5VnR56i-LdH-AicATnxZYq0Wn-GPI1FpZipiCg?e=fAM3c9.

Methods
The thesis will mostly consist in analysing biomechanical data and coding the personalisation framework. The latter will mainly be performed in MATLAB. We will run the simulations on the supercomputer of VUB, to speed up computations.

During the thesis, you will perform the following tasks:
- literature study on personalised musculoskeletal models and predictive simulations,
- search for/create* a suitable dataset to validate your personalisation framework,
- familiarize yourself with OpenSim and its typical processing pipeline,
- familiarize yourself with the existing personalisation framework, the MATLAB code and the HPC (VUB's supercomputer),
- extend the personalisation framework, adding a custom cost function, to take into account speed-dependent kinematics,
- look into ground contact calibration methods and evaluate how they transfer to predictive simulations,
- validate your simulations against the recorded data (kinematics, GRFs, EMG, cost of transport), for different conditions (different speeds).

*Depending on the availability of online datasets, there is the option to create a small dataset, using the lab's equipment, for walking at different speeds. This would include recording optical motion markers, ground reaction forces, sEMG data and the energetic cost of walking (metabolic cost).

Depending on your own interests, we can also discuss specific research questions or ideas. The proposed tasks are meant as a guideline, but your **own input is always welcome**! We're always happy to have a small chat to discuss ideas!

Prerequisites
There are no specific prerequisites for the thesis. Knowledge of MATLAB, or programming in general, is a plus.

Location
VUB-Brubotics (Pleinlaan 9, -1, 1050 Brussel). Teams meetings can be held to limit displacements.

Contact

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Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Lien : https://vub-my.sharepoint.com/:b:/g/personal/menthy_denayer_vub_be/IQAHXobFA5VnR56i-LdH-AicATnxZYq0Wn-GPI1FpZipiCg?e=fAM3c9, https://youtu.be/AEZfg9TsUgY

Degradation-Aware Autonomous Mode Switching for Multi-Sensor VIO fro Drone Navigation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Two complementary VIO pipelines address different failure modes of UAV state estimation: VTIO (thermal + RGB + IMU) is optimised for visual degradation, while RVIO (range + RGB + IMU) is optimised for scale ambiguity and altitude uncertainty. In practice, a drone encounters both failure modes during a single mission, and sometimes simultaneously. A fixed pipeline cannot handle this. What is needed is a meta-system that monitors sensor health in real time and autonomously reconfigures the active estimation pipeline. This thesis builds a degradation detection and mode-switching layer that sits above the VTIO and RVIO pipelines. It continuously evaluates sensor-specific health indicators (RGB feature count and distribution, thermal contrast, altimeter return quality, IMU vibration level) and selects the optimal pipeline configuration: full R-VTIO when all sensors are healthy, VTIO-only when range data is unreliable, RVIO-only when thermal adds no value, or a minimal IMU-propagation fallback during total sensor dropout. The switching must be seamless, no state discontinuities at transitions.

Research Questions

- What sensor health metrics most reliably predict imminent pipeline failure, and how far in advance can failure be detected?
- Can mode switching be performed without introducing state discontinuities or jumps in the estimated trajectory?
- What is the optimal switching strategy: hard mode selection, soft blending of pipeline outputs, or dynamic factor graph reconfiguration?
- How does the autonomous switching system compare against a fixed R-VTIO pipeline and against manual operator intervention in edge-case scenarios?

What the Student Does

- Define and implement real-time health indicators for each sensor modality: RGB (feature count, spatial distribution, reprojection error), thermal (contrast ratio, feature stability), range (return signal strength, consistency with visual depth), IMU (vibration spectrum, bias drift rate)
- Design a mode-switching controller: implement and compare three strategies: (a) rule-based thresholding, (b) learned classifier (lightweight MLP or decision tree trained on labelled degradation data), and (c) soft blending via dynamic covariance scaling in the factor graph
- Implement seamless state handover between pipeline configurations: when switching from RVIO to VTIO, the thermal channel must be initialised consistently with the current state estimate

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE
Number of topics	1

Supervision

Supervisor : Adrian Muntenu

Contact : adrian.munteanu@vub.be

Vision-Language-Action Model for Autonomous Drone Mission Execution

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Background
Classical autonomous drone mission planning relies on a hand-engineered stack: a mission planner generates waypoints, a path planner finds collision-free trajectories, and a low-level controller tracks them. This pipeline is brittle: it cannot reason about abstract goals ("survey the tree line while avoiding foggy areas"), adapt to unexpected environmental conditions described in natural language, or leverage the rich semantic understanding embedded in modern foundation models. Vision-Language-Action (VLA) models, such as RT-2 and OpenVLA, have demonstrated the ability to map language instructions and visual observations directly to robot actions in manipulation tasks. However, their application to aerial robotics remains largely unexplored. This thesis investigates whether a VLA can serve as a high-level mission executor for a drone equipped with multispectral sensors. The VLA receives natural language mission commands and onboard camera streams (RGB and thermal) and outputs action commands (velocity setpoints or waypoints). A tightly-coupled RVIO pipeline provides metric grounding, ensuring that the VLA's outputs remain geometrically consistent and safe.
Research Questions

- Can a VLA model fine-tuned on drone flight data convert natural language mission descriptions into executable action sequences with acceptable spatial accuracy?
- Does grounding the VLA's output through the RVIO metric pipeline prevent the geometric inconsistencies (scale drift, altitude errors) typical of end-to-end vision-to-action models?

What the Student Does

- Survey existing VLA architectures (RT-2, OpenVLA, Octo) and select one suitable for adaptation to the aerial domain, considering compute constraints and action space differences
- Design the action space interface: the VLA outputs high-level velocity commands or waypoint deltas; the RVIO pipeline provides real-time metric state for closed-loop control

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE
Number of topics	2

Supervision

Supervisor : Adrian Munteanu

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Deep learning for estimation of instrument tip force from surface EMG signals

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Proper tissue handling is crucial in laparoscopic surgery, where surgeons must be mindful of the forces applied to and by their instruments to avoid tissue damage or procedural errors. By capturing muscle activation data from surface electromyographic (sEMG) sensors placed on the surgeon's arm, this project aims to estimate the force exerted at the tip of laparoscopic instruments.This thesis focuses on developing a model to estimate the force at the instrument's tip based on the muscle activity detected by sEMG sensors. A 1D force load cell is already integrated at the tip of a laparoscopic tool, and sEMG sensors will be placed on the operator's arm. The student will work on both the refinement of the hardware setup and the full software development pipeline, using neural network architectures such as recurrent neural networks (RNNs) and LSTMs, with the goal of mapping the relationship between muscle activation and instrument tip force.

Context:

Minimally invasive surgery, and laparoscopic surgery in particular, has transformed modern surgical practice by significantly reducing patient trauma, recovery time, and post-operative complications. However, it also introduces unique challenges: surgeons operate through small incisions using long rigid instruments, which drastically reduces tactile feedback and proprioceptive awareness compared to open surgery. This loss of haptic information makes it difficult to gauge the forces being applied to delicate tissues, increasing the risk of accidental damage such as perforation or excessive compression. Sensorised surgical instruments equipped with force transducers at the tool tip offer a direct means of measuring interaction forces, but their integration into clinical workflows remains limited by cost, sterilisation constraints, and mechanical complexity. An alternative and complementary approach lies in estimating tip force indirectly from the neuromuscular signals generated by the surgeon's own musculature. Surface electromyography (sEMG) is a non-invasive technique that records the electrical activity of muscles during contraction, and has been widely used in prosthetics, rehabilitation, and human-robot interaction for gesture and force estimation. Applying sEMG-based force estimation to the surgical context is an emerging research direction: if the relationship between forearm muscle activation and instrument tip force can be reliably learned, it becomes possible to infer force continuously and non-intrusively without modifying the surgical tool beyond its existing load cell, which here serves as the ground truth signal for training. Deep learning models, in particular sequential architectures such as RNNs and LSTMs, are well suited to capture the temporal dynamics of sEMG signals and their mapping to force output. This thesis addresses that challenge, contributing both an experimental data acquisition protocol and a trained deep learning model for instrument tip force estimation from surface EMG.

Objectives:
- Data acquisition: Familiarise with the existing hardware setup (sEMG sensors and laparoscopic tool with integrated load cell), contribute to refining sensor placement and synchronisation, and collect a structured dataset of synchronised sEMG and tip force recordings across multiple subjects and controlled task conditions.
- Preprocessing & feature extraction: Apply signal conditioning to raw sEMG recordings (filtering, segmentation, normalisation) and extract relevant time-domain features. Prepare the force signal as a continuous regression target, ensuring temporal alignment with the EMG windows.
- Model development & evaluation: Train and evaluate deep learning models (RNN, LSTM) to map sEMG signals to instrument tip force. Compare against baseline approaches and assess generalisation using standard regression metrics (RMSE, MAE, R^2) across subjects and task types.
- (Optional) Explore real-time inference feasibility or more advanced architectures such as Temporal Convolutional Networks or Transformers.

Pre-requisites:
- Experience with data acquisition and sensor integration.
- Familiarity with signal processing.
- Basics of programming skills in Python

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

Contact : tom.verstraten@vub.be

Adaptive airflow-based robotic gripper for delicate raspberry harvesting

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

1) Objectives of the project

Raspberry harvesting is a labor-intensive and costly process because high-quality raspberries must typically be harvested manually to avoid damage. While vibration-based harvesting machines are used in fields, they are not suitable for delicate fruits such as fully matured raspberries for eating. As a result, soft robotic grippers have been increasingly explored as an alternative for automated harvesting. However, most existing soft grippers rely on direct contact forces to grasp the fruit, which still introduces the risk of bruising or damaging these highly fragile fruits.

An even gentler method than mechanical contact is the use of fluidic forces, where airflow can be used to drag the fruit without applying significant mechanical pressure. This approach has strong potential for delicate fruit harvesting. However, several key challenges remain. First, high suction flow rates are often required to generate sufficient lifting force, leading to poor energy efficiency. Second, once the fruit is lifted, an adaptive structure is needed to securely hold and stabilize the raspberry without damaging it.

In our previous research, we developed origami-inspired elastomer actuators that can be fabricated using elastomer 3D printing or molding. These structures allow programmable shape change. Building on this technology, this project aims to design an adaptive orifice structure with a tunable diameter, inspired by origami mechanisms, to efficiently control suction airflow and gently capture raspberries. Such a system has strong potential to address challenges in the rapidly growing agricultural robotics sector, particularly within the raspberry market valued at approximately €3 billion.

The final goal is to develop a prototype suction-based adaptive gripper capable of gently picking raspberries energy-efficiently and improving reliability.

2) Methodology

This project focuses on designing adaptive airflow structures that combine fluidic suction and compliant mechanical response. The project will include:

i) Literature study on robotic harvesting of delicate fruits and suction-based gripping technologies.
ii) Design of origami-inspired tunable orifice structures capable of dynamically adjusting opening diameter.
iii) Fabrication of prototypes using elastomer 3D printing or molding techniques.
iv) Integration of suction airflow systems with the adaptive orifice structure.

v) Experimental evaluation of airflow efficiency, fruit handling stability, and damage reduction performance using the raspberry.

To support this project, we already have experience with origami-inspired elastomer actuators and elastomer fabrication methods. The student will build upon these existing technologies and contribute to developing next-generation agricultural robotic solutions.

3) The prerequisites needed to succeed in this project

We are looking for students who have interests in:

i) CAD design and mechanical design
ii) 3D printing or molding of soft materials
iii) Basic knowledge of mechanics
iv) Hands-on prototyping and experimental testing
v) Interest in robotics, agriculture, or bio-inspired design

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	M-IRCNE, M-IRIFS, M-IRELE
Number of topics	1

Supervision

Supervisor : Zhanwei Wang

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Co-supervisor: Seppe Terryn

Contact : Seppe.Terryn@vub.be

Lien : https://www.youtube.com/watch?v=ZAHmhGE_f-M)

Design of an adaptable non-linear transmission for personalized exoskeleton actuation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context and objectives:
Exoskeletons are wearable devices that augment the movements of its user by means of electric motors. These motors are very efficient for a certain operating point (a combination of torque and speed). However, during human locomotion, many different operating points with different requirements in joint torque and velocity are traversed where the motor's efficiency drops considerably.
Another issue with using traditional actuators and transmissions such as gearboxes is that the resulting exoskeleton joint does not mimic the human joint motion perfectly, as the latter are more complex than a simple hinge joint. The knee joint, for example, involves both rolling and sliding motion during flexion and extension.
One possible way to circumvent this issue is to include a non-linear transmission (e.g. four bar linkage, cam, etc.) between the motor and exoskeleton joint, which alters the output torque depending on the joint angle. As such, the provided torque can be tuned to an appropriate value throughout the motion while keeping the motor near its optimum efficiency. Moreover, the Instantaneous Center of Rotation (ICR) of the mechanism can be optimized to follow the trajectory of the human joint, most notably the knee. This transmission would be designed for one specific walking trajectory, but every person has their own particular joint trajectory and way of walking. The goal of this project is thus to design a transmission mechanism that can be adapted in some way to fit their personal requirements.

Methodology:
To do this, you would first study different existing non-linear transmission mechanisms from literature and select one based on the requirements of a lower limb exoskeleton application. Then, starting from data on the dynamics of walking (i.e. torque, joint angle and velocity evolution throughout a step, as well as knee ICR trajectory), you would first optimize the parameters (dimensions, material, ...) of the chosen mechanism to simultaneously achieve the desired transmission ratio and ICR trajectory for the average person. Then, you would design and build a prototype which can be adjusted to personalize the trajectory (e.g. by changing the length of a link).

Prerequisites:
Interest in mechanisms, basic programming (MATLAB, Python, etc.), CAD design (Inventor, Solidworks, etc.), basic prototyping knowledge (3D printing, machining, etc.)

Language	EN (english)
Open to other master's programs	No

Eligible master's programs	
Number of topics	1

Supervision

Supervisor : Tom Verstraten

Contact : Tom.Verstraten@vub.be

Lien : https://vub-my.sharepoint.com/:b:/g/personal/elias_thiery_vub_be/IQC_BuxZfHejQJc1N24V4SMfAVVkm2EHwFK1FKZMaB_UDPk?e=00G0zQ

Unified Range-Multispectral-Inertial Odometry for Autonomous Drone Navigation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Background

Standard Visual-Inertial Odometry (VIO) pipelines fuse RGB imagery with IMU data but degrade in two distinct failure modes: visual degradation (fog, smoke, low light) and scale/altitude ambiguity in featureless terrain. Existing work has addressed these failure modes independently: Multispectral VIO (VTIO) introduces thermal-infrared (TIR) imagery as an alternative visual channel, while Range-Visual-Inertial Odometry (RVIO) incorporates LiDAR altimeter range constraints and coarse-to-fine map registration. No published system currently fuses all four modalities (RGB, Thermal, Range, IMU) in a single tightly-coupled estimation framework for UAV navigation. This thesis fills that gap by designing a unified factor-graph-based odometry system. Range-Visual-Thermal-Inertial Odometry (R-VTIO). The Tarot 990 platform, equipped with two FLIR Blackfly cameras, a thermal core, a radar altimeter, and an IMU, provides the hardware foundation.

Research Questions

- Does a unified R-VTIO framework outperform the individual VTIO and RVIO baselines in trajectory accuracy and robustness across degraded environments?
- What is the marginal contribution of each sensor modality (RGB, Thermal, Range) to overall odometry accuracy, as measured by an ablation study?

What the Student Does

- Implement a unified factor graph (GTSAM or Ceres) that jointly optimises over RGB features, thermal features, IMU pre-integration, and altimeter range factors
- Run a full ablation study: RGB-only, RGB+IMU, RGB+Thermal+IMU (VTIO), RGB+Range+IMU (RVIO), and full R-VTIO — on identical flight logs

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE, M-IREMR-M
Number of topics	2

Supervision

Supervisor : Adrian Munteanu

Contact : adrian.munteanu@vub.be

Design, Fabrication and Experimental Evaluation of an Ultra-Fast Racing Drone

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Please find the details of the proposal at https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg
When interested, please contact bryan.convens@vub.be to discuss the details during a Microsoft Teams meeting.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-A, M-IREMR-E, M-IREMR-O
Number of topics	3

Supervision

Supervisor : Bram Vanderborght

Contact : bram.vanderborght@vub.be

Co-supervisor: Bryan Convens

Contact : bryan.convens@vub.be

Lien : https://vub-my.sharepoint.com/:f:/g/personal/bryan_convens_vub_be/IgBI9W0iRlpcTYOq0smzEhdEAQ4rkr6I_fYt8wBzDMGZXZs?e=NJRPtg

Study of a high-transmission ratio compliant actuator for robotics

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

The project aims to improve a high-efficiency Wolfrom gearbox for robotics by adding compliance to enhance safety in human-centered applications.
You will model the gearbox in Simscape, design a compliant element, and determine its optimal placement, followed by experimental validation.
It requires motivation and hands-on skills in CAD design, manufacturing (3D printing/molding), and mechanical assembly

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	2

Supervision

Supervisor : PABLO LOPEZ GARCIA

Contact : pablo@ailos-robotics.com

The measurement of elastomers self-healing efficiency using Electrical Impedance Tomography sensing

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

1) the objectives of the project

Self-healing materials are emerging as a promising technology for improving the durability and reliability of soft robotic systems, flexible electronics, and wearable devices. When damage occurs, such materials can autonomously recover their mechanical and electrical properties, extending the lifetime of components and reducing maintenance requirements. However, monitoring the healing process and evaluating the healing efficiency remain significant challenges, especially when the damage occurs inside soft materials and cannot be directly observed.

In our previous research, we developed a self-healing Electrical Impedance Tomography (EIT) sensor, which can reconstruct conductivity distributions inside soft materials and detect damage such as cuts or cracks. Based on this technology, we discovered that EIT sensing can also be used to monitor the recovery process of damaged materials, providing valuable insight into the healing status and efficiency over time.

This project aims to further investigate the use of EIT sensing as a non-invasive method to monitor the healing status of self-healing materials. The objective is to develop a sensing system capable of tracking damage and healing evolution inside soft materials, and to evaluate how effectively the material restores its functionality after damage. Such technology can be broadly useful for soft robotics, structural health monitoring, wearable devices, and smart materials.

2) the methodology

This project focuses on developing experimental methods to monitor self-healing processes using EIT sensing. The project will include:

(i) A literature study on self-healing materials and Electrical Impedance Tomography sensing methods.
(ii) Fabrication of self-healing material samples integrated with electrode arrays for EIT measurement.
(iii) Implementation of damage and healing experiments, including controlled cutting and healing cycles.
(iv) Use our data acquisition and image reconstruction methods to visualize healing evolution inside the material.
(v) Quantitative evaluation of healing efficiency based on electrical and mechanical recovery.

To support this project, we already have experience with EIT-based sensing and self-healing materials, as demonstrated in our previous publications. The student will build upon existing experimental platforms and contribute to advancing smart sensing technologies for monitoring material health.

3) Prerequisites needed to succeed in this project

(i) Electronics and sensor systems
(ii) Programming and data processing
(iii) Interest in experimental testing and hands-on engineering
(iv) Interest in smart materials, sensing, or health monitoring systems

Language	**EN (english)**
Open to other master's programs	No
Eligible master's programs	M-IRMAE, M-IRIFS, M-IRELE
Number of topics	1

Supervision

Supervisor : Zhanwei Wang

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Co-supervisor: Seppe Terryn

Contact : Seppe.Terryn@vub.be

Lien : https://researchportal.vub.be/en/publications/a-self-healing-electrical-impedance-tomography-sensor-for-the-sel/

Human-Aware Velocity Regulation using Explicit Reference Governors for Safe Human–Robot Interaction

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis focuses on the development of a safety-aware control mechanism for robotic manipulators operating in environments shared with humans. According to international human–robot interaction standards, such as ISO 10218 and ISO/TS 15066, robot velocity and impact energy must be limited depending on the proximity to the human body and the specific body region involved.

The objective of this thesis is to design an Explicit Reference Governor (ERG) capable of detecting human presence in the robot workspace and dynamically regulating robot velocity to ensure safe interaction. The governor will enforce velocity limits derived from safety standards while maintaining smooth and predictable robot motion.

The student will:

Study human–robot interaction safety standards and velocity limits
Implement a perception-based human detection mechanism
Define distance-dependent velocity constraints
Integrate these constraints into the ERG framework
Evaluate safety and performance in simulated human–robot interaction scenarios

The expected outcome is a predictive safety mechanism that ensures compliant and safe robot behavior in the presence of humans while preserving operational efficiency.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Human–robot interaction safety guidelines and ERG framework documentation (to be provided to the student)

Multi-robot localisation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis topic is a broad collection of subtasks that can be undertaken within multi-robot localisation research.
This includes topics such as:
- Multi-agent SLAM.
- UWB Anchored localisaiton
- Relative pose estimation
- Map sharing
- ODometry sensors: IMU, Camera, VIO, LiDAR, LIO.

And this on multiple different robots:
- AGVs
- Humanoids
- Drones.

In case you want to discuss possibilities in this research field please contact yuri.durodie@vub.be for more details.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	5

Supervision

Supervisor : Bram Vanderborght

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Human-Aware Velocity Regulation using Explicit Reference Governors for Safe Human–Robot Interaction

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis focuses on the development of a safety-aware control mechanism for robotic manipulators operating in environments shared with humans. According to international human–robot interaction standards, such as ISO 10218 and ISO/TS 15066, robot velocity and impact energy must be limited depending on the proximity to the human body and the specific body region involved.

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The student will:

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Integrate these constraints into the ERG framework
Evaluate safety and performance in simulated human–robot interaction scenarios

The expected outcome is a predictive safety mechanism that ensures compliant and safe robot behavior in the presence of humans while preserving operational efficiency.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Human–robot interaction safety guidelines and ERG framework documentation (to be provided to the student)

Constraint-Based Control for Friction-Induced Manipulation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Many real-world manipulation tasks involve hybrid contact behaviors, where objects transition between sticking, sliding, and separation. While most non-prehensile manipulation approaches assume a single contact mode (typically sticking), this assumption limits their applicability.

Recent work highlights that controlled sliding can be exploited as a manipulation strategy, but introduces hybrid dynamics and complex constraint enforcement challenges [1–3]. Explicitly modeling friction constraints and managing transitions between contact modes is therefore essential for achieving robust and safe manipulation. The goal of this project is to enable safe and controlled sliding manipulation.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE
Number of topics	2

Supervision

Supervisor : Greet Van de Perre

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Co-supervisor: Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : https://vub-my.sharepoint.com/:b:/g/personal/mohayad_abdelmonim_mahmoud_omer_vub_be/IQCJeUSBC-ewQZ3YnriOxvW_AUDsI4pnmlgvkQniENAyr0c?e=OMkL5Q

Optimizing spatiotemporal pressure control of actuated cuffs for wearable robots

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
One of the most critical challenges for development of exoskeletons and exosuits is the design of physical attachments – mechanical braces, cuffs, and straps – that connect the robot to the human user. In addition to securing the device to the human body, the attachments transmit mechanical energy from the robot to the body. Higher pressure at the interface between the attachment and the body improves energy transmission but also results in worse human comfort and soft-tissue injury risk. Recent work from our group suggests that dynamically modulating interface pressure location and timing via pneumatically-actuated straps can overcome this tradeoff between energy transmission and comfort/safety. However, the optimal spatiotemporal distribution for different postures, tasks, and humans users is unknown.
Objective
The objective of the thesis is to optimize control of pressure in soft robotic straps to maximize energy transmission and human comfort/safety.
Methods
The student will develop an optimization procedure for controlling pressure of robotic straps on the human arm during common movement tasks. This involves implementing human-in-the-loop or other optimization methods for efficiently and accurately converging on an optimal set of control parameters for each user and use case. The student will perform experiments with human participants to measure energy transmission and human comfort/safety achieved by different pressure patterns. Energy transmission and tissue safety will be assessed via force and motion data and human comfort via self-reports.
The hardware and low-level controls for three pneumatically-actuated straps are currently usable for testing but can also be further modified to explore different spatiotemporal patterns. A six-dof commercial robot arm is available for measuring interaction force and relative motion, or the student can implement embedded sensors in the straps as an alternative measurement method.
Prerequisites
- Arduino programming for real-time mechatronic systems
- ROS for control of a commercial robotic arm
- Experience in or willingness to learn human-subject testing
- Matlab or other software for data analysis

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Mengnan Wu

Contact : mengnan.wu@vub.be

Lien : https://iopscience.iop.org/article/10.1088/1361-665X/ae2555#supplDataLink

Multispectral Visual Place Recognition for Long-Range Drone Loop Closure for Autonomous Drone Navigation

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Visual Place Recognition (VPR) is the ability to recognise a previously visited location from its visual appearance, enabling loop closure in SLAM systems and bounding long-term drift. State-of-the-art VPR methods (NetVLAD, AnyLoc, CosPlace) operate exclusively on RGB images and degrade significantly under appearance changes caused by lighting variation (day vs. dusk), weather (clear vs. fog), or seasonal shifts. From an aerial platform, these appearance changes are even more severe due to altitude-dependent viewpoint variation. Thermal-infrared imagery offers a complementary signal: thermal signatures of buildings, roads, vegetation, and water bodies remain far more stable across illumination and weather changes than their RGB appearance. This thesis develops a multispectral VPR system that learns joint descriptors from RGB and thermal images, producing place signatures that are robust to the appearance variations encountered during long-duration GNSS-denied drone flights. The resulting VPR module is integrated as a loop closure backend into a VTIO or R-VTIO pipeline, correcting accumulated drift on flights of 10 minutes or more.

- Does fusing thermal and RGB features into a joint VPR descriptor significantly improve place recognition recall under appearance changes (day/night, clear/fog) compared to RGB-only baselines?
- Which fusion strategy works best: early fusion (concatenated image input), mid-level fusion (shared backbone with modality-specific heads), or late fusion (separate descriptors combined at retrieval)?
- How much drift reduction does multispectral loop closure provide on flights exceeding 10 minutes, compared to DBoW2 and AnyLoc RGB-only loop closure?

What the Student Does

- Collect a multispectral place recognition dataset: fly repeated trajectories over the same area at different times of day, weather conditions, and altitudes, recording synchronised RGB and thermal imagery with GNSS RTK ground truth for place identity labels
- Implement and compare three fusion architectures: (a) early fusion — 4-channel input (RGB+T) to a modified NetVLAD/AnyLoc backbone, (b) mid-level fusion — dual-encoder with cross-attention, (c) late fusion — separate RGB and thermal descriptors combined via learned weighting
- Train on the collected dataset and evaluate recall@1, recall@5 against RGB-only AnyLoc and NetVLAD baselines under matched and cross-condition (day-query/night-database) retrieval
- Integrate the best-performing model as a loop closure module in the VTIO or R-VTIO pipeline (replacing DBoW2 in VINS-Fusion or equivalent)

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE, M-IREMR-M
Number of topics	2

Supervision

Supervisor : Adrian Munteanu

Contact : adrian.munteanu@vub.be

Adaptive Dynamic Safety Margin Design for Force-Regulated Explicit Reference Governors

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

This thesis investigates the design of adaptive safety margins for Explicit Reference Governors (ERG) applied to robotic manipulators operating under external forces and contact constraints.

Explicit Reference Governors ensure constraint satisfaction by predicting future system behavior and evaluating a Dynamic Safety Margin (DSM) that quantifies the distance to constraint violation. In current implementations, safety margins are typically defined using fixed worst-case bounds on modeling uncertainty and force-estimation errors. While this guarantees safety, it often leads to conservative robot behavior and reduced performance.

The objective of this thesis is to develop an adaptive tightening mechanism that adjusts the safety margin online based on measurable uncertainty indicators such as force-estimation residuals, prediction error, or disturbance dynamics. The proposed method will be integrated into an existing force-regulated ERG framework for robotic manipulators.

The student will:

Analyze the baseline ERG and DSM formulation
Design an adaptive uncertainty bound for force and motion prediction
Integrate the adaptive margin into the ERG safety mechanism
Validate the approach through simulation and experimental evaluation
Compare performance against fixed-bound safety margins

The expected outcome is a safer and less conservative ERG controller capable of maintaining constraint satisfaction while improving responsiveness and task efficiency.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : Bram Vanderborght

Contact : Bram.Vanderborght@vub.be

Lien : Git repository and documentation of the force-regulated ERG framework (to be provided to the student)

🤖 Building the Safety Intelligence Layer for Physical AI: A Multi-Disciplinary Robotics Challenge (In partnership with coera — 5 positions available) 🤖

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Robots are leaving their cages. But the world they're entering wasn't designed for them — it was designed for us. What's missing isn't better robots. It's a layer of intelligence that doesn't exist yet.

This project, in collaboration with coera, tackles that challenge across five interconnected research tracks — from how a robot perceives and interprets the unpredictable humans around it, to how it decides, reacts, and physically interacts with the world. You'll work on real-time perception, sensor fusion, adaptive control, compliant mechanism design, or structural optimization — each a piece of a larger puzzle that very few teams in the world are trying to solve.

If you're looking for a thesis that sits at the intersection of mechanical engineering, AI, and something that will actually reshape how robots enter society — this is it.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCNE, M-IRIFS, M-IRELE
Number of topics	5

Supervision

Supervisor : Bram Vanderborght

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Co-supervisor: Constantin Scholz

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Power consumption estimation for legged mobile robots (humanoids or quadrupeds)

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context:
Modern robotics is relying increasingly on legged mobile robots, such as humanoids and quadrupeds, because of their ability to operate in complex and unstructured environments. Compared with wheeled robots, legged systems offer greater mobility on uneven terrain, stairs, and obstacle-rich spaces, making them attractive for inspection, logistics, search and rescue, and service applications.
However, this improved mobility comes with higher energy demand and more complex power consumption patterns. The power usage of legged robots changes significantly depending on the mission, locomotion mode, terrain, payload, and task duration. Understanding and predicting this power consumption is important for mission planning, battery sizing, energy-aware control, and robot reliability.
Objective:
The objective of this thesis is to create a power consumption dataset for legged mobile robots and develop a data-driven model to estimate and characterize their energy demand during operation.
The thesis will address the following research questions:

- How does a legged robot's mission profile affect its power consumption?
- How does the power load profile evolve during a mission, and which energy-related features best distinguish one mission from another in terms of power consumption?
- Is it possible to classify mission power requirements based on the observed power profile?

Methodology:
The student will collect and organize a dataset of power consumption measurements from an available legged mobile robots, with focus on humanoid or quadruped platforms, under different operating conditions and mission profiles. The dataset may include information such as robot state, locomotion mode, mission type, speed, terrain condition, actuators load, battery variables, and measured power consumption.
Based on this dataset, the student will develop and evaluate data-driven models for power consumption estimation. The work will also investigate how mission characteristics influence the power load profile, identify meaningful energy-related features, and assess whether different mission types or power demand levels can be classified from the recorded profiles.
Requirements:
Preferred student qualifications include experience in AI modeling, knowledge of ROS (Robotic Operating System), and coding proficiency with Python and/or C++. A passion for multidisciplinary research and a willingness to learn and enhance their skills in these areas are essential.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRELE, M-IREMR-E
Number of topics	2

Supervision

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Dual-motor drive for e-bikes

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Dual-motor actuators use two motors to improve control, torque distribution, and efficiency in applications like robotics and e-bikes, enhancing performance and user experience.
This project supports the characterization of the OWURU drivetrain by E2Drives, used in Decathlon BTWIN bikes, leveraging R&MM expertise.
It includes performance testing (torque, speed, efficiency, inertia) and development of a new dual-motor actuator concept.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRELE, M-IREMR-A, M-IREMR-E
Number of topics	1

Supervision

Supervisor : PABLO LOPEZ GARCIA

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Dynamic Dual-Arm Grabbing and Throwing of Objects

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Dynamic manipulation tasks such as catching and throwing require precise coordination, timing, and force control. Unlike static grasping, these tasks involve dynamic interactions and prediction of object motion.
In this project the student will have to solve the problem of grabbing an object (i.e., box) and throw it to a particular location.

This thesis addresses the problem of enabling a dual-arm robotic system (Franka Panda) to:
- Grabb an object (e.g., a box)
- Throw it accurately to a desired target

Objectives

- Develop a real-time catching strategy for moving objects
- Design a dual-arm coordination framework for shared manipulation
- Generate throwing methodology ensuring accurate landing
- Validate the approach on real robot hardware

Methodology: Rigid-body modelling and development of a grabbing strategy. Dual-arm coordination is achieved through constraint-consistent control ensuring stable grasp and force distribution during manipulation. Throwing is performed via optimized release timing and velocity.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRIFS
Number of topics	2

Supervision

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Studying the relationship between fatigue and torque generation in older adults during tasks of daily living

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
Age-related mobility impairment is a major challenge for older adults and is strongly associated with reductions in muscle mass and muscle quality. Lower limb exoskeletons have been proposed as a promising strategy to help this population. They can serve as rehabilitation tools that facilitate repetitive, task-specific training and promote muscle strengthening. On the other hand, when used as assistive devices, exoskeletons may enable older adults with mobility impairments to remain physically active in daily life. One of the major challenges in exoskeletons is providing the correct amount of assistance throughout the different activities of daily life. The exoskeleton should be aware of the activity the user is performing (e.g. walking, stair ascent/descent), but also understand when and how much to provide assistance withing this specific activity. Many methods exist for controlling these devices, but each have different drawbacks that should be considered.
Objective
In this thesis the student will develop a controller for a lower-limb exoskeleton (hip-knee). Two control strategies are proposed, but the student can also choose to come up with their own control strategy.

Methods
In this thesis you will try to find a relationship between fatigue and muscle torque generation using biomechanical simulations and earlier obtained data. This data exists of kinematics of different older adults performing activities of daily living (stair ascent/descent, level walking, slope ascent/descent and sit to stand). These activities have been recorded over different self-reported fatigue levels.
Using this data in a biomechanical simulation allows to estimate joint torques in the different lower limb joints. To this end, we will use the open source software OpenSim, to scale a musculoskeletal human model to the size of each participant. You will then use the recorded kinematics data from the inertial measurement units (IMUs) to compute the joint angles of each joint. Finally, we will use these computed joint angles to solve an optimization problem, that minimizes the difference with the recorded data, in order to predict ground reaction forces, joint torques and even muscle activations. For these simulations, you can use MATLAB, and VUB's supercomputer to speed up the computations. We hypothesize that as the older adults get more and more fatigued, small changes in kinematics will be observed. These small changes in kinematics can be used to estimate changes in joint torques to determine the relationship between fatigue and torque generation in muscles. By understanding this relationship, we can later adapt assistance appropriately to fatigue.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IREMR-A
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Co-supervisor: Louis Flynn

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Optimizing spatiotemporal pressure control of actuated cuffs for wearable robots

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
One of the most critical challenges for development of exoskeletons and exosuits is the design of physical attachments – mechanical braces, cuffs, and straps – that connect the robot to the human user. In addition to securing the device to the human body, the attachments transmit mechanical energy from the robot to the body. Higher pressure at the interface between the attachment and the body improves energy transmission but also results in worse human comfort and soft-tissue injury risk. Recent work from our group suggests that dynamically modulating interface pressure location and timing via pneumatically-actuated straps can overcome this tradeoff between energy transmission and comfort/safety. However, the optimal spatiotemporal distribution for different postures, tasks, and humans users is unknown.
Objective
The objective of the thesis is to optimize control of pressure in soft robotic straps to maximize energy transmission and human comfort/safety.
Methods
The student will develop an optimization procedure for controlling pressure of robotic straps on the human arm during common movement tasks. This involves implementing human-in-the-loop or other optimization methods for efficiently and accurately converging on an optimal set of control parameters for each user and use case. The student will perform experiments with human participants to measure energy transmission and human comfort/safety achieved by different pressure patterns. Energy transmission and tissue safety will be assessed via force and motion data and human comfort via self-reports.
The hardware and low-level controls for three pneumatically-actuated straps are currently usable for testing but can also be further modified to explore different spatiotemporal patterns. A six-dof commercial robot arm is available for measuring interaction force and relative motion, or the student can implement embedded sensors in the straps as an alternative measurement method.
Prerequisites
- Arduino programming for real-time mechatronic systems
- ROS for control of a commercial robotic arm
- Experience in or willingness to learn human-subject testing
- Matlab or other software for data analysis

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS
Number of topics	1

Supervision

Supervisor : Tom Verstraten

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Lien : https://iopscience.iop.org/article/10.1088/1361-665X/ae2555#supplDataLink

Optimal Fidelity Level for a Battery Digital Twin in Robotic Applications

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context:
Mobile robots operate in dynamic environments and rely on batteries as their main energy source. Because battery capacity is limited, energy availability directly affects mission duration, task execution, and system reliability. For efficient robot operation, it is important to estimate battery behavior accurately during runtime.
A battery digital twin can provide a virtual representation of the battery state and behavior by combining models with real-time data. In robotic applications, such a digital twin can support energy-aware operation, improve monitoring, and enable better prediction of remaining performance. However, higher model fidelity often increases computational cost and integration complexity. This creates a trade-off between model accuracy and real-time usability in robotic systems.
Objective:
This thesis focuses on determining the optimal fidelity level of a battery digital twin for robotic applications and integrating it into Robotic Operating System (ROS) for evaluation under representative robot operating conditions. The final digital twin will be validated on the ROS-based mobile robots available in the group
The thesis will address the following research questions:

- Which battery digital twin fidelity level achieves the best trade-off between estimation accuracy and computational cost when deployed on a mobile robot platform?
- To what extent can a battery digital twin model be adapted to different battery chemistries and pack configurations while maintaining acceptable modelling effort and estimation performance?
- How strongly do different robotic tasks and operating conditions affect the performance of pre-trained battery digital twin models, and when is model re-tuning or retraining required?

Methodology:
The student will use standard battery datasets and a robotic-specific battery dataset to train and validate battery digital twin models. Deep learning methods will be used to capture nonlinear battery behavior and degradation under realistic robotic operating conditions. The models will be evaluated in terms of accuracy, computational efficiency, and robustness across different fidelity levels, battery chemistries, and robot task profiles. Their feasibility for practical deployment will then be assessed through implementation in ROS and testing on the group’s mobile robots, with consideration of both cloud and edge platforms with limited computational capacity.

Requirements:
Preferred student qualifications include experience in AI modeling, knowledge of ROS (Robotic Operating System), and coding proficiency with Python and/or C++. A passion for multidisciplinary research and a willingness to learn and enhance their skills in these areas

are essential.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IREMR-E
Number of topics	2

Supervision

Supervisor : Bram VANDERBORGHT

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Biomechanics-based optimization of bike drivetrain

Program : EM - Robotics & mechatronics constructions - M-IREMR-M

Description

Context
When cycling, the cyclist applies a force on the back wheel through the pedals, chainwheel, chain, and pinion. The force and speed of the wheel depend on the ratio between the size of the chainwheel and pinion, as well as on the force applied by the user. However, for a given force applied by the user, the torque transmitted to the chainwheel varies based on the position of the pedals. Indeed, the rotation of the pedals changes the lever arm between the foot and the center of rotation, as well as the angle of application of the force. This leads to an uneven effort during the motion and wasted effort.
Goal of the thesis
Previously, the issue of uneven torque transmission was studied, and it was proposed to use a non-circular chainwheel to even the torque transmission. This project aims to propose an alternative non-circular chainwheel that, instead of trying to even the torque, will optimize its shape to maximize power transmission by optimizing the shape of the chainwheel and pinion.
Based on biomechanics studies, such as an available Biodex dataset (measurement of the torque capability of each joint of the leg), it can be observed that strength is highly dependent on the leg joint angle and speed. This project aims to combine this knowledge of biomechanics and the use of a non-circular chainwheel to allow the user to apply their maximum force at all points in the pedaling motion.
In this thesis, the student will analyze the biomechanics of the leg when cycling based on an existing Biodex dataset and then will design a bike drivetrain with a non-circular chainwheel to optimize power output. Finally, a prototype will be built and tested to assess the ability to increase performance.

Language	**EN (english)**
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Number of topics	1

Supervision

Supervisor : Verstraten Tom

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Topics offered to students by other master's programs

TARGET PROGRAM

EM MECHATRONIC ENGINEERING

Master's program offering the topic: Architectural engineering - M-IRARE

Incorporating Sustainability in the design process of products, processes and businesses.

Description

How to design products that have a better impact on environment, social and economy? This thesis starts with a state of art review of methods for 'Design for Sustainability'. What are methods to decision on sustainability and what are the remaining challenges and pitfalls? The aim of the thesis is to formulate a novel way to embed sustainability in the decision process of companies and link it to existing methods for corporate sustainability reporting.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Messagie Maarten (maarten.messagie@vub.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Bistable structures for bronchoscopy

Description

Context: Bistable structures enable multi-equilibrium states without the energy consumption ex-cept for switching from state to state. They are key in many applications, among which building engineering or soft robotics (https://www.non-linearity.com/conference/ftn2026). At small scale they could provide extra degrees-of-freedom to orientate and position endo-scopic cameras such as the video-endoscope developed by Lys Medical.
Objectives: This master thesis aims to design and numerically model a bistable structure actuated by hydrogel actuators.
Methods: Literature review. Finite elements modelling (Batir). Design. Fabrication and characteriza-tion (Tips).
Prerequisites:

- Mechanical design
- Interest for civil, mechanical, biomedical and bio-engineerin

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Automated Muscle and Tendon Fiber Orientation Tracking in Calf Ultrasound Images Using Computer Vision

Description

Understanding how muscle and tendon fibers are oriented in the calf is essential for assessing athletic performance, diagnosing musculoskeletal conditions, and guiding rehabilitation. Ultrasound imaging offers a non-invasive, real-time window into this fiber architecture, but extracting quantitative orientation data currently requires manual tracing by trained specialists. This thesis designs and validates a computer vision pipeline that automatically detects and tracks fiber orientation in ultrasound images of the calf region. By combining classical image processing techniques with deep learning-based segmentation, the system estimates pennation angles, fiber bundle trajectories, and tendon alignment across static and dynamic acquisition sequences. The tool is evaluated in both laboratory and clinical contexts, with the goal of providing a reproducible, accessible measurement instrument for clinicians, physiotherapists, and sports scientists.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Development of a dedicated, affordable ultrasound system for Automated Detection of Inflammatory Activity in Inflammatory Bowel Disease

Description

This project focuses on designing a low-cost ultrasound device tailored for intestinal imaging in inflammatory bowel disease (IBD). IBD monitoring currently relies on invasive procedures like colonoscopy, while ultrasound offers a non-invasive and patient-friendly alternative. However, interpretation remains operator-dependent, limiting its broader adoption. The goal is to develop a simple, portable, and possibly open-source system capable of acquiring clinically relevant images. The project also integrates AI-based feedback to assist users in assessing image quality and detecting inflammation. Ultimately, it aims to democratize access to reliable IBD monitoring tools.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Implementation of an electrode to stimulate Vagus Nerve

Description

This project aims to design and implement a stimulation electrode for the vagus nerve to enable closed-loop neuromodulation. Vagus nerve stimulation (VNS) is used in epilepsy treatment, but current approaches are largely empirical and not fully optimized. The work involves understanding electrode design constraints, including materials, geometry, and implantation techniques. A prototype electrode will be developed and tested both in vitro and in vivo. This will complete an existing recording setup and enable responsive stimulation based on detected physiological signals. The project contributes to improving personalized neuromodulation therapies.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Simulation of a biocompatible and implantable optical fiber-based flexure sensor

Description

This project focuses on developing an implantable sensor to monitor bladder volume in patients with neurogenic bladder dysfunction. Current management techniques are often invasive and uncomfortable, underscoring the need for continuous, reliable monitoring solutions. The proposed approach relies on optical fiber sensors, which are small, biocompatible, and immune to electromagnetic interference, making them well-suited for in vivo applications. The sensing principle is based on bending-induced light loss, where changes in bladder curvature affect the transmitted optical signal. The work involves modeling and simulating the sensor's coupled mechanical and optical behavior under different design configurations. Ultimately, the goal is to identify an optimal, compact, and implantable solution that could enable closed-loop bladder management and improve patients’ quality of life.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Estimating physical workload during manual tasks using wearable sensing

Description

Many industrial tasks involve lifting, holding components or working in constrained postures, which can lead to physical fatigue and musculoskeletal disorders.

Recent wearable sensing technologies (e.g. inertial sensors) enable monitoring human motion during such tasks. However, translating these measurements into meaningful indicators of physical workload remains an open challenge.

In this thesis, the student will investigate how wearable motion data can be used to estimate simple indicators of physical workload.

The work includes:
- Literature study on ergonomic workload assessment and wearable sensing
- Experimental measurements using wearable sensors during manual tasks
- Extraction of motion features from recorded data
- Development of simple workload indicators
- Analysis of these indicators across different tasks

The thesis combines experimental work and data analysis, and will be carried out in the AugmentX research infrastructure at VUB (Brussels). The student will gain hands-on experience with wearable sensors and real experimental data in an industrially relevant context.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : El Makrini Ilias (ilias.el.makrini@vub.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Development of a realistic and easy-to-use mucus simulant

Description

Context: Over the last years, the respiratory drug delivery has drawn a strong interest due to the large surface area of the airway mucosa, providing an easy access to the blood. In particular, nasal sprays intending to treat non-local disorders, like migraine or hypoglycaemia, have appear. Compared to oral medicines, they are easier to use, act faster and can be given to unconscious patients [1]. However, the current characterisation techniques for spray are still lacking. Cutting-edge methods, such as experimental and digital models of the nose aims to bridge this gap but further development is still needed to reproduce adequately spray deposition in the nose. In particular, the interactions between the spray particles and the mucus lining the interior of the nose governs the final deposition site of the spray.
Objective: This thesis aims to develop a realistic and easy-to-use fluid replicating the nasal mucus. This simulant needs to reproduce the rheological characteristics of the biological mucus [2] and must be coated easily into nasal replicas. This mucus simulant will then be used to assess the influence of its properties (viscoelasticity, viscoplasticity, surface tension,...) on the trajectories of impacting particles. These results would strengthen the current understanding of the mucus-particles interactions and help to validate advanced simulation models.

Langue	EN (english)
Ouvert à d’autres masters	yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

An AI-based automated analysis of electroencephalographic (EEG) recording to aid in the diagnosis of epilepsy

Description

This project aims to develop AI algorithms to automatically detect epileptic patterns in EEG recordings. Manual analysis is time-consuming and prone to variability, especially with large datasets. The work will explore different machine learning approaches, including CNNs and recurrent neural networks. The developed models will be trained and validated on clinical EEG databases. Their performance will be compared with expert annotations and existing methods. The final goal is to support clinicians with reliable, automated tools for epilepsy diagnosis.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Acoustic cough analysis

Description

This project focuses on improving the clinical usability of an acoustic cough analysis tool for patients with swallowing disorders. Current clinical assessments are subjective, while the existing software uses complex features that are difficult to interpret. The goal is to simplify these features into a small number of meaningful indicators. A user-friendly interface will be developed for clinicians to visualize and interpret results. Clinical validation will ensure the tool’s relevance and usability in real-world settings. Ultimately, the system aims to help identify patients at risk of lung infections.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Improved adenoid hypertrophy treatment through nasal replicas

Description

Context: Adenoid hypertrophy is the pathologic enlargement of the tonsils at the back of the nose. It is one of the most common no-infectious ENT affection in children with a prevalence of about over 30%. Nowadays, the first-line treatment of adenoid hypertrophy is corticosteroid nasal sprays. While half of the patients shows improvement with this treatment, it is ineffective for the other half [1]. One issue may be that the current treatments aim for maximum coverage of the nasal cavity and not maximal penetration. Consequently, only a small part of the medicine reaches directly its site of action. New medication strategies, combining adapted devices, formulations and administration procedures [2], could increase the success of corticosteroid treatment and decrease the use of surgery in children.
Objective: This thesis aims to maximise the amount of drug reaching the pharyngeal tonsils. The fraction of drug reaching the site of action will be determined using a 3D-printed nasal replica of a child anatomy. The main goal is to combine the characteristics of the spray (viscosity, surface tension) and the administration procedure (instillation angle, inspiration) to increase the amount of drug reaching the back of the nasal cavity. Correlations between the characteristics of the sprays and the deposition in the nose should also be drawn to provide simple guidelines for future medicine development.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Experimental platform for human–exoskeleton collaboration in construction tasks

Description

Many construction and industrial tasks involve handling components, maintaining constrained postures, and performing repetitive operations such as fastening or drilling. These activities can lead to significant physical workload and fatigue.

Industrial exoskeletons aim to support workers during such tasks, but understanding how they interact with human movement in realistic situations remains an open challenge.

In this thesis, the student will develop a laboratory platform to study human–exoskeleton collaboration during simplified construction-like tasks.

The work includes:
- Literature study on exoskeleton use in industrial and construction environments
- Design of a laboratory mock-up (e.g. panel handling, alignment, fastening)
- Development of repeatable task scenarios for experiments
- Integration of wearable sensing technologies to capture human motion
- Pilot experiments with participants
- Analysis of human motion and human–exoskeleton interaction

The thesis combines experimental design, hands-on setup development and data analysis, and will be carried out in the AugmentX research infrastructure at VUB. The student will work on a realistic setup linked to ongoing research in human–robot collaboration.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : El Makrini Ilias (ilias.el.makrini@vub.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

NeuroBridge: From Scanned PDFs to Unified Diagnosis, an AI Pipeline Bridging Radiology and Anatomopathology Reports

Description

Neurological diagnosis draws on two complementary medical specialties, radiology and anatomopathology, yet their reports are produced independently, in inconsistent formats, and often only available as scanned PDF documents. This thesis develops NeuroBridge, an AI-driven pipeline that transforms raw PDF inputs including low-quality scans into structured, machine-readable clinical data. Combining OCR, layout analysis, and domain-specific NLP, the system extracts key diagnostic findings from both report types and maps them onto a shared semantic framework. The outcome is an integrated diagnostic view designed to support clinicians in identifying concordances and discrepancies across the two protocols, reducing the cognitive load of cross-specialty interpretation.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

AI-Driven Assessment of Intestinal Ultrasound for Automated Detection of Inflammatory Activity in Inflammatory Bowel Disease

Description

This project develops an AI-based system to automatically analyze intestinal ultrasound images in Inflammatory Bowel Disease (IBD). The goal is to reduce operator dependency and improve diagnostic consistency. The approach involves a two-step pipeline: first assessing image quality, then detecting inflammatory activity. Deep learning models (e.g., CNNs or transformers) will be trained on annotated datasets. Performance will be evaluated against expert clinicians and standard metrics. This work aims to facilitate wider adoption of ultrasound in IBD monitoring.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

A Web-Based Air Quality Platform for Patient-Centric Environmental Exposure Assessment in Clinical Research

Description

Environmental air quality has a measurable impact on patient health, yet clinicians and clinical researchers currently lack practical tools to assess individual exposure at thir home work etc. This thesis builds a web-based platform that takes a patient address as input and automatically queries all available air quality databases to reconstruct a comprehensive environmental exposure profile. The tool is designed to assist clinicians during clinical studies by surfacing relevant environmental context alongside patient records, enabling more informed interpretation of health outcomes and facilitating the inclusion of air quality as a structured variable in clinical research protocols.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Machine Learning-Driven Trace Extraction from Kymographs for Quantitative Analysis of Intracellular Dynamics in Wild-Type and Mutant Models

Description

Kymographs provide a compact visual representation of how particles, vesicles, or molecular motors move along a biological structure over time, making them widely used in studies of axonal transport, ciliary beating, and cytoskeletal dynamics. Despite their utility, extracting meaningful quantitative data from kymographs currently requires laborious manual tracing, a process that is slow, subjective, and poorly scalable when comparing wild-type organisms to genetic mutants across large experimental datasets. This thesis presents a machine learning pipeline that automates the detection and extraction of individual traces from fluorescence kymograph images and derives physiological parameters directly from their geometry and intensity profiles. The system classifies trace populations by directionality and motility state, computes transport metrics such as velocity and run length distributions, and generates structured comparative outputs enabling statistically robust phenotype quantification between experimental groups.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Signal quality in intraneural and extraneural electrodes

Description

This project compares signal acquisition quality between intraneural and extraneural electrodes used for nerve recordings. These electrodes are critical for monitoring vagus nerve activity in neuromodulation applications. A phantom nerve model will be developed to simulate realistic conditions, including noise sources such as electromyographic interference. Both electrode types will be tested to assess signal amplitude, noise, and reliability. The study aims to better understand trade-offs between invasiveness and signal quality. Results could guide the design of more effective neural interfaces.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

AI-Driven Assessment of Rehabilitation Quality Through Joint Angle Trajectory Analysis

Description

Assessing whether a patient is performing rehabilitation exercises correctly and progressing over time is a task that currently depends heavily on the availability and judgment of a trained therapist. This thesis proposes a data-driven platform that uses recorded joint angle measurements to automatically evaluate the quality of rehabilitation sessions. By analyzing angular trajectories captured through wearable sensors or video-based pose estimation, the system computes objective quality indicators such as range of motion compliance, movement symmetry, inter-repetition variability, and adherence to prescribed motion patterns. Machine learning models trained on expert-annotated exercise recordings learn to map these features onto quality scores aligned with clinical standards. The resulting tool provides physiotherapists with structured, session-by-session feedback and longitudinal progress tracking, supporting more informed and personalized rehabilitation management without requiring continuous in-person supervision.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Biophysics of Red Blood Cells and Platelets

Description

This project explores the physical behavior of blood, focusing on red blood cells (RBCs) and platelets (PLTs), which play a key role in processes such as thrombosis and hemorrhage. Blood is a complex fluid composed of deformable and electrically charged cells, making its dynamics difficult to model and understand. The project combines experimental and numerical approaches to investigate how cell shape variability and interactions influence blood flow behavior. A particular focus is placed on platelet transport mechanisms, including unconventional dynamics such as Lévy-flight-like motion observed under certain conditions. Additionally, the role of electrical charges on RBC interactions will be studied by applying electric fields in flow experiments. Overall, the work aims to deepen fundamental understanding of blood biophysics with potential implications for medical research and diagnostics.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Variable stiffness catheter for lung cancer diagnosis

Description

Context: Lung cancer is the leading cause of cancer death worldwide [1]. As part of the screening process, lung nodules (suspected cancer) are regularly found in peripheral areas that are difficult to access by endoscopy. As most of these nodules are not cancerous, it is essential to be able to take a local biopsy to make a precise diagnosis. However, the lung is like a lab-yrinth, with sections that shrink with each division, and access to a precise peripheral zone is difficult. In addition, the need to use flexible and miniaturized tools implies certain limita-tions. Indeed, the need for flexibility is necessary to avoid damaging the tissue or injuring the patient but means that the tools may deform before the biopsy is taken.
A family of solutions that are being developed uses the concept of controllable/variable stiffness to cope with these issues [2]. These solutions use materials and/or specific geometries that can change rigidity given a certain stimuli (change of temperature, pressure, ...).
Objectives: Develop a prototype of a variable stiffness catheter using different equipment present in the lab (molding techniques, 3D printers).
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and evalua-tion of the built prototype.
Prerequisites:

- Mechanical design
- Interest for mechanical and biomedical engineering

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Depth Camera-Based Person Tracking for Quantitative Balance Assessment

Description

This master's thesis presents a computer vision system for the automatic assessment of postural balance using a depth camera. By leveraging 3D skeletal tracking and point cloud analysis, the system continuously estimates key biomechanical parameters, such as center of mass projection, sway path, and postural stability indices , without requiring wearable sensors or clinical-grade force platforms. The proposed pipeline integrates real-time person detection, joint localization, and temporal motion analysis to produce quantitative balance metrics comparable to standard neuropsychological assessment protocols. The system is evaluated on a cohort of participants under various stance conditions, demonstrating its potential as a low-cost, non-intrusive tool for clinical screening and rehabilitation monitoring in collaboration with neuropsychological practice.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Optimized GNNs for Interpretable Brain Connectivity

Description

This project explores the use of Graph Neural Networks (GNNs) to analyze brain connectivity for epilepsy diagnosis. Brain connectivity captures interactions between brain regions and provides richer information than traditional EEG analysis. While previous machine learning approaches showed promising results, more complex GNNs have not yet achieved optimal performance. The objective is to design improved GNN architectures that enhance predictive accuracy. A second key goal is to incorporate explainable AI methods to identify clinically meaningful brain subnetworks. This work bridges advanced machine learning with interpretable neuroscience.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Electrical modeling and control of cold atmospheric plasma for endoscopes

Description

This project investigates the use of cold atmospheric plasma (CAP) for disinfecting endoscope channels. CAP shows strong antimicrobial potential but introduces thermal risks that could damage sensitive medical devices. The work aims to build an electrical and electro-thermal model linking plasma operation to temperature effects. Based on this model, control strategies will be developed to regulate temperature while maintaining disinfection efficiency. Experimental validation will compare open-loop and closed-loop performance. The final objective is a safe, optimized plasma-based sterilization approach for medical applications.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Nonclercq Antoine (antoine.nonclercq@ulb.be)

Master's program offering the topic: Biomedical engineering - M-IRCBS

Biopsies in the periphery of the lung: shape sensing catheter tip

Description

Context: Lung cancer is the leading cause of cancer death worldwide [1]. As part of the screening process, lung nodules (suspected cancer) are regularly found in peripheral areas that are difficult to access by endoscopy. As most of these nodules are not cancerous, it is essential to be able to take a local biopsy to make a precise diagnosis. However, the lung is like a lab-yrinth, with sections that shrink with each division, and access to a precise peripheral zone is difficult. In addition, the need to use flexible and miniaturised tools implies certain limita-tions. Indeed, the need for flexibility is necessary to avoid damaging the tissue or injuring the patient, but means that the tools may deform before the biopsy is taken. One way to ensure that the biopsy is taken at the right location is to have knowledge on the position and deformation of the catheter tip. Despite the exploration of various technologies such as electromagnetic sensors (EM), optical fibers, X-rays, etc [2], [3] , biopsy outcomes remain highly variable and dependent on a variety of factors including the type and number of used equipment, experience of the practician, location of the nodule in the lung. [4]
Objectives: This master thesis aims to design and develop a system enabling the practicians to know how the tip of the catheter is deformed in the lungs, due to their mechanical contact with the bronchii and the internal efforts developed in the catheter. Given the very small size of the peripheral bronchi (<1 mm), the system can be initially developed at a larger scale. Some inspiration can be taken from textile-based sensors, or other resistive strain gauges [5].
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and charac-terization of a shape sensing catheter tip.
Prerequisites:

- Mechanical design, electronics
- Interest for mechanical and biomedical engineering

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-A, M-IREMR-M, M-IREMR-O

Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Biomedical engineering - M-IRCBS

Depth Camera-Based Person Tracking for Quantitative Balance Assessment

Description

This master's thesis presents a computer vision system for the automatic assessment of postural balance using a depth camera. By leveraging 3D skeletal tracking and point cloud analysis, the system continuously estimates key biomechanical parameters, such as center of mass projection, sway path, and postural stability indices , without requiring wearable sensors or clinical-grade force platforms. The proposed pipeline integrates real-time(opt.) person detection, joint localization, and temporal motion analysis to produce quantitative balance metrics comparable to standard neuropsychological assessment protocols. The system is evaluated on a cohort of participants under various stance conditions, demonstrating its potential as a low-cost, non-intrusive tool for clinical screening and rehabilitation monitoring in collaboration with neuropsychological practice.

Langue	EN (english)
Ouvert à d’autres masters	No
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Chemical & Materials engineering - M-IRMAE

Process parameter optimization for 3D printing of Functionally Graded rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

Rocket nozzles need FGMs to withstand extreme thermal and mechanical stresses by gradually transitioning from heat-resistant materials at the throat to tougher structural metals, improving durability, reducing thermal mismatch, and preventing failure. This is why rocket nozzles are manufactured with a graded transition from 316L or Inconel to copper as shown on Fig. 2-3.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October 2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and doesn't rely yet on the FGM technology.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. When printing FGMs, these parameters increase in number and must be actively tuned during the build as the material transitions from one type to another. The results of the manufacturing of the miniature FGM rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping, crack formation, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

The aim of this master thesis will be to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores, cracks, or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic: Chemical & Materials engineering - M-IRMAE

Plasmonic nanoparticles inside PNIPAM hydrogel for light-driven soft actuators using femtosecond laser writing

Description

Context: Soft matter can serve as an actuator in microrobotics by deforming under external stimuli (light, heat, or pH…) and producing mechanical outputs like force or displacement. At the microscale, these smart materials can be 3D printed without assembly. In our lab, we use two-photon polymerization (2PP) to fabricate soft actuators from a thermo-responsive pol-ymer, poly(N-isopropylacrylamide) (pNIPAM). This material swells below its lower critical solution temperature (LCST) by absorbing water and shrinks above the LCST by expelling it. Recently, we fabricated 50 µm × 50 µm × 50 µm active cubes capable of bending, contract-ing, twisting, or shearing in heated water [1]. To achieve precise, multidirectional motion control, multiple actuators could be combined and selectively triggered by different wave-lengths of light. This is possible by doping them with photothermal nanomaterials that lo-cally convert light into heat [2]. Metallic nanostructures like gold (Au) and silver (Ag) nano-particles or nanorods have been used to actuate PNIPAM-based hydrogels [3]. However, they are usually dispersed uniformly, preventing spatial control. An alternative approach uses a tightly focused femtosecond laser in a PNIPAM hydrogel swollen with silver nitrate, locally forming Ag nanoparticles by multiphoton reduction [4]. Applying this method to our actuators would enable spatially selective nanoparticle patterning, allowing localized, pre-cise activation.

Objective: The aim of this thesis is 3D print photosensitive nanoparticles inside PNIPAM hydrogels with the 2PP machine. After printing, light will be used to illuminate the actuators and will be converted into heat by the nanoparticles. The generated heat will trigger actuator mo-tion by shrinking the hydrogel.

Methods: Literature review. Hydrogel fabrication (with 2PP printing). Printing of Ag/Au nanoparti-cles i.e., tune the printing parameters to obtain nanoparticles and optimize the actuation. Characterization: UV absorbance spectra, SEM imaging, and measuring the light respon-siveness of the structures.

Prerequisites: Materials (to develop the fabrication process and understand the behavior of the hydrogels with and without nanoparticles).

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master's program offering the topic: Civil engineering - M-IRCNE

Investigation of the Micro-Profiling Effect on the Mechanical Behaviour of Thin Steel Sheeting

Description

Cold-formed steel sheeting is widely used in lightweight construction systems such as roofs, floors, and composite decks. In addition to the primary corrugation geometry that provides global bending stiffness, manufacturers increasingly introduce micro-profiling (small-scale surface indentations or ribs) in the flanges of the sheeting (Figure 1). These micro-profiles are intended to improve local stability (delay local buckling), and increase stiffness without significantly increasing material usage [1,2]. Composite slabs are outside the scope of this thesis; consequently, indentations related to composite action are not considered.

Two representative industrial products illustrate this concept:

Figure 1: JI 106-250-750 (Joris Ide) left and – T130M-75L-930 (Ruukki) (right) featuring light micro-profiling on the top flange, and on both top and bottom flanges, respectively.

While the global structural behaviour of profiled steel sheeting is well documented, the mechanical contribution of micro-profiling remains insufficiently quantified. Initiation and development of local buckling modes in the compressed flanges under bending loading will be studied in this thesis at the small scale.

This thesis is embedded in a broader research framework studying acoustic roof decking as sustainable and environmental friendly solution with light weight and low end-of-life impacts.

In this thesis, detailed FE models of micro-profiled, small-scale panels will be developed and used for a parametric study allowing a direct comparison between micro-profiling effects for different micro-profile geometries. To ensure reliability, the developed numerical models will be experimentally validated through compression tests on small-scale panels incorporating micro-profiling.

Research Objectives

To quantify and understand the mechanical influence of micro-profiling on thin cold-formed steel sheeting through validated finite element modelling.

1

Geometrical Characterisation and Performance

o

Digitally reconstruct representative micro-profiling geometries of selected sheeting types.

o

Develop parametrised small-scale panel models incorporating realistic micro-profile details. Systematically vary:

▪

Depth,

▪

Spacing,

▪

Shape,...

o

Quantify using finite element modelling the influence on:

▪

Bending stiffness,

▪

Elastic buckling resistance,

▪

Load redistribution mechanisms.

2

Experimental Validation

Manufacture or obtain small-scale micro-profiled panels.

Conduct controlled compression tests.

Measure:

Load–displacement response,

Buckling modes,

Strain development.

3

Validation

Calibrate and validate FE models against experimental results.

Summarize insights.

References

[1] R. Studziński, Z. Pozorski, A. Garstecki (2015). Structural behavior of sandwich panels with asymmetrical boundary conditions. Journal of Constructional Steel Research 104: 227–234

[2] X. Ma, J.W. Butterworth, G.C. Clifton (2008). Unilateral contact buckling of lightly profiled skin sheets under compressive or shearing loads. International Journal of Solids and Structures, 45: 840–849

Objectives of the master thesis

This research is expected to:

- Give a well-structured comprehensive overview of the state of the art.
- Provide a mechanistic understanding of how micro-profiling modifies elastic stress fields in thin steel sheeting.
- Establish validated finite element modelling strategies for small-scale micro-structured panels.
- Clarify the relative structural efficiency of micro-profiling compared to flat panels.
- Deliver quantitative design-oriented insights for manufacturers aiming to optimise sheet geometry without increasing material thickness.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IREMR-A, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Pyl Lincy (Lincy.Pyl@vub.be)

Master's program offering the topic: Civil engineering - M-IRCNE

Mesoscale computational model of continuously reinforced fused filament fabrication

Description

The goal of this master's thesis is to achieve a thorough understanding of the influence of reinforcements on mesoscale stress concentrations. To this end, the addition of geometric features representing reinforcing fiber tows to the geometries presented in [2] is envisioned.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Berke Péter (peter.berke@ulb.be)

Master’s program offering the topic: Civil engineering - M-IRCNE

Mechanical characterization of non-linear materials to be used as miniaturized actuators

Description

Context: Active soft matter can be used as an actuator in microrobotics. It can deform under an external stimulus such as light, heat, or pH to generate a mechanical output (force and dis-placement). At the microscale, these smart materials can be 3D printed without assembly. In the lab, we use the two-photon polymerization method (2PP) to shape 50µm soft actua-tors out of a thermo-responsive polymer (pNipam = poly(N-isopropylacrylamide)). These active cubes demonstrate bending, contraction, twist, or shear deformation in a heated wa-ter bath [1]. Their mechanical performances such as Young modulus, force-displacement characteristics, or response time must now be characterized.
Objective: The aim of this thesis is to use a setup to measure the force-displacement characteristics of such actuators and to analyze the indentation data with the help of a finite element ap-proach to decouple the elastic parameters (Young modulus, Poisson coefficients) from the visco-elastic parameters.
Methods: Literature review on modeling soft material at microscale. Develop a code to analyze the experimental data. Eventually, the results obtained may be supplemented and compared with data obtained with an environmental AFM, at UMons, and/or a nanoindentation sys-tem [4], at EMPA (Thun, Switzerland).
Prerequisites: Numerical methods

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : LAMBERT Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: Civil engineering - M-IRCNE

Investigation of thermal fields during the manufacturing of 3D printed composites

Description

Context of the master thesis

3D printed composites combine the flexibility of additive manufacturing with the improved mechanical properties of composite materials. An important aspect of the printing process is the thermal field that develops during material deposition, as it directly affects interlayer bonding, residual stresses, and defect formation. Quantifying these thermal fields allows better control of printing parameters and leads to improved print quality and structural performance. A clear understanding of the thermal behavior during printing is therefore essential for improving the reliability of 3D-printed composite components1.

The master's student will employ infrared cameras during the printing of simple structures to capture thermal fields and use them to perform finite element analysis (FEA). This approach facilitates learning the intricacies of the 3D printing process, camera setup, and subsequent data post-processing along with the basics of FEA. The post processing will be achieved in Python using image processing techniques and the FEA in the ABAQUS software. Through this master thesis, the student will gain a holistic understanding of: additive manufacturing (printing process), thermal mechanics (influence of thermal fields), and FEA, equipping them with valuable skills for future endeavors in technology and engineering fields.

Fig. 1 Thermal image during printing.

References

1)

Cattenone, A., Morganti, S., Alaimo, G., & Auricchio, F. (2019). Finite element analysis of additive manufacturing based on fused deposition modeling: Distortions prediction and comparison with experimental data. Journal of Manufacturing Science and Engineering, 141(1), 011010.

Objectives of the master thesis

- Measure transient thermal fields during the 3D-printing process using infrared cameras.
- Process infrared data using Python-based image processing techniques.
-

Analyze the influence of printing parameters on the evolution of thermal fields.

•

Implement simplified thermal finite element models in Abaqus using experimentally obtained data.

•

Assess the implications of thermal fields on the printing process.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IREMR-A, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Pyl Lincy (Lincy.Pyl@vub.be)

Master's program offering the topic: Civil engineering - M-IRCNE

Computational analysis of the dynamic transformation behavior of bistable scissor structures

Description

This work consist of (i) understanding the concept and challenges of bistable scissor structures and a literature review on modeling efforts of their dynamic behavior, (ii) set up of 3D FEM models in a commercial FE software, (iii) investigating their dynamic deployment including the proposal of damping solutions, using appropriate loads and boundary conditions, (iv) proposing a design strategy that incorporates notions of the dynamic behavior of BDS.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Berke Péter (peter.berke@ulb.be)

Master’s program offering the topic: Civil engineering - M-IRCNE

Incorporating adaptivity in quasi-discrete modeling of the fracture of heterogeneous materials

Description

This work consist of (i) the in-depth understanding of the quasi-discrete (QD) approach, (ii) the application of the quasi-discrete methodology to benchmark problems, (iii) the extension of QD by adaptivity, i.e. the coarsening and refinement of the spatial resolution on the fly.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Berke Péter (peter.berke@ulb.be)

Master’s program offering the topic: Civil engineering - M-IRCNE

Computational modeling of the residual stresses generated in the 3D printing process employing continuous fiber reinforced filaments

Description

The objective of this master’s thesis is a thorough understanding and the development of a FEM-based workflow to generate thermal histories and a good estimate of residual stresses in FDM printed parts, accounting for the thermo-mechanical anisotropy of continuous carbon fiber reinforced filaments. The modeling is envisioned to be done in Abaqus by progressively activating finite elements in the mesh based on the printing path.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Berke Péter (peter.berke@ulb.be)

Master’s program offering the topic: Civil engineering - M-IRCNE

Treatment of contact conditions within the isogeometric method, application to complex contact geometries

Description

The main task is the implementation of the contact treatment within the isogeometric framework. This will require: (i) understanding the concepts of the isogeometric method for structural applications in linear elasticity, (ii) a literature review on the available contact formulations (with and without friction), (iii) the implementation and validation of the chosen one and (iv) the application of the resulting non-linear computational tool to a contact problems (e.g. rough surface contact).

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Berke Péter (peter.berke@ulb.be)

Master's program offering the topic: Computer science and engineering - M-IRIFS

Recognition of construction work activities using wearable sensors

Description

Wearable sensing technologies such as inertial measurement units (IMUs) enable continuous monitoring of human motion and are increasingly used to analyse work activities in industrial environments.

Automatically recognising which task a worker is performing could support future intelligent assistance systems, such as exoskeletons that adapt their behaviour depending on the task.

In this thesis, the student will investigate how motion data from wearable sensors can be used to recognise different construction-related activities.

The work includes:
- Literature study on activity recognition using wearable sensors
- Collection or use of an experimental dataset of simple construction tasks
- Extraction of relevant motion features from sensor data
- Implementation of simple classification methods
- Evaluation of recognition performance across different activities

Example activities include walking, panel handling, static holding and fastening operations.

The thesis combines data analysis and experimentation, and will be carried out in the AugmentX research infrastructure at VUB. The student will work on a practical problem with applications in intelligent assistance systems and human–robot collaboration.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : El Makrini Ilias (ilias.el.makrini@vub.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

Automating 3D Geometric Measurement of Mechanical Test Benches Using Structured Scanning and Point Cloud Analysis

Description

Mechanical test benches must meet strict geometric tolerances to ensure that experimental measurements accurately reflect material and structural behavior rather than setup artifacts. Verifying these tolerances manually is a slow and error-prone process that becomes particularly burdensome when benches are frequently reconfigured or when high-precision applications demand exhaustive dimensional audits. This thesis designs and validates an automated system that acquires the complete 3D geometry of a mechanical test bench using a scanning sensor mounted on a motorized positioning stage, and processes the resulting point cloud data to extract quantitative geometric parameters without manual intervention. The system plans acquisition trajectories to ensure full coverage, registers multi-view scans into a unified coordinate frame, and computes deviations from CAD reference geometry to identify misalignments, deformations, and tolerance violations. Output is presented as an interactive 3D deviation map and a structured dimensional report, giving mechanical engineers a rapid, reproducible qualification tool that replaces manual measurement campaigns and supports traceability in accredited testing environments.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

Privacy-by-Design People Counting in Lecture Halls Using an Embedded Depth Camera System

Description

This master's thesis addresses the challenge of occupancy monitoring in academic environments through the design of a GDPR-compliant, privacy-by-design vision system capable of counting individuals in a lecture hall without capturing or processing any identifying information. Built around a low-power embedded platform, it requires a lightweight inference pipeline, optimised for constrained hardware, performs robust people detection and counting.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

Construction of a multiple-criteria evaluation process for student engineering projects

Description

Every bachelor student at Ecole Polytechnique de Bruxelles (EPB) must realize at least two projects during their first two years of study. These projects involve multiple different aspects, namely the construction of some model, the realization of a prototype implementing the model, the writing of a technical report, an oral presentation of the work, and in the case of the second project, an overview of the project management.
Currently, the evaluations of these points are performed separately by different parties using predefined evaluation grids. Such grids are great to objectivize the expectations of the teaching staff and tend to uniformize the grading if performed by different people. They are however based on natural language values (e.g.: “The slides are overall clear and allow the transfer of information”) and translating these to a numerical grade is not trivial. Moreover, combining the different grids also involve subjective choice that is not clear to pre-define, such as a weight associated to each grid.
In this master thesis, the student is expected to apply concepts from multiple criteria decision aid and natural language preference learning to develop a realistic and applicable evaluation process for bachelor projects. Ideally, the method(s) developed by the student could be compared with existing approaches and eventually applied in the following years.
Concerning the supervision, I would be available for weekly meetings (at the student’s demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentations skills.
In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be interested in didactics and will be confronted to an open applied problem with many possible leads to try. Moreover, this subject lies between multiple fields, some of which I do not master (at all). The student should thus be able to take initiatives, remain curious and be independent in its research.

Langue	FR (français)
Ouvert à d’autres masters	Yes

Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	1

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master's program offering the topic: Computer science and engineering - M-IRIFS

GPS and IMU-Aided Time-Lapse Imaging Platform for Automated Condition Monitoring of Linear Infrastructure

Description

Roads, canals, and other linear infrastructure assets degrade gradually over time, yet systematic visual monitoring of these structures at scale remains logistically complex and costly. This thesis designs and validates a mobile time-lapse camera system that acquires continuous image sequences along linear infrastructure corridors, enriched with GPS position and IMU orientation data at each capture event. By anchoring every frame to a precise spatial reference, the system enables the construction of georeferenced image timelines that can be compared across acquisition campaigns to detect and localize structural changes. Automated analysis modules identify surface deterioration, deformation patterns, and anomalies by applying computer vision techniques to temporally aligned image pairs. The result is a practical, low-cost survey tool that provides infrastructure managers and engineers with a structured, queryable visual record of asset condition, supporting proactive maintenance decisions and regulatory reporting.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

Machine Learning-Based Digitization of Seismic Traces from Scanned Historical Seismograms for Archival Data Recovery

Description

Seismological observatories worldwide hold vast collections of paper seismograms recording earthquakes and ground motion events going back to the late nineteenth century. This historical data is of exceptional scientific value for long-term seismic hazard assessment, source characterization of pre-instrumental earthquakes, and the calibration of modern seismic models, yet it remains largely inaccessible because converting analog traces into digital waveforms requires expert manual tracing on a record-by-record basis. This thesis builds a machine learning system that automates the recovery of seismic waveform data from scanned seismogram images. Starting from raw scan inputs, the pipeline handles document restoration, trace isolation, and waveform vectorization, translating the visual trace geometry into calibrated time series data that can be ingested by standard seismological software. The system is designed to process large archival collections with minimal human intervention, enabling seismologists to unlock decades of previously inaccessible observational data for modern reanalysis.

Langue	FR (français)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Debeir Olivier (olivier.debeir@ulb.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

On intransitive indifference relations and PROMETHEE methods

Description

When a problem involves multiple (conflicting) criteria, the notion of an “optimal” solution is ill-defined. Consider for example the problem of choosing the best place to host a conference, i.e. the least expensive, fanciest, and most accessible. It seems very unlikely that one place is the best on all these criteria.

The field of Multiple Criteria Decision Aid (MCDA) emerged in the 1960s to help decision makers who face such problems. In this context, the PROMETHEE I and PROMETHEE II methods rely on pairwise comparisons and preference functions to construct rankings of the available alternatives. In PROMETHEE, decision makers begin by describing their preferences regarding each criterion. When these preferences are crisp (strict), the procedure yields, for each criterion, a binary relation between alternatives that generally satisfies transitivity of strict preference (if $a > b$ and $b > c$ then $a > c$) but not transitivity of indifference ($a \sim b$ and $b \sim c$ but $a > c$).

However, the PROMETHEE I and II aggregation procedure produce rankings, and hence a form of global indifference that is transitive, since alternatives with identical net flows are considered indifferent. This raises several theoretical and practical questions: how does the aggregation process “repair” the non-transitive local indifference into a globally transitive indifference? To what extent is the global indifference meaningful when the underlying unidimensional relations exhibit cycles of indifference? Can alternative aggregation procedures or variants of PROMETHEE preserve or reflect the structure of local indifference more faithfully?

In this master thesis, the student is expected to investigate the contrast between non-transitive indifference at the criterion level and transitive indifference in the final ranking, both from a theoretical and methodological perspective. This could include revisiting the formal properties of PROMETHEE preference functions and the binary relations they generate; studying the structure of local indifference cycles and their propagation during aggregation; exploring alternative formulations or extensions that preserve local structures (e.g., partial orders, forest orders, interval-based flows, robust PROMETHEE approaches); or evaluating whether modified procedures could yield rankings that better reflect decision makers’ intent.

Concerning the supervision, I would be available for weekly meetings (at the student’s

demand), and the student would be expected to give a ten-minute presentation of their work every six to eight weeks in order to receive regular feedback on their presentation skills. In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be ready to work on theoretical mathematics, in particular on binary relations on sets and orders representations.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	1

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master's program offering the topic: Computer science and engineering - M-IRIFS

Non-compensatory grading methods for university exams

Description

At Ecole polytechnique de Bruxelles (EPB), most exams are composed of multiple questions supposed to evaluate the students' understanding or mastery of various concepts. Each question is graded independently and all grades are then aggregated, often using a weighted sum approach. In the fields of multiple-criteria decision aid (MCDA) and multi-objective optimization, the weighted sum approaches are often criticized for various reasons, one of which is that they are subject to compensations. In short, this means that a defect on one criterion can always be compensated by an improvement on another. In the context of grading mentioned above, if a student scores perfectly on one questions (20/20) and completely fails another (0/20) their final score is 10/20 and they succeed the exam. This would be the same if the student scored 10/20 at both questions, though from the perspective of the teacher the second case might be considered better or worse than the first. Some MCDA methods are non-compensatory by construction, for example ELECTRE methods, the lexicographic methods or treshold-based methods.
In this master thesis, the student is expected to navigate between theoretical aspects of MCDA and practical constraints of teaching activities to explore and propose realistic grading methods with good mathematical properties (non-compensations, monotony, robustness, etc.).
Concerning the supervision, I would be available for weekly meetings (at the student's demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentations skills. In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC. Expected profile: the student should be interested in didactics and will be confronted to an open problem with many possible leads to try.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master’s program offering the topic: Computer science and engineering - M-IRIFS

Explainability of decisions from PROMETHEE based models

Description

In many real-world decision problems — selecting candidates for a position, ranking infrastructure projects, or allocating research funding — stakeholders are not only interested in the outcome of a decision process, but also in understanding why a particular alternative was preferred over another. This need for transparency is both ethical, as decisions may significantly affect individuals or organizations, and practical, as trust in a decision support tool should be constructed.

The PROMETHEE I and PROMETHEE II methods, developed in the 1980s, are widely used outranking methods in multiple-criteria decision aid (MCDA). They rely on pairwise comparisons across criteria, weighted preference functions, and the aggregation of these into net flow scores that induce a ranking of alternatives. While the mathematical structure of PROMETHEE is relatively transparent compared to black-box approaches such as neural networks, translating its outputs into natural language justifications that are meaningful to a non-expert decision maker remains an open challenge. For instance, stating that alternative a outranks alternative b because its net flow is higher offers little intuitive value without further context about which criteria drove that difference, how decisive those differences were, and whether the conclusion is robust to small changes in the model parameters.

In this master thesis, the student is expected to investigate explainability in the context of PROMETHEE-based decision models, drawing on concepts from both MCDA and the broader literature on explainable artificial intelligence (XAI). This could include formalizing notions of explanation suited to outranking methods (e.g., criterion-level contribution decompositions, contrastive or counterfactual explanations of the form “alternative a would have been preferred if criterion k had been weighted differently”); studying the relationship between robustness analysis tools already available in PROMETHEE and the production of explanations; or developing a prototype explanation module that generates human-readable justifications for a given ranking. The practical applicability of the proposed approach should be evaluated, ideally on a real or realistic decision problem.

Concerning the supervision, I would be available for weekly meetings (at the student’s demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentation skills.

In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be interested in didactics and will be confronted to an open problem with many possible leads to try. The student should be comfortable with discrete mathematics and logic. Familiarity with probability and statistics is a plus.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	2

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master's program offering the topic: Computer science and engineering - M-IRIFS

Learning preferences of students towards course practices

Description

University courses are composed of a wide variety of teaching and assessment practices: lectures, exercise sessions, project work, oral examinations, written tests, flipped classroom approaches, peer feedback, and many others. While instructors often choose these practices based on experience or tradition, little is typically known about how students themselves perceive and value different combinations of course activities.
Understanding student preferences is non-trivial. A student may prefer oral exams over written ones in general, yet that preference may weaken or reverse when the course involves heavy mathematical content. Such context-dependent and potentially inconsistent preferences are difficult to capture with simple questionnaires or Likert scales. The field of preference learning, at the intersection of machine learning and multiple-criteria decision aid (MCDA), offers structured methods to elicit, represent, and reason about such preferences from observed data or pairwise comparisons.
In this master thesis, the student is expected to design and apply a preference learning methodology to model how students rank or evaluate different course practice profiles. This includes identifying relevant course attributes (e.g., type of assessment, frequency of feedback, degree of autonomy), collecting preference data through an appropriate elicitation protocol, and fitting a preference model - such as a utility function, a sorting rule, or an outranking relation - to the collected data. The work should also address the robustness of the inferred preferences and discuss the practical implications for course design. Ideally, the methodology could be piloted within one or more courses at Ecole polytechnique de Bruxelles and the results compared across student profiles (year of study, discipline, prior academic performance).
Concerning the supervision, I would be available for weekly meetings (at the student's demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentation skills.
In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be interested in didactics and will be confronted to an open problem with many possible leads to try. The student should be ready for data-driven

approaches. Ideally, the student would propose an end-to-end pipeline to apply on courses or cohorts.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	2

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

Improving sparse wearable motion tracking using IMU and UWB sensor fusion

Description

Wearable motion sensing using inertial measurement units (IMUs) is widely used for motion analysis and ergonomic monitoring. However, accurate motion reconstruction typically requires multiple sensors, which can be intrusive and difficult to deploy in real environments.

Using a reduced number of sensors is more practical, but often leads to reduced accuracy and ambiguities in motion estimation.

In this thesis, the student will investigate how combining IMU measurements with ultra-wideband (UWB) ranging can improve motion tracking using a minimal set of wearable sensors.

The work includes:
- Literature study on wearable motion tracking and sparse sensing
- Exploration of IMU and UWB sensing hardware
- Development of a simple experimental setup combining both modalities
- Collection of motion data during representative upper-body movements
- Implementation of a basic sensor fusion approach
- Evaluation of reconstructed motion against a reference system

The thesis combines sensing, algorithm development and experimental validation, and will be carried out in the AugmentX research infrastructure at VUB. The student will work on a challenging and relevant problem in wearable sensing and motion tracking.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : El Makrini Ilias (ilias.el.makrini@vub.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

Flight trajectory-based UAV classification

Description

Context:

Recent conflicts have highlighted the growing operational importance of Unmanned Aerial Vehicles (UAVs) and the urgent need for countermeasures that rely on reliable identification and recognition systems. One promising direction for UAV classification is the analysis of flight trajectories, which can reveal distinct behavioral patterns characteristic of different drone types. Radar-based UAV trajectory classification builds on this principle by using radar systems, typically frequency modulated continuous wave (FMCW) radars, to track airborne targets and extract motion related features.

Objectives:

The goal of this project is to design a reliable UAV classification method based on flight trajectory analysis, combining dynamic motion modeling with deep learning. The approach focuses on describing drones through their motion patterns, since different UAV types often exhibit characteristic behaviors shaped by their design and control systems.
To do this, the project will extract key behavioral features from trajectory data - such as velocity changes, acceleration profiles, turning behavior, and maneuverability. These features will then serve as inputs to deep learning models capable of handling time-dependent data, including recurrent neural networks (RNN) such as LSTM or GRU or transformer based architectures.

Methodology :

- Identify main databases of UAV trajectories in the literature and define UAV categories
- Build a radar observation model and extract relevant features
- Train and validate a deep-learning model based on RNN or transformers for UAV classification
- Assess the classification performance with confusion matrices

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Horlin Francois (francois.horlin@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

Homecare Radar Fall Detection

Description

Context:

One of today’s challenges consists in taking care of elderly persons. In particular, within the
context of society 5.0, it is considered as a real possibility to have elderly people stay longer
at home, which require robust and reliable sensing capabilities to warn relatives about potential issues. Moreover, even when in nursing home, elderly people need to be monitored. In particular, monitoring the fall of people is one of the major issue as it can happen any time.
This monitoring is today based on sensors relying on imaging techniques, which has the main drawback of not preserving the privacy of the people. Moreover, the false alarm rate is too high, which results in a non-trustable solution.
To counter these two aspects, SDR-Engineering has developed a radar platform and the associated signal processing to robustly detect the fall of people.

Objectives:

The project aims to validate and refine existing signal processing algorithms to detect the fall
of (elderly) people using radar signals. The refined algorithms will then be ported on the existing radar platform, and tested in a real environment.

Methodology :

- Understand the existing signal processing algorithms on Matlab.
- Acquire radar signals in various environments.
- Validate & suggest improvements for the existing algorithms based on defined KPIs.
- Implement the improved algorithms.

Langue	EN (english)
Ouvert à d’autres masters	Yes

Masters concernés	M-IRCBS, M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Horlin Francois (francois.horlin@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

Design, implementation and testing of an FM-based Wireless CAN protocol

Description

Motivation

The Controller Area Network (CAN) bus protocol is used for cabled broadcast networks in industrial and automation environments. It is favored because it guarantees low latency, prioritization of messages and heavy network loading. One of the unique features of CAN busses is it’s medium access control protocol, the CSMA/NDA protocol. Thanks to a concept of dominant and recessive bits on the communication bus, the CSMA/NDA implements a protocol that determines which nodes gets access to the medium without losing any time or bandwidth.
It was commonly thought that CSMA/NDA could only be implemented in cabled networks, but we’ve recently proven that it is possible to define a wireless PHY layer protocol that is compatible with the CSMA/NDA protocol of the MAC layer. In a proof-of-concept experiment, we designed and tested wireless transceivers that are fully compatible with the CAN controller of our microcontroller systems, proving the feasibility of wireless CAN (WiCAN) communications.
However, our current systems has several problems:
- Data rates are limited because of the wireless transceivers that are used;
- The system lacks robustness, as any wireless interferer could impact the WiCAN system.

To tackle these problems, it is proposed to evaluate the feasibility of a Frequency-modulation (FM)-based WiCAN system, where the dominant/recessive bit mechanism is implemented in a digital system. The proof-of-concept demonstrator will be based on simple, off-the-shelf components. Additionally, such a solution would allow to superimpose CDMA to the FM-based WiCAN to increase the robustness of the system

Objective
This Master’s thesis will have to perform the following tasks :
- Design a FM-based Wireless CAN system using off-the-shelf components, and integrate it with a commercial CAN controller;
- Design the digital logic in the FPGA using the available logic on PSOC

microcontrollers;

- Add and test the CDMA to the FM-based WiCAN system

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Quitin Francois (francois.quitin@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

[JUNO1] Generative AI for Fast Detector Simulation in Low-Level Trigger Studies

Description

The Jiangmen Underground Neutrino Observatory (JUNO) is a large particle physics experiment whose main goal is to act as a multipurpose observatory for neutrinos produced by artificial and natural sources. JUNO is currently in construction in the Jiangmen underground facility in Southern China.

• Background: Accurate simulation of detector response is fundamental for developing and optimizing trigger algorithms in high-energy physics experiments like JUNO. However, traditional Monte Carlo (MC) methods, while precise, are computationally intensive, creating a significant bottleneck for the rapid exploration and tuning of low-level trigger strategies.

• Objective: This project aims to develop and validate a fast simulation framework based on Generative AI to produce realistic JUNO detector response data tailored specifically for low-level trigger algorithm research. The goal is to drastically reduce the time needed for data generation compared to full MC simulations, while maintaining sufficient fidelity for trigger-relevant features, thereby accelerating the trigger R&D cycle.

• Methodology: The research will leverage JUNO's unique structure (20,000 Photo-Multiplier Tubes (PMTs), representable as a graph) and the availability of high-fidelity MC simulation data for training.

• Key steps include:

-Designing and optimizing generative AI models (e.g., Graph Neural Networks combined with GANs, VAEs, or Diffusion Models) capable of capturing the spatio-temporal characteristics of PMT responses.

-Training these models on large datasets generated by the existing, reliable JUNO simulation tools.

-Developing rigorous validation metrics to compare AI-generated data against MC data, focusing on distributions and correlations critical for low-level triggering (e.g., hit times, charge patterns, cluster properties).

-Demonstrating the utility of the fast simulator by integrating it into a typical workflow for trigger algorithm evaluation or optimization.

• Expected Outcomes: The primary outcome will be an efficient and validated generative AI model capable of rapidly producing JUNO detector response data. The research will provide a quantitative assessment of the speed-up factor and the fidelity achieved compared to traditional MC methods.

• Keywords: Generative AI, Deep Learning, Detector Simulation, Fast Simulation, Surrogate Modeling, JUNO, Trigger System, Low-Level Trigger, Monte Carlo Simulation, Graph Neural Networks, High Energy Physics.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Robert Frederic (frederic.robert@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

DVB-T based passive radar for wide coverage UAV detection

Description

Context:

Low flying Class 1 drones represent a growing threat to critical infrastructures such as airbases, airports, and energy facilities. To mitigate these risks, wide area detection systems capable of providing early alerts are essential.
Passive radars are an attractive solution because they use illuminators of opportunity - such as broadcast television and communication signals - allowing surveillance over a wide area without resorting to dedicated transmitters. Recent research highlights the strong potential of passive radars for UAV detection using continuous, high power, and widely deployed DVB T signals. They enable long range UAV detection, with demonstrations achieving detection distances of up to 5 km, including direction of arrival (DoA) estimation.

Objectives:

The project aims to design, develop, and demonstrate a DVB-T based passive radar system capable of detecting and locating mid size UAVs (approximately 50 cm). The system will be validated using a software defined radio (SDR) receiver, enabling flexible signal acquisition and adaptation to different operational scenarios.

Methodology :

- Investigate the properties of DVB-T signals when used as illuminators of opportunity
- Acquire the DVB-T signal over-the-air with the USRP setup and implement the decoder
- Build the DVB-T-based passive radar and simulate it in Matlab
- Validate the passive radar experimentally for the detection of a mid-size UAV at varying distances from the radar

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-M, M- IRPH

Nombre de sujets	3

Supervision

Supervisor : Horlin Francois (francois.horlin@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

[JUNO2] An Intelligent Agent System for Automated Monitoring and Debugging Support of the JUNO Electronics system

Description

The Jiangmen Underground Neutrino Observatory (JUNO) is a large particle physics experiment whose main goal is to act as a multipurpose observatory for neutrinos produced by artificial and natural sources. JUNO is currently in construction in the Jiangmen underground facility in Southern China.

• Background: The JUNO Electronics system is a complex, distributed system responsible for processing signals from 20,000 PMTs (photomultipliers). Ensuring its stable operation requires continuous monitoring of performance metrics, analysis of large data volumes, and timely diagnosis of potential hardware faults. Current approaches often rely heavily on manual inspection and expert intervention, which can be time-consuming and difficult to scale, especially with evolving personnel.

• Objective: This project aims to develop an Intelligent Agent system designed to automate the monitoring, analysis, and debugging support workflow for the JUNO Electronics system. The agent will act as an "intelligent assistant," proactively analyzing operational data, identifying anomalies, providing contextual information, and streamlining the troubleshooting process for human experts.

• Methodology: The research will focus on integrating modern AI agent frameworks with existing analysis tools and domain knowledge.

Key steps include:

-Designing the agent architecture using a framework like AutoGen or LangChain, enabling it to perceive system status, plan analysis steps, and execute actions.

-Implementing automated workflow execution, allowing the agent to orchestrate existing data analysis scripts and algorithms (developed by previous researchers) as callable "tools."

-Developing data-driven anomaly detection modules to continuously monitor key performance indicators and flag statistically significant deviations potentially indicative of hardware issues.

-Building a local JUNO Electronics system knowledge base (from design documents, historical logs, expert notes) and integrating it using Retrieval-Augmented Generation (RAG) with Large Language Models (LLMs) and vector databases. This allows the agent to query the knowledge base to provide context for anomalies or answer expert queries.

-Designing the system with modularity and extensibility in mind, allowing easy integration of new tools, data sources, or diagnostic capabilities.

• Expected Outcomes: The project will deliver a functional prototype of the Intelligent Agent system for JUNO Electronics system monitoring and debugging support, including demonstrated automation of routine analysis tasks, successful identification of predefined anomaly types, effective knowledge retrieval via RAG, and a well- documented, extensible framework. This system aims to significantly enhance operational efficiency, accelerate problem resolution, and preserve critical expert knowledge for the JUNO experiment.

• Keywords: Intelligent Agents, AI Agent, Automation, System Monitoring, Fault Diagnosis, Debugging Support, JUNO, Backend Electronics , Workflow Automation, Knowledge Base, RAG (Retrieval-Augmented Generation), Large Language Models (LLM), Anomaly Detection, High Energy Physics Operations, Extensible Framework.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Robert Frederic (frederic.robert@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

Radar-Based Pedestrian Tracking with Recurrent Neural Networks

Description

Context:

Understanding pedestrian mobility patterns enables better infrastructure planning, reduced congestion, and improved user experience. Tracking pedestrian trajectories in public areas is therefore essential to promote soft mobility. Cameras are often used but suffer from poor performance in low-light conditions and raise privacy concerns. In contrast, radars can accu-rately detect and track motion under challenging conditions while preserving privacy. They are also low-cost and easy to deploy.
The most common technology is the Frequency Modulated Continuous Wave Radar (FMCW), which estimates target range and Doppler and often uses MIMO antenna arrays to deter-mine target angles. Recent FMCW radars operate at millimeter-wave frequencies. While ra-dar has proven effective for pedestrian tracking, most studies focus on scenarios with only a few individuals and aim mainly at counting or classifying targets. However, critical situations require simultaneously tracking the trajectories of many individuals.

Objectives:

Once the radar system is properly designed and implemented, the detections obtained after radar signal processing must be further processed to enable the recovery of pedestrian tra-jectories. Classical approaches typically combine a Kalman filter with a data association al-gorithm. In this work, the use of recurrent neural networks (RNN) designed to process se-quential data will be considered for radar-based tracking.

Methodology:

- Understand the physical principles and signal processing of the Frequency-Modulated Continuous Wave Radar.
- Master machine learning concepts in order to rigorously justify the choice of the se-lected RNN for pedestrian tracking using radar data. Advanced RNN architectures such as the LSTM and GRU will be considered.
- Train the model and validate its performance using both simulations and real-world

measurements (the real-world measurements will be provided).

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Horlin Francois (francois.horlin@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

Design, implementation and testing of a wideband Wireless CAN protocol

Description

Motivation

The Controller Area Network (CAN) bus protocol is used for cabled broadcast networks in industrial and automation environments. It is favored because it guarantees low latency, prioritization of messages and heavy network loading. One of the unique features of CAN busses is it's medium access control protocol, the CSMA/NDA protocol. Thanks to a concept of dominant and recessive bits on the communication bus, the CSMA/NDA implements a protocol that determines which nodes gets access to the medium without losing any time or bandwidth.
It was commonly thought that CSMA/NDA could only be implemented in cabled networks, but we've recently proven that it is possible to define a wireless PHY layer protocol that is compatible with the CSMA/NDA protocol of the MAC layer. In a proof-of-concept experiment, we designed and tested wireless transceivers that are fully compatible with the CAN controller of our microcontroller systems, proving the feasibility of wireless CAN (WiCAN) communications.
However, our current systems has several problems:

- Data rates are limited because of the wireless transceivers that are used;
- The system lacks robustness, as any wireless interferer could impact the WiCAN system.

To tackle these problems, it is proposed to evaluate the feasibility of a high-bandwidth WiCAN system, and evaluate it's feasibility on a software-defined radio testbed.

Objective
This Master's thesis will have to perform the following tasks :

- Evaluate which type of high-bandwidth system (OFDM, SC-FDE, CDMA) would be the best candidate for high-bandwidth WiCAN systems;
- Prototype a proof-of-concept system on software-defined radios to prove the feasibility of high-bandwidth WiCAN communications. The proof-of-concept prototype will first run offline (i.e. not real-time)
- In order to reach a real-time implementation, the proposed design will be ported to

the FPGA of the software-defined radio.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Quitin Francois (francois.quitin@ulb.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Experimental and numerical investigation of structural adhesive behavior under multiple loading conditions

Description

Context of the master thesis

Adhesive joints are commonly used to bond components in composite structures. Adhesive bonding not only facilitates lightweight designs but also offers significant advantages over mechanical fastening, including excellent durability, fatigue resistance, and the ability to evenly distribute stress across the joint. Despite these benefits, adhesive joint failure often reduces the lifespan of composite structures [1]. Therefore, comprehensive experimental characterization of structural adhesives and the development of reliable numerical models are essential for understanding adhesive joint behavior in large-scale structures, such as wind turbine blades. Due to the cross-linking nature of epoxy adhesives, their tensile, shear, and compressive behaviors differ. These differences can be accounted for using a pressure-dependent material model [2]. The Drucker-Prager model, a commonly used pressure-dependent material model, has been applied by researchers to simulate epoxy-based adhesives, though most studies are limited to the linear form of the model [3]. In this master's thesis, structural adhesive specimens will be tested under tensile, shear, and compressive loading to characterize material behavior, including post-yield response, and to extract material constants for the Drucker-Prager exponential model. Each experiment will be simulated using ABAQUS finite element (FE) software to replicate the observed material behavior and damage propagation. Following complete characterization and modeling of the adhesive, fracture tests will be performed on Single Edge Notch Bending (SENB) specimens under various loading conditions. The developed advanced material model will then be used to numerically replicate these experiments, demonstrating the applicability of the exponential Drucker-Prager model in simulating the behavior of epoxy adhesives.

References

[1] P. Zuo and A. P. Vassilopoulos, "Review of fatigue of bulk structural adhesives and thick adhesive joints," Int. Mater. Rev., vol. 66, no. 5, pp. 313–338, 2021, doi: 10.1080/09506608.2020.1845110.

[2] X. P. Morelle, J. Chevalier, C. Bailly, T. Pardoen, and F. Lani, "Mechanical characterization and modeling of the deformation and failure of the highly crosslinked RTM6 epoxy resin,"

Mech. Time-Dependent Mater., vol. 21, no. 3, pp. 419–454, 2017, doi: 10.1007/s11043-016-9336-6.
[3] A. Sharma et al., "Combined computational-experimental investigation of residual stresses and pre-cracking in mode I behaviour of thick adhesively bonded GFRP composite joints," Compos. Struct., vol. 351, p. 118549, Jan. 2025, doi: 10.1016/J.COMPSTRUCT.2024.118549.

Objectives of the master thesis
1. To perform advanced mechanical characterization of epoxy-based adhesives experimentally.
2. To develop a numerical model that replicates adhesive behavior under tensile, shear, and compressive loading.
3. To assess the model's capability to predict damage propagation in cracked specimens.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Investigation of Combined Noise Transmission and Reflection Cancellation in Industrial Duct Systems

Description

Industrial compressors produce significant pressure pulsations, and thus noise, within their exhaust system. Conventional solutions to dampen these acoustic waves is the use of passive silencers. However, their integration becomes challenging for state-of-the-art variable speed drive (VSD) applications. Active noise cancellation, with the implementation of an actively controlled loudspeaker, to dampen the compressor’s pressure pulsations is an interesting alternative that provides various benefits in VSD applications, compared with conventional silencers.

The loudspeaker itself will generate anti-phase pressure waves that destructively interfere with the pressure waves produced by the compressor. Noise transmission cancellation is therefore achieved towards the remaining exhaust system. However, a single loudspeaker will inherently also reflect pressure waves back towards the compressor which is not desired. Implementing 2 loudspeakers, 1 for noise transmission and 1 for noise reflection can solve this problem. Thus, a detailed investigation of the coupling between these 2 loudspeakers is necessary.

You will be performing simulations and experiments with loudspeakers in an exhaust system in order to study the interaction between them when cancelling the exhaust noise, thereby trying to minimize the pressure pulsations that gets transmitted and reflected.

The simulations will be performed in MATLAB Simulink. The basic models will be provided by the supervisor. The goal will be to simulate various configurations of these devices as well as performing parametric studies. An experimental setup is available to validate the simulations. The setup is comprised of various duct elements and loudspeakers that can be put in various configurations. Here, incoming noise can be generated (that simulate the industrial machinery noise). The passive and active attenuation devices will then be steered to dampen the noise. The most optimal configuration will then be searched for based on the power consumption of the actuator.

Depending on the fluidity of the project, a final experiment on a 45 kW compressor can be performed.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Verrelst Bjorn (Bjorn.Verrelst@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Development of a thermal PID closed-loop controller for 316L/CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future. However, ensuring that each alloy composition (of a multi-material) is processed in the optimal manner requires the development of a dedicated and advanced (thermal) closed-loop controller.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will first perform system identification for the different materials / mixtures considered in the framework of this thesis. The student will develop a model between the laser power input and thermal response of the melt, highlighting the differences that exist depending on the processed mixture. The student will then develop, simulate and implement a (PI) controller and perform practical tests to evaluate the controller’s actions, depending on the processed mixture. The student will evaluate the necessity of a mixture-specific controller, and will propose a framework as to how to adjust controller parameter based on varying compositions (e.g. additional controller input). The student may suggest machine modifications with the purpose of enhancing the quality of the produced multi-material samples through closed-loop control.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

On-line measurement and validation of thermal gradients during 3D metal printing through IR-camera measurements.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is an metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible.

Fig. 2 shows a 3D tower part that has been manufactured in a hybrid way with the MiCLAD machine. During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part.

In this context, two thermal cameras (FLIR and SWIR) have been integrated into the machine, and a dedicated tool has been developed to enable in-process thermal gradient monitoring. The use of both cameras allows for broader thermal range coverage, capturing the various temperature the part experiences during the process. The tool enables simultaneous recording from both cameras and provides real-time visualization of thermal gradients through a dedicated application, with the aim of enabling online thermal gradient control in the future. An example of a captured thermal field of the build plate during process is shown in Fig. 5.

This setup and tool now require further development and validation to assess the accuracy of the results. To this end, an experimental campaign will be conducted under varying

heat input boundary conditions, primarily focusing on laser power and build plate preheating settings. The resulting data will be analyzed to gain a deeper understanding of the thermal history of parts during the DED process and ultimately to reduce the thermal gradient and resulting residual stresses.

In parallel, the measured thermal gradients will be compared with numerical simulations using an existing DED process model. This comparison aims to validate the model as well as the associated material parameters (such as density, latent heat, and heat capacity) and boundary conditions against the experimental results. A specific parameter matrix will be defined for both the experimental and numerical campaigns. The thermal history simulations will be carried out using Morfeo (Manufacturing Oriented Finite Element tOol), an extended finite element (FEM) code developed by the Belgian research center Cenaero [3].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Post-processor extension to 3D material allocation for metal 3D printing through Directed Energy Deposition manufacturing process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part/sprocket that has been manufactured with the MiCLAD machine.

Functionally Graded Materials (FGM) are components with gradual changes in composition or structure across their volume, designed to optimize mechanical or thermal performance. In DED, FGMs are produced by dynamically adjusting the metal powder or wire feed rates during the deposition process. This enables smooth transitions between different metal alloys (e.g., stainless steel to copper), reducing residual stresses and improving bonding. Such FGMs are ideal for applications requiring a combination of properties like high strength, corrosion resistance, and thermal stability within a single part.

FGMs are used for example in injection molding molds, as shown in Fig. 3 [3], to optimize performance by combining high thermal conductivity near the mold surface for faster cooling with a tougher core for structural strength. This gradient in properties improves cycle times, reduces wear, and extends mold life. The production of such a part required a different material allocation in 3 dimensions (x, y, and z), see Fig. 4.

CAD/CAM software (Computer-Aided Design / Manufacturing) plays a crucial role in DED by converting CAD models into toolpaths that guide the deposition head and define process parameters. However, current commercial solutions lack the capability to handle FGMs by assigning specific materials and corresponding process settings to precise locations within a part. To address this, the AM-Lab developed the CamLink post-processor, which serves as a translator between the CAD/CAM software and the CNC machine, enabling advanced control over material deposition.

It allows the generation of machine compatible Gcode from any geometry, incorporating the desired material gradient at specified locations, via a standalone MATLAB application. However, at this stage, material allocation is limited to the -z and -x directions. An example of a composition transition from copper to 316L in the x-direction is shown in Fig. 6–7.

The aim of this master thesis is to further develop the existing CamLink post-processor to enable material allocation in all three spatial dimensions, thereby allowing complete design freedom in the manufacturing of FGMs. In the next phase, this extension will be validated through simple experiments using the DED machine. Subsequently, process parameters will be optimized, based on microstructural analysis, to ensure defect-free transitions between material compositions. Finally, the enhanced post-processor will be validated through the production of a demonstrator part featuring composition gradients in all three directions.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Development of the wedge test for thick adhesive joints to prevent crack deviation under mode I loading

Description

Context of the master thesis

Adhesive joints are widely used across various industries, including wind turbine manufacturing, shipbuilding, aerospace, and automotive applications. Compared with traditional joining methods, adhesive bonding offers several advantages, such as the ability to join similar and dissimilar materials, weight savings, improved stress distribution along the bond line, and enhanced corrosion and fatigue resistance. When considering thick adhesive joints, however, the definition varies across industries. For example, in the wind turbine and shipbuilding sectors, thick adhesive joints typically have an adhesive layer thickness of approximately 10 mm or greater [1]. The influence of adherend constraint, joint geometry, and residual stresses on crack kinking under mode I loading conditions is well documented in the literature [2], [3]. Nevertheless, to date, no experimental setup has been proposed that enables stable crack propagation within the mid-plane of the adhesive layer under pure mode I loading. To address this gap, the present master’s thesis will employ a combined numerical–experimental approach to develop a test method capable of promoting stable crack growth in thick joints. A series of numerical models will first be developed using ABAQUS finite element (FE) software to evaluate fracture parameters under mode I loading using conventional Double Cantilever Beam (DCB) specimens subjected to point loading. In the subsequent step, in addition to the opening load applied normal to the crack plane, an auxiliary load will be applied in a perpendicular direction. This auxiliary load is intended to reduce crack-tip constraint arising from joint geometry and residual stresses. Based on the numerical results, the appropriate load ratio between the parallel and perpendicular loading directions will be determined, and a wedge-based support system capable of delivering this load ratio will be designed. Experimental tests will then be conducted on pre-cracked thick adhesive joint specimens to assess the feasibility and effectiveness of the proposed method. Finally, the wedge test experiments will be replicated through FE simulations to provide a comprehensive understanding of the underlying fracture mechanisms and crack propagation behavior.

References

[1] R. Lopes Fernandes, S. Teixeira de Freitas, M. K. Budzik, J. A. Poulis, and R. Benedictus,

"From thin to extra-thick adhesive layer thicknesses: Fracture of bonded joints under mode I loading conditions," Eng. Fract. Mech., vol. 218, no. August 2019, p. 106607, 2019, doi: 10.1016/j.engfracmech.2019.106607.
[2] A. S. Kojouri et al., "A new equivalent crack length technique for mode I fracture of adhesively bonded joints," Compos. Part B Eng., p. 112733, Jun. 2025, doi: 10.1016/j.compositesb.2025.112733.
[3] A. Sharma et al., "Combined computational-experimental investigation of residual stresses and pre-cracking in mode I behaviour of thick adhesively bonded GFRP composite joints," Compos. Struct., vol. 351, p. 118549, Jan. 2025, doi: 10.1016/J.COMPSTRUCT.2024.118549.

Objectives of the master thesis
1. To determine the fracture parameters of thick adhesive joints under point-load conditions.
2. To identify fracture parameters that mitigate unstable crack propagation in adhesive joints and to design a wedge-based loading system accordingly.
3. To experimentally evaluate the proposed setup for facilitating stable crack propagation.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Control Strategy Development of a Variable Loudspeaker Enclosure for Minimal-Power Consumption During Active Noise Cancellation in Industrial Duct Systems

Description

Industrial compressors produce significant pressure pulsations, and thus noise, within their exhaust system.
Conventional solutions to dampen these acoustic waves is the use of passive silencers. However, their integration
becomes challenging for state-of-the-art variable speed drive (VSD) applications. Active noise cancellation, with
the implementation of an actively controlled loudspeaker, to dampen the compressor’s pressure pulsations is an
interesting alternative that provides various benefits in VSD applications, compared with conventional silencers.
The actively controlled loudspeaker generates anti-phase pressure waves that destructively interfere with the
pressure waves produced by the compressor. The loudspeaker therefore consumes a certain amount of electrical
power. This power can be minimized when the loudspeaker operates at its mechanical resonance frequency.
However, in VSD applications, the excitation frequency shifts with operating speed, hence the need for a variable
resonance frequency of the loudspeaker. The mechanical resonance frequency of the loudspeaker can be shifted
by having a variable back-cavity enclosure volume. Doing so, the loudspeaker can operate in a wider frequency
range at minimal power.

Previous work has already been conducted where an initial design of a variable back-cavity volume loudspeaker
was made. Experiments have shown that the resonance frequency of the system could be shifted from 200 to 300

Hz by varying the piston position via a stepper motor.

Previous work has already been conducted where a fixed-volume loudspeaker was used to perform active noise
cancellation in an industrial duct system.

Your job will be to combine these 2 systems. The idea will be to control the loudspeaker to achieve active noise cancellation (reduce noise in the duct system) while the loudspeaker operates at minimal power consumption.
MATLAB Simulink models will be provided to you by the supervisor in order to investigate different control methods (feedforward/feedback) to control the stepper motor, and hence the enclosure volume, in such a way that the loudspeaker works in its most efficient working point. Afterwards, the control strategies can be experimentally evaluated on an academic test setup.

Depending on the fluidity of the project, a final experiment on a 45 kW compressor can be performed.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Verrelst Bjorn (Bjorn.Verrelst@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Parameter study for laser ablation of metal 3D-printed surfaces for patterning and roughness reduction.

Description

Context of the master thesis:
Metal 3D-printing or Additive Manufacturing (AM) of metallic structures is an emerging technology for making solid 3D object from a digital file. The design, fabrication, distribution of products and the use of components made with AM techniques are low carbon consuming and highly efficient in their use of virgin material [1]. Airbus and other aerospace companies have denoted AM as a game changing technology for 21 century. An article by The Economist [2] details "The third industrial revolution". Additive manufacturing is highlighted as the production technology of the future, enabling mass customization instead of mass production. One of the remaining key challenges is to eliminate and control the roughness level in the produced parts. The reduction of the roughness level is a crucial element to support the application of AM components in the aeronautical industry for critical applications. The objective of the thesis is to study the different parameter sets of a nano-second pulsed laser system available at the Additive Manufacturing Research Lab (AMRL) at the VUB. The tasks listed below are for information and depending on the student interest can be adapted. For more information don't hesitate to contact the contact person below.

Tasks:

- Literature study of surface roughness reduction and laser patterning with nano-second lasers.
- Definition of evaluation framework of the parameter study.
- Definition of parameter sets to be evaluated.
- Development of an experimental set-up
- Performance of experimental study with developed experimental set-up.

See also external link

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-M, M- IRPH
Nombre de sujets	2

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Processing and characterization of a 316L to CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will engage in the explorative research regarding the process-material-property relationship of this multi-material. Especially the effect of ultrasound excitation during the DED processing of such 316L/CuCr1Zr multi-material will be explored. Samples with varying/gradient compositions will be manufactured and mechanically/microstructurally characterized to further optimize the processing conditions. The effects on corrosion resistance will be evaluated as well. The student will suggest process parameter optimizations and machine modifications with the purpose of enhancing the quality of the produced multi-material samples.

Practically, coupons will be produced under varying processing conditions, amongst which the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. Additionally, corrosion testing will be conducted macroscopically, and at localized regions to carefully evaluate the performance along the build direction. The functional properties (thermal/mechanical/corrosion) will be compared to reference conditions without ultrasound excitation.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O

Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Measurement, modelling and compensation of a modulated high power fiber laser for metal 3D-print applications

Description

Context of the master thesis:
Additive manufacturing (AM), particularly selective laser melting, and directed energy deposition have a significant potential impact on the production of complex parts and components. The ability to create intricate geometries layer by layer offers advantages in various industries, from aerospace to medical devices. Conventionally, continuous-wave lasers have been the workhorses for metal AM, operating at high power levels. However, emerging new fiber laser technologies present an exciting opportunity to enhance the precision and efficiency of this process. Continuous wave lasers have been evaluated with calorimetric measurement solutions. Since calorimetry is based on a thermal process, its time constant is relatively high compared to the time constants associated with lasers. This implies that the calorimeter effectively behaves as a lowpass filter, filtering out any laser dynamics, i.e. only statements concerning the average laser power can be made. The new available thin film sensor technology enables a significant extension of the dynamic range (10 kHz) without jeopardizing laser damage resistance property. Two dynamic laser effects are distinguished in literature viz. ’steady state power variation’ and ’switching behaviour’. Continuous lasers, while effective, lack the fine-grained control necessary for intricate AM processes. The modulated laser is a dynamic light source that allows precise modulation of output power. By adjusting the amplitude, duty cycle and/or the modulation frequency, we can tailor the energy deposition during the AM. The aim of the master’s thesis is to measure, model and compensate for the dynamic behaviour of a modulated laser source. More specifically you will:

Tasks:

- Use a modulated laser system and optimized input excitations signals to characterize its behaviour using advanced laser power and PXI measurement equipment. Here it is key to accurately measure the dynamic behaviour of the laser, including power fluctuations, modulation frequency, and other relevant parameters during AM experiments.
- Apply system identification tools to model the laser’s dynamic response to the modulation input.
- Develop a compensation algorithm based on the earlier retrieved model to

compensate for the dynamic behaviour of the laser.

Don’t hesitate to reach out to us if you want more information!

See also external link

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Development of a MIMO closed-loop controller for 316L/CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future. However, ensuring that each alloy composition (of a multi-material) is processed in the optimal manner requires the development of a dedicated and advanced closed-loop controller.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will first investigate the particular challenges related to the development of a closed-loop process controller for multi-materials. By utilizing the existing closed-loop controller (only laser power control), the student will compare samples against open loop trials. The existing closed-loop controller will then be further optimized (PID parameter tuning, setpoint, temperature estimation models), challenged for different geometries and extended (e.g. including scan speed control). The student may suggest machine modifications with the purpose of enhancing the quality of the produced multi-material samples through closed-loop control.

The student will characterize the process (system identification) and develop a state-space model of the process. A Model Predictive Controller (MPC), based on Matlab/Python scripting, will be developed. The student will be involved in the practical integration, machine control implementation and parameter tuning of the to-be-developed closed-loop process controller. Coupons will then be produced under varying controlling strategies (open loop, existing closed-loop, new solution) after which metallurgical evaluation will reveal the obtained part quality. Machine modifications may be suggested towards further enhancing the DED process.

Langue	EN (english)

Ouvert à d’autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

test

Description

test

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : test test (test@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Unraveling the effect of geometry on crack kinking under mode I loading using biaxial testing

Description

Context of the master thesis

Fracture mechanics is a branch of solid mechanics that studies the behavior of structures in the presence of cracks. In real structures, crack initiation can occur in regions of high stress or due to material voids, among other causes. Understanding material and structural behavior in the presence of cracks is crucial for avoiding catastrophic failure and enabling fail-safe design methodologies. To achieve this, fracture behavior must be studied under different loading modes, i.e., mode I, mode II, and mode III [1]. Mode I, or opening mode, is the most common loading condition encountered in real structures [1]. Experimental studies on mode I have shown that cracks do not always propagate in a straight path; rather, they often kink due to geometric constraints. In other words, changing the specimen geometry under the same loading conditions can lead to different crack propagation behaviors [2], [3]. Despite extensive experimental work, the primary factors triggering crack kinking remain not fully understood. It is well recognized that altering the geometry from Single Edge Notch Tension (SENT) to Double Cantilever Beam (DCB) specimens under mode I loading can induce unstable crack propagation [2], [3]. In this master’s thesis, PMMA (polymethyl methacrylate) DCB specimens will be modeled under the Linear Elastic Fracture Mechanics (LEFM) framework using ABAQUS finite element (FE) software to determine the stress field and fracture parameters at the crack tip. Subsequently, biaxial loading conditions will be applied to the specimens, and the corresponding fracture parameters will be evaluated. The main objective is to identify a biaxial loading condition that suppresses crack kinking in the DCB specimen. Once the appropriate loading conditions are determined, the specimens will be tested using a biaxial testing machine to validate the simulations. This research will provide high-quality insights into the influence of geometry and loading conditions on crack trajectory under mode I, enhancing our understanding of fracture behavior in engineering structures.

References

[1] T. L. Anderson, FRACTURE MECHANICS: Fundamentals and Applications, Fourth Edition. 2017. doi: 10.1201/9781315370293.

[2] N. Razavi, M. R. Ayatollahi, and F. Berto, “A synthesis of geometry effect on brittle

fracture," Eng. Fract. Mech., vol. 187, pp. 94–102, 2018, doi: 10.1016/j.engfracmech.2017.10.022.
[3] M. R. Ayatollahi, M. Rashidi Moghaddam, N. Razavi, and F. Berto, "Geometry effects on fracture trajectory of PMMA samples under pure mode-I loading," Eng. Fract. Mech., vol. 163, pp. 449–461, Sep. 2016, doi: 10.1016/J.ENGFRACMECH.2016.05.014.

Objectives of the master thesis

For the first time, the combined effects of specimen geometry and loading on mode I fracture will be investigated. This study aims to achieve the following objectives:

1. To understand the effect of geometry on crack trajectory under mode I loading.
2. To identify loading conditions that mitigate unstable crack propagation under mode I.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Effects of Passive Attenuation Devices on the Requirements of an Active Noise Cancellation Loudspeaker in Industrial Duct Systems

Description

Industrial compressors produce significant pressure pulsations, and thus noise, within their exhaust system. Conventional solutions to dampen these acoustic waves are the use of passive silencers. However, their integration becomes challenging for state-of-the-art variable speed drive (VSD) applications. Active noise cancellation, with the implementation of an actively controlled loudspeaker, to dampen the compressor’s pressure pulsations is an interesting alternative that provides various benefits in VSD applications, compared with conventional silencers.
However, a hybrid approach using both passive and active attenuation devices could be beneficial to lower the actuator’s dynamic requirements. One example of a passive resonator is a quarter-wavelength resonator side branch. When incoming pressure waves arrive at this side branch, part of the noise will go inside the resonator. At the resonator’s resonance frequency, this pressure wave will get reflected back to the main duct with the opposite phase, hence cancelling the primary wave. The loudspeaker, when placed downstream of the resonator, would in theory need to deliver very little anti-noise since a large portion of the noise cancellation is already achieved via the passive device. However, many different configurations can be thought of to place these devices with respect to each other. Therefore, a detailed investigation of the interaction between these passive (acoustic resonators) and active (loudspeakers) attenuation devices is of interest.

You will be performing simulations and experiments with passive and active attenuation devices in an acoustic duct network in order to study the interaction between these devices and the effect on the loudspeaker’s dynamic requirements.
The simulations will be performed in MATLAB Simulink. The basic models will be provided by the supervisor. The goal will be to simulate various configurations of these devices as well as performing parametric studies. The most interesting configurations can afterwards be experimentally evaluated on an academic setup.
A modular academic test-setup is available where various ducts, passive resonators, and active loudspeakers can be assembled in various configurations. Different configurations can be examined where the interaction between the passive and active devices is measured, as well as the power consumption of the loudspeaker for full cancellation of the

noise. The most optimal configuration, where the loudspeaker's power draw is minimal will then be searched for.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Verrelst Bjorn (Bjorn.Verrelst@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Development of a ML-based controller for 316L/CuCr1Zr functionally graded additive materials

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future. However, ensuring that each alloy composition (of a multi-material) is processed in the optimal manner requires the development of a dedicated and advanced closed-loop controller.

The current thesis proposal targets the challenging processing of a 316L to CuCr1Zr multi-material. The student will first investigate the particular challenges related to the development of a closed-loop process controller for multi-materials. The student will select and train multiple regression-based machine-learning (ML) models and compare their performance to classify coaxial melt-pool images with varying alloy compositions. A real-time process controller will be implemented to control the DED-LB process, thereby utilizing the ML model classification as input to know how to process the alloy optimally (e.g. target melt-pool temperature, adjust powder feed rates). A comparison between open-loop processing, traditional closed-loop control and ML-based controller is planned (target composition (EDS), and part quality (metallurgical analysis).

The student will propose processing trials in which melt-pool images are captures to train a regression-based ML model. The developed model will be evaluated against an unseen set of melt-pool images with varying compositions to evaluate the estimation accuracy and pinpoint classification errors. The resulting coupons will be metallurgically characterized (EDS) and serve as the ground truth for classification purposes. A second part of the thesis will then involve the development of a control loop in which the actual melt-pool composition is compared to the targeted one, allowing to change the powder feed rates and utilize the optimal processing conditions for the actual melt pool composition.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Numerical study for thermal gradient reduction during 3D printing Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

During the DED process, the thermal history of the part is very important for the final quality and directly influences the residual stresses, see Fig. 3. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build strategy on the thermal history of the part. Next to the process parameters, as shown on Fig. 3, buildplate preheating involves heating the baseplate before material deposition begins, is also used to reduce the thermal gradients.

Preheating minimizes the temperature difference between the incoming molten material and the cooler buildplate. This helps controlling the thermal history of the part, and might lead to better overall quality of the printed part.

The aim of this master thesis is to investigate numerically the effect of temperature dependent material parameters (density, latent heat, heat capacity, ...) and build plate preheating settings on the thermal history of the part.

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol) an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Feasibility study of Probability of Dectection for new Structural health monitoring solutions of 3D printed aeronautical structures.

Description

Context of the master thesis:
Structural health monitoring (SHM) is an emerging technology for continuously monitoring of the structural integrity of the structural system. SHM has a high added value potential for different industries. A new innovative crack detection SHM system has been developed within the acoustics and vibration research group. The technological readiness level of the new SHM system can be extended if the Probability of Detection (PoD) is clarified. A PoD allows the user to verify the likelihood of detecting cracks with a certain length by the SHM system. The main objective for the Master thesis student would be to investigate the feasibility and applicability of the PoD concept for the developed SHM system in numerically or experimentally manner.

Tasks:
- Literature study of existing SHM and NDT (Non Destructive Testing) system for aeronautical structures and additive manufacturing.
- Literature study of Probability of Detection (PoD) for SHM and NDT operational systems.
- Definition of potential approaches.
- Development of experimental setup or/and numerical simulation in order to verify working principles.
- Selection of potential PoD approach.
- Implementation of an initial verification tests or/and numerical simulation procedure to generated data to support a PoD.
- Conclusion on the feasibility of the PoD approach for the new SHM concept.

If time permits the research can be extended to 3D printed aeronautical structures. Further details regarding the concepts can be provided by the contact person on request.

Langue	EN (english)
Ouvert à d'autres masters	Yes

Masters concernés	M-IRCNE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of milling process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters and build/cutting strategy on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [3].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [4] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of a post milling operation (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [5,6].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Development of aeronautical demonstrator 3D printed component with integrated Structural health monitoring solution.

Description

Context of the master thesis:
Structural health monitoring (SHM) is an emerging technology for continuous monitoring of the structural integrity of the structural components. They can unleash the full potential of 3D printed (additive manufactured AM) components and in the long run improve our carbon footprint. The technological readiness (TRL) level of an in house developed SHM system can be further increased by proving its applicability also on a demonstrator level besides the current available coupon level results. The main objective for the Master thesis student would be to investigate and develop new designs with integrated SHM technology of typical mechanical system such as lug bolt configurations. The objective is to prove numerically and if time permits also experimentally the increase of the TRL level.

Tasks:

- Literature study of additive manufacturing and topological optimization.
- Manual redesign of the component exploiting the design freedom offered by AM with integrated SHM solution.
- Static hand calculations in conjunction with Finite Element Analysis of manually optimized design solutions.
- Static Finite Element Analysis of topology optimized design solutions.
- Crack growth analysis at one specific location on the component.
- Analysis of the performance of a structure with an without integrated SHM solution.
- Conclusion on the increase in TRL level.

If time permits the research can be extended with printing of the component and experimental testing. Further details regarding the concepts can be provided by the contact person on request.

See also external link

Langue	EN (english)

Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Thermo-mechanical simulation of ablation process on 3D printed metal parts.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, the powder particles, and the melt pool (high intensity spot) are visible. Fig. 2 shows a 3D part that has been manufactured on the MiCLAD machine.

Hybrid Additive Manufacturing is based on the combination of multiple processes improving the cost, quality, functionality, and efficiency of the

parts [3]. Possible examples of additive-subtractive combination are Hybrid-AM by Machining or hybrid-AM by Ablation [4]. The MiCLAD machine is equipped with a 5-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive milling operations for the production of a part. The lab is also equipped with an external ablation stage that will be soon integrated in the machine.

During the additive and subtractive operations, the thermal history of the part is very important for the final quality and directly influences the residual stresses. It is therefore very important to monitor the temperature of the part during the process and to set up efficient numerical tools in order to study the effect of process parameters on the thermal history of the part. The MeMC and MECH departments of the VUB are cooperating to study these effects in the context of the HiPAS SBO project [5].

The DED thermal history simulations are runned with Morfeo (Manufacturing Oriented Finite Element tOol), an eXtended Finite Element (X-FEM) code developed by the Belgian research center Cenaero [6] and compared with the in-situ thermal monitoring tools available on the MiCLAD (pyrometer data and hyperspectral melt pool temperature estimation).

The aim of this master thesis is to extend the existing simulation tool of the DED addition process by investigating numerically the effect of the ablation process (subtraction process) on the thermal history and residual stresses of a DED part, and to identify the main influencing parameters [7].

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Temperature estimation methods study for metal 3D-printing.

Description

Context of the master thesis:
Metal 3D-printing or Additive Manufacturing (AM) of metallic structures is an emerging technology for making solid 3D object from a digital file. The design, fabrication, distribution of products and the use of components made with AM techniques are low carbon consuming and highly efficient in their use of virgin material [1]. Airbus and other aerospace companies have denoted AM as a game changing technology for 21 century. An article by The Economist [2] details "The third industrial revolution". Additive manufacturing is highlighted as the production technology of the future, enabling mass customization instead of mass production. To obtain good quality manufactured parts in AM, temperature control of the printing process is required. Therefore, one of key challenges resides on the temperature estimation method. The objective of the master thesis is to get acquainted with different temperature estimation methods, identify the advantages and disadvantages of each method, and define what methods are suitable for monitoring the AM process.

Tasks:

- Literature review of different temperature estimation methods
- Understanding of hyperspectral cameras
- Development of temperature estimation algorithms
- Temperature estimation methods assessment

See also external link

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-M, M- IRPH
Nombre de sujets	2

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Development and test of an in-situ monitoring framework for wire-based Directed Energy Deposition

Description

This master thesis focuses on the implementation of a synchronized in-situ monitoring framework for the LW-DED system at VUB AMRL, the generation of a multi-modal dataset through a structured experimental campaign, and its preliminary analysis using unsupervised learning techniques. The objective is to establish a foundation for future intelligent monitoring and control strategies, ultimately improving process reliability and part quality.

Langue	FR (français)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Development of manufacturing strategies for functionally Graded Additively Manufactured Parts

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the production process, each region can be processed individually, with different processing conditions and material compositions, ultimately targeting varying material properties across the part. Generating an unprecedented level of design freedom for the parts of the future. In view of many mechanical applications that involve heat, the use of a copper-to-steel gradient is considered a viable solution to increase part performance. The examples below show two example cases in which functional graded materials are used/researched.

Computer Aided Manufacturing (CAM) tools generate, based on the CAD design, the necessary machine code to automate the manufacturing process (planned motion path & process parameters). While such software tools exist for homogeneous, single material prints, those tools are in need to be further developed to accommodate multi-material prints and incorporate the necessary transient conditions. The current thesis proposals targets the extension of CAM tools for such complex geometries for multi-materials 3D printing. The outcome of the thesis is ultimately a software-add on/Matlab program, that manipulates the CAM program to accommodate the multi-material aspect of the print.

The thesis will start with an exploration of existing CAM tools at their disposal (Siemens NX, Cura, etc.) and will explore the current capabilities and limitations. Based on this analysis, one CAM software package will be selected for further development. The thesis work will then comprise the development of such add-on tool to modify the original CAM code, starting with simplest geometries and gradually increasing the complexity of the modification. The work then comprises a dry-run of the generated code to evaluate the proper running thereof, before effective trials are executed on the 3D printing machine. Subsequent analysis of the process behavior should then confirm the modifications that were implemented.

As the thesis mostly comprises software development, we especially look for a student that has strong programming skills in combination with interests in advanced manufacturing processes (and 3D printing in specific).

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

A passive bi-directional overrunning clutch for compliant actuation

Description

The integration of clutches in actuators and drivetrains enables advanced dynamics suitable for a wide range of applications. This project will concentrate on passive, bi-directional, overrunning clutches. These clutches allow for the transmission of power from input to output in both clockwise and counterclockwise directions but freewheel when power flows from the output. The ability to switch between these two modes (driving and freewheeling) passively, without the need for additional actuators, is particularly advantageous. If well designed and characterized, this clutch has the potential to be useful for a wide range of robotic applications: for robot arms to avoid shock damage, for wearable robotics such as exoskeletons to allow freedom of motion to the user and enable the use of smaller actuators, etc.

In this thesis, the student will design and build a passive, bi-directional, overrunning clutch with a particular emphasis on understanding the switching behaviors. Then, its performance and impact on the drivetrain will be studied and tested (efficiency, switching behavior, torque capability, etc.). Lastly, the student will use the clutch for compliant actuation. The ability of the clutch to disconnect when backdriving will be used to protect an actuator from shocks; this ability will be tested by implementing the prototype in a drivetrain and studying a use case to be chosen by the student (exoskeleton, robotic arms, ...).

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Verstraten Tom (Tom.Verstraten@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Characterization of the liner/composite overwrap interface in type IV hydrogen storage vessels

Description

Context of the master thesis

Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation,Hydrogen is widely recognized as a promising clean energy carrier due to its high specific energy and zero direct emissions. However, its low volumetric energy density under ambient conditions necessitates the use of high-pressure storage vessels to achieve practical storage efficiency for applications such as fuel-cell electric vehicles and stationary energy systems. Among the available storage technologies, Type IV hydrogen storage tanks, consisting of a polymer liner fully wrapped with a carbon fibre-reinforced composite overwrap, have emerged as a leading solution for on-board gaseous hydrogen storage, owing to their lightweight construction and high pressure-bearing capability. In these vessels, the polymer liner primarily serves as a hydrogen permeation barrier, preventing gas leakage and isolating the stored hydrogen from the composite structure, while the composite overwrap bears the mechanical loads associated with high-pressure operation. Despite their advantages in weight reduction and performance, Type IV tanks present critical challenges at the interface between the polymer liner and the composite overwrap that directly affect safety and durability. During high-pressure filling, hydrogen can permeate into the polymer liner and subsequently accumulate at the liner–overwrap interface. Upon rapid depressurization, this trapped hydrogen may generate local pressure differentials, leading to binder cavitation, interfacial void growth, and, in severe cases, liner collapse [2]. Furthermore, repeated pressurization–depressurization cycles can induce fatigue damage and progressive interfacial degradation, increasing hydrogen permeation, reducing structural reliability, and ultimately shortening the service life of the storage vessel. This thesis will focus on the characterization of the liner–composite overwrap interface in a Type IV hydrogen storage vessel. Mechanical testing will include double cantilever beam and T-pull tests to quantify the interfacial adhesion between the polymer liner and the composite overwrap. The effects of temperature and hydrogen exposure on interfacial properties will also be investigated. In addition, fatigue testing will be conducted to evaluate the long-term durability of the storage vessel.

References
[1] U. Eberle, R. von Helmolt, GMHydroGen4 – A Fuel Cell Electric Vehicle based on the Chevrolet Equinox, Fuel Cells Data, Facts Fig. (2016) 75–86. https://doi.org/10.1002/9783527693924.ch08.
[2] Y.T. Li, W.J. Huang, Y.M. Zhang, M. Fan, Z.M. Xiao, W.G. Li, Investigation of liner collapse behaviors in Type IV hydrogen storage vessels at different temperatures, J. Energy Storage 129 (2025) 1–18. https://doi.org/10.1016/j.est.2025.117307.
[3] J. Pépin, E. Lainé, J.C. Grandidier, G. Benoit, D. Mellier, M. Weber, C. Langlois, Replication of liner collapse phenomenon observed in hyperbaric type IV hydrogen storage vessel by explosive decompression experiments, Int. J. Hydrogen

Objectives of the master thesis
This thesis will aim to develop a comprehensive understanding of the interfacial behaviour between the polymer liner and the composite overwrap in Type IV hydrogen storage tanks under service-relevant conditions, including hydrogen exposure, cryogenic temperatures, and cyclic mechanical loading. The insights obtained from this work are expected to support the design, material selection, and optimization of hydrogen storage systems with improved durability and safety performance.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Ultrasonic welding of thermoplastics and thermoplastic composites-Parametric study and optimization

Description

Context of the master thesis

Thermoplastic materials are widely used in many industries, either as plain materials or in composites where they are reinforced with fibers, leading to lightweight and resistant structures, which at the same time offer sustainable solutions. The reason for this is that thermoplastics are processed at high temperatures in order to obtain their final shape and since they can be melted, solidified and re-heated, they offer great recyclability potential. This property however offers much more industrial interest, since thermoplastics can also be welded, providing therefore alternatives compared to traditional mechanical fastening using e.g. bolts or rivets. One of the most promising welding methods is ultrasonic welding. Ultrasonic plastic welding (USW) is the joining or reforming of thermoplastics through the use of heat generated from high-frequency mechanical motion. It is accomplished by converting high-frequency electrical energy into high-frequency mechanical motion. That mechanical motion, along with applied force, creates frictional heat at the plastic components’ mating surfaces (joint area) so the plastic material melts and forms a molecular bond between the parts. Ultrasonic welding can offer a very fast and energy-efficient way for joining materials and in particular thermoplastics. Despite its potential and the fact that ultrasonic welding is being used in some industries for joining thermoplastics together, there is still a lot of open research related to the understanding of the impact of the different parameters involved in the process on the quality of the obtained joints. Moreover, automation of the welding process and optimization of the different parameters is of great importance, towards its further and more well-established industrialization. During this thesis subject, the student will initially have to perform a dedicated literature review on ultrasonic welding. Then, an experimental campaign will be performed, during which joints of thermoplastic parts will be manufactured by altering the parameters related to the ultrasonic welding process, e.g. applied load, weld time and hold time. The quality of the manufactured joints will be controlled through ultrasonic measurements after their production, in order to be directly correlated to the combination of welding parameters used. Moreover, mechanical testing will be performed and the damage of the joints will be evaluated through non-destructive methods, i.e. acoustic emission and digital image correlation. Based on the data collection through the ultrasonic welding process and the performed tests, in the final step of the thesis, the student will use machine learning/AI tools in order to use the obtained data in the most optimal way for the optimization of the method through closed-loop automation controls.

Objectives of the master thesis

1. Parametric study on ultrasonic welding of thermoplastics.
2. Damage evaluation of ultrasonic welds using non-destructive methods.
3. Optimisation of ultrasonic welding parameters combining experiments with machine learning.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Kalteremidou Kalliopi-Artemi (Kalliopi-Artemi.Kalteremidou@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Metallurgical, mechanical & corrosion characterization of ultrasonic assisted additively manufactured 316L

Description

Additive Manufacturing (AM) is a manufacturing process that individually processes every region of the part. Layer by layer, a metal part is built from a feedstock material (powder) that is molten together to form a three-dimensional object. During the Directed Energy Deposition process, each region can be processed individually, with different processing conditions and material compositions. On-demand tailoring of the microstructure results in locally varying and optimized material properties across the part, generating an unprecedented level of design freedom for the parts of the future.

The current thesis proposal targets the processing of single 316L alloy, yet Functionally Graded, constituting of a microstructural gradient by grain refinement through ultrasonic assisted additive manufacturing. Without such ultrasound assistance, grains tend to grow to elongated and larger grains during the solidification step, typically resulting in undesired, anisotropic material properties. The ultrasound excitation perturbs the melt pool during the solidification step, causing an interrupted grow of these elongated grains, and leading to a more refined and more isotropic material properties. The student will engage in the explorative research regarding the process-material property relationship through the addition of ultrasound excitation.

Practically, the student will be involved in the practical integration and machine control implementation of an ultrasonic stack to harmonically work alongside the additive manufacturing process. Coupons will then be produced under varying processing conditions, including primarily the amplitude of the ultrasonic excitation, after which metallurgical evaluation will reveal the obtained microstructure. The work will then continue to print larger coupons with gradient microstructures, which will then be metallurgically and mechanically characterized. The anisotropy of the mechanical properties will be compared to reference conditions without ultrasound excitation. Besides, a systematic microstructural characterization will be conducted by SEM to evaluate, not only the grain structure, but also the sub-granular micro-segregation cell structure and inclusion formation along the build direction; since these aspects have a very important impact on the properties of the material.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Hinderdael Michaël (michael.hinderdael@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Process parameter optimization for 3D printing of single alloy rocket nozzle through Directed Energy Deposition process.

Description

3D printing is a very popular additive process during which layers of material are superposed to create a 3D part. In the past decade it gained a lot of interest due to an important increase in accessibility.

Directed Energy Deposition (DED) [1] is a specific metal additive manufacturing (AM) or 3D printing technique which uses a focused laser source to melt metal powder which is simultaneously fed by a nozzle.

The Additive Manufacturing Research Lab (AM-lab) of the VUB developed an in-house hybrid DED machine, called the MiCLAD, which is extensively presented in [2]. It is equipped with a 3-axis CNC control and has the particularity to allow the combination of and fast change between DED additive deposition and subtractive drilling/milling operations for the production of a part. An in-situ monitored image of the process is shown in Fig. 1 on which the nozzle, and the melt pool (high intensity spot) are visible.

Rocket nozzles must be extremely resistant to withstand the intense thermal and mechanical loads experienced during launch, see Fig. 2-3. They are exposed to temperatures exceeding 3000 °C and high-pressure exhaust gases moving at supersonic speeds. In addition, they endure significant thermal gradients, vibrations, and mechanical stresses from the combustion chamber and external aerodynamic forces. As a result, nozzle materials and designs must ensure high thermal conductivity, oxidation resistance, mechanical strength, and structural integrity throughout the mission.

Producing the rocket nozzle using DED offers significant advantages. It allows for precise control over material deposition, enables the fabrication of complex geometries, function integration minimizes material waste, and supports rapid iteration.

The BE Rocket Team [3] is a Belgian inter university student initiative (VUB, KU Leuven, ULB, RMA, Liège, Mons, Bruges) aiming to design, build, test, and launch amateur solid fuel rockets to compete in the European Rocketry Challenge (EuRoC). The 21st of October

2024, Be-Rocket successfully launched their first rocket, Bossart-I, at the military base of Elsenborn in Belgium. Fig. 4-6 shows the rocket during boost phase, and the nozzle design that was used for the tests. However, the nozzle has been conventionally manufactured and not with additive manufacturing techniques.

In parallel at the AM-Lab of VUB, preliminary experiments have been performed for the production of miniature rocket nozzles. During the DED process, the thermal history of the part is critical to the final quality and directly influences residual stresses. Many interconnected physical phenomena occur, and the process is defined by several parameters such as laser power, scan speed, powder feed rate, scanning path, track overlap, and more. The results of the manufacturing of the miniature rocket nozzle are shown in Fig. 7-10. However, several processing challenges remain, including dripping due to the printing on inclined surfaces, lack of fusion, and other microstructural defects. These issues highlight the need for further process optimization to produce a high-quality rocket nozzle.

This master thesis will ai to manufacture a structurally sound rocket nozzle for the next Be-Rocket student rocket, the design of which is shown in Fig. 6. The work will involve conducting an extensive parametric study to enable the production of a high-quality miniature nozzle demonstrator, meeting criteria such as dimensional accuracy, appropriate microstructure, and minimal defects like pores or lack of fusion. Various manufacturing strategies available in our lab must considered be explored (for example remelting, controlled cooling to reduce cracking, regulation of melt pool temperature, etc.).

The results of these strategies will need to be compared to identify the most efficient manufacturing approach for manufacturing a real size nozzle. The best demonstrator will then be on the test bench for solid rocket motors at the rocket propulsion test facility of the ULB, as shown on Fig. 11-12.

Upon successful completion of the master thesis, the continuation in a PhD position is a possibility to be evaluated.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Jardon Zoé (zoe.jardon@vub.be)

Master’s program offering the topic: EM - Aeronautics - M-IREMR-A

Novel Indicators for Detecting Structural Changes During Vibration Testing of Satellites During Qualification Tests

Description

Satellites undergo high levels of vibrations during the different phases of launch to orbit, which can be the cause of partial or total loss of structural integrity, and potentially failure of the mission.

Qualification tests are designed to reproduce as well as possible the intensity of such vibrations in the laboratory, before the launch, to make sure that the satellites are resistant enough and avoid partial or total mission failure.

During qualification tests, the current practice is to use damage indicators based on frequency and amplitude shifts which are often misleading due to “settling” phenomena—components stabilize under vibration without actual damage, triggering false nonconformities.

Objectives of the master thesis
The main objective of the master thesis is to develop alternative damage indicators which are not sensitive to the settling phenomena, while being still sensitive to structural damage. This will require to

- Analyze vibration signatures across multiple test campaigns to characterize variability.
- Develop alternative indicators based on energy distribution over a broader bandwidth.
- Recommend criteria to distinguish real damage from normal settling behavior.

The master thesis is proposed in collaboration with Dr Cédric Dumoulin from Aerospacelab, a Belgian company designing and manufacturing satellites.

Langue	EN (english)

Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Deraemaeker Arnaud (arnaud.deraemaeker@ulb.be)

Master’s program offering the topic: EM - Energy - M-IREMR-E

Grid-Forming Droop Control with Seamless Islanding Transition for a Battery-Based Vehicle-To-Grid Unit

Description

The ability of a vehicle-to-grid (V2G) unit to transition seamlessly between grid-connected and islanded operation is critical for microgrid resilience. This thesis will design a droop-based grid-forming controller that detects islanding and autonomously reconfigures its control loops, validated experimentally using the battery-connected inverter as the grid-forming source and a machine as a local load.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

Master’s program offering the topic: EM - Energy - M-IREMR-E

Digital twin simulations of offshore wind turbines

Description

At the Vrije Universiteit Brussel (VUB) we are heavily involved in monitoring the structural health of offshore wind turbines (OWT) in the Belgian North Sea. We are currently monitoring wind turbines on all Belgian offshore wind farms for fatigue life, structural integrity and their overall dynamic behaviour. Digital twin are more and more used in the wind industry to predict remaining lifetime, predictive maintenance, and structural integrity. Commonly differentiated in data-driven digital twins, which represents the structure completely based measured inputs, and physics based digital twins, which are build based on existing physical relations. Through their rooting in known physical relations, physics-based digital twins often provide better transparency of their behaviour.

- Objective:

In this Master Thesis you will validate the physics-based digital twin of an offshore wind turbine in the Belgian North Sea with real-world data using the aeroelastic simulation software ASHES.

- Prerequisites/special skills (optional)

An interest in structural dynamics and programming is desired. A good knowledge of numerical methods such as the finite element method as well as prior experience with aeroelastic software such as OpenFast can be advantageous. This master thesis gives you the opportunity to learn about the modelling and dynamic behaviour of Offshore Wind Turbines as well as the work of OWI-lab in the structural health monitoring of wind turbines.

- Other information:

This topic is an umbrella topic in which direction can be given aligned with the student's interests and skillset. E.g. the focus can be put on the control of the turbine, the soil-structure interaction, the performance under anomaleous behaviour, the automatic integration between database and simulation, …

Your thesis work builds on past master thesis's and starts from their latest findings.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Three-phase Active Power Filter for Vehicle-To-Grid Applications

Description

Harmonic pollution injected into the grid by nonlinear loads is a well-known power quality issue, and V2G inverters can be leveraged to actively suppress these harmonics without relying on heavy and expensive passive filters. Building directly on experience already acquired with single-phase proportional-resonant (PR) controllers for active filtering, this thesis extends the concept to the three-phase case using the existing bench inverter and MicroLabBox II platform. The student will implement selective harmonic compensation using parallel resonant controllers tuned to the 5th, 7th, and 11th harmonics in a synchronous reference frame, and validate the results experimentally with a nonlinear load.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Finite-Control-Set Model-Predictive Control for a Vehicle-To-Grid Bidirectional Inverter

Description

Classical PI current controllers with PWM are the industry standard for grid-connected inverters, but finite-control-set model-predictive control (FCS-MPC) has emerged as an attractive alternative that eliminates the modulator and offers intuitive multi-objective tuning. This thesis will implement both control strategies in Simulink on the MicroLabBox II for the same two-level inverter and battery setup, and compare them experimentally in terms of current THD, dynamic response, and ease of tuning. The FCS-MPC implementation will use a single prediction step (horizon = 1) as a baseline, with extension to longer horizons left as an option for motivated students.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

Master’s program offering the topic: EM - Energy - M-IREMR-E

Real-Time State-of-Charge-Aware V ehicle-To-Grid Power Scheduling with Grid Frequency Support

Description

Effective vehicle-to-grid (V2G) participation requires the inverter controller to be aware of the battery's state of charge and to respond to grid frequency deviations in a coordinated way. This thesis will develop a supervisory layer combining a real-time SoC estimator (e.g. extended Kalman filter or adaptive observer) for the LiFePO4 pack with a primary frequency droop response, dynamically modulating injected/absorbed power according to SoC constraints. The MicroLabBox II will run both the SoC estimator and the power reference generator in real time, enabling full closed-loop V2G frequency support experiments.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Virtual-Synchronous-Machine Control of a Vehicle-To-Grid Bidirectional Inverter Using a LiFePO4 Battery Pack

Description

Grid-forming control via Virtual Synchronous Machine (VSM) emulation is one of the most active research areas in power electronics, as inverter-dominated grids increasingly lack the natural inertia of synchronous generators. This Master thesis will build upon previous work and implement a VSM algorithm on the MicroLabBox II to make the battery-side inverter behave like a synchronous generator, providing synthetic inertia and voltage support. The student will tune the virtual inertia and damping coefficients and validate the frequency response experimentally.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

Master’s program offering the topic: EM - Energy - M-IREMR-E

Experimental testing of a monitoring hardware for application in floating offshore wind turbines.

Description

At the Vrije Universiteit Brussel (VUB) we are heavily involved in monitoring the structural health of offshore wind turbines (OWT) in the Belgian North Sea. We are currently monitoring wind turbines on all Belgian offshore wind farms for fatigue life, structural integrity and their overall dynamic behavior. Floating Offshore Wind Turbines (FOWT) refer to offshore wind turbines mounted on floating platforms, allowing them to be deployed in deeper waters where fixed-bottom turbines are not feasible.

- Objectives of the master thesis;
This master's thesis focuses on building and testing a small-scale experimental setup to evaluate a monitoring hardware system (GNSS/IMU). The objective is to assess the hardware’s ability to provide accurate position for an instrumented device—such as a scaled FOWT. When combined with other sensor types, this data will help us better understand the motion characteristics of FOWTs and how they relate to mooring line tensions and overall system dynamics. This project is conducted in collaboration with 24SEA, a company specializing in monitoring solutions for offshore wind turbines.

- Prerequisites/special skills (optional)
An interest in structural dynamics, experimental work and programming is desired. The thesis also includes working with sensors and hardware, and doing experimental validation of the sensor setups. A thesis suitable for someone with a strong 'MacGyver'/'Maker' -spirit.

- Other information
This thesis might require you to travel occassionally to 24SEA, situated just outside Brussels.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH

Nombre de sujets	1

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Mechanical characterization of polymeric soft materials to be used as miniaturized actuators

Description

Context: Soft matter is used as an actuator in microrobotics. It can deform under an external stimu-lus (light, heat, or pH…) to generate a mechanical output (force and displacement). In the lab, we utilize the two-photon polymerization method (2PP) to shape 50µm soft actuators from a thermo-responsive polymer (pNIPAM = poly(N-isopropylacrylamide)). These active cubes demonstrate bending, contraction, twist, or shear deformation in a heated water bath [1]. Their mechanical performances must be characterized statically, to determine the elastic properties (Young modulus, Poisson coefficients) and/or dynamically, to determine the viscoelastic properties.
Objective: The aim of this thesis is to develop a setup to measure the force-displacement character-istics of such actuators. Inspired by Micro-Electro-Mechanical Systems (MEMS) force sen-sors [2] and/or atomic force microscopy (AFM) [3], this set-up will be fabricated in using glass microstructures (to be produced with the FemtoPrint machine) or with other materi-als deemed relevant by the candidate.
Methods: Literature review on characterizing the mechanical performance of soft material at microscale. Design the set-up considering the following criteria: 1) samples are character-ized in water to allow them to swell and shrink, 2) a heating system (conventional or laser) will be used to drive the actuators, and 3) the sensor must be in contact with small samples (50 to 200 µm). Eventually, the results obtained may be supplemented and compared with data obtained with an environmental AFM, at UMons, and/or a nanoindentation system [4], at EMPA (Thun, Switzerland).
Prerequisites: Mechanics (to determine the device shape and develop the different part of the set-up using CAD software), coding (to automatically control the setup), and materials (to un-derstand the material model obtained from experimental measurements).

Langue	EN (english)
Ouvert à d’autres masters	No
Masters concernés	M-IRCBS, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Lambert Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Unified Range-Multispectral-Inertial Odometry (R-VTIO) for Autonomous Drone Navigation

Description

Background:
Standard Visual-Inertial Odometry (VIO) pipelines fuse RGB imagery with IMU data but degrade in two distinct failure modes: visual degradation (fog, smoke, low light) and scale/altitude ambiguity in featureless terrain. Existing work has addressed these failure modes independently. Multispectral VIO (VTIO) introduces thermal-infrared (TIR) imagery as an alternative visual channel, while Range-Visual-Inertial Odometry (RVIO) incorporates LiDAR altimeter range constraints and coarse-to-fine map registration. No published system currently fuses all four modalities (RGB, Thermal, Range, IMU) in a single tightly-coupled estimation framework for UAV navigation. This thesis fills that gap by designing a unified factor-graph-based odometry system: Range-Visual-Thermal-Inertial Odometry (R-VTIO).

Research Questions:

- Does a unified R-VTIO framework outperform the individual VTIO and RVIO baselines in trajectory accuracy and robustness across degraded environments?
- What is the marginal contribution of each sensor modality (RGB, Thermal, Range) to overall odometry accuracy, as measured by an ablation study?

Objectives:

- Implement a unified factor graph (GTSAM or Ceres) that jointly optimises over RGB features, thermal features, IMU pre-integration, and altimeter range factors
- Run a full ablation study: RGB-only, RGB+IMU, RGB+Thermal+IMU (VTIO), RGB+Range+IMU (RVIO), and full R-VTIO
- Collect flight data in at least two degraded scenarios: night flight and high-altitude featureless terrain
- Benchmark against GNSS RTK ground truth and compare with VINS-Fusion and ROVIO baselines

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Global Pose Estimation with Multiple Sensors," arXiv preprint arXiv:1901.03642, 2019.
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[4] M. Bloesch, M. Burri, S. Omari, M. Hutter, and R. Siegwart, "Iterated Extended Kalman Filter Based Visual-Inertial Odometry Using Direct Photometric Feedback," IJRR, vol. 36, no. 10, pp. 1053–1072, 2017.
[5] N. Khedekar, M. Kulkarni, and K. Alexis, "MIMOSA: A Multi-Modal SLAM Framework for Resilient Autonomy against Sensor Degradation," in Proc. IEEE/RSJ IROS, pp. 7153–7159, 2022.
[6] J. Michalczyk, R. Jung, and S. Weiss, "Radar Visual Inertial Odometry and Radar Thermal Inertial Odometry: Robust Navigation even in Challenging Visual Conditions," in Proc. IEEE/RSJ IROS, 2021.
[7] M. Nissov, N. Khedekar, and K. Alexis, "Degradation Resilient LiDAR-Radar-Inertial Odometry," in Proc. IEEE ICRA, pp. 8587–8594, 2024.
[8] F. Dellaert and GTSAM Contributors, "borglab/gtsam," Georgia Tech Borg Lab, 2022. Available: https://github.com/borglab/gtsam

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : Munteanu Adrian (adrian.munteanu@vub.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Optimizing spatiotemporal pressure control of actuated cuffs for wearable robots

Description

Context
One of the most critical challenges for development of exoskeletons and exosuits is the design of physical attachments – mechanical braces, cuffs, and straps – that connect the robot to the human user. In addition to securing the device to the human body, the attachments transmit mechanical energy from the robot to the body. Higher pressure at the interface between the attachment and the body improves energy transmission but also results in worse human comfort and soft-tissue injury risk. Recent work from our group suggests that dynamically modulating interface pressure location and timing via pneumatically-actuated straps can overcome this tradeoff between energy transmission and comfort/safety. However, the optimal spatiotemporal distribution for different postures, tasks, and humans users is unknown.
Objective
The objective of the thesis is to optimize control of pressure in soft robotic straps to maximize energy transmission and human comfort/safety.
Methods
The student will develop an optimization procedure for controlling pressure of robotic straps on the human arm during common movement tasks. This involves implementing human-in-the-loop or other optimization methods for efficiently and accurately converging on an optimal set of control parameters for each user and use case. The student will perform experiments with human participants to measure energy transmission and human comfort/safety achieved by different pressure patterns. Energy transmission and tissue safety will be assessed via force and motion data and human comfort via self-reports.
The hardware and low-level controls for three pneumatically-actuated straps are currently usable for testing but can also be further modified to explore different spatiotemporal patterns. A six-dof commercial robot arm is available for measuring interaction force and relative motion, or the student can implement embedded sensors in the straps as an alternative measurement method.
Prerequisites
-Arduino programming for real-time mechatronic systems

-ROS for control of a commercial robotic arm

-Experience in or willingness to learn human-subject testing

-Matlab or other software for data analysis

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Verstraten Tom (Tom.Verstraten@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Comparative study of physics-enhanced graph neural network approaches for multiple degrees-of-freedom system response estimation

Description

- Context of the master thesis

Wind turbines are the biggest dynamic, mass-produced, man-made structures. Their structural response to environmental and operational variations is highly complex and non-linear. As such, both physical modelling and data-driven inference have difficulties in accurately estimating the response. The former require simplifications which, along with unknown quantities (e.g. blade geometry), undermine accuracy. The latter may achieve high performance, but are limited to their training space, and extrapolation isn’t trustworthy. This is also the case for virtual sensing, where limited instrumentation limits the ability to capture the full dynamics of the system, leading to uncertain predictions at unsensed locations, especially outside observed operational conditions.

In this context, physics-enhanced or hybrid modelling has come to the foreground. The philosophy behind it is straightforward: data-driven algorithms have problem-specific physical knowledge embedded into their architectures (loss function, differentiable equations, etc.) which improve generalization and performance. In this thesis, a comparative study of different approaches into embedding physical knowledge into a data-driven algorithm will be research by analyzing performance over multiple degrees-of-freedom systems (MDOF). These (MDOF), represent idealized reductions of real-world structures (e.g. wind turbines, bridges, etc.) and are extremely convenient, as they have low computational costs and their parametrization enables varied response simulation. The baseline algorithm will be a graph neural network.

- References

§ Haywood-Alexander, Marcus, et al. "Discussing the spectrum of physics-enhanced machine learning: a survey on structural mechanics applications." Data-Centric

Engineering 5 (2024): e30.
§ Cicirello, Alice. "Physics-Enhanced Machine Learning: a position paper for dynamical systems investigations." Journal of Physics: Conference Series. Vol. 2909. No. 1. IOP Publishing, 2024.
§ Mehrjoo, Azin, Eleonora M. Tronci, and Babak Moaveni. "A Physics-Informed Framework for Input Load Estimation in Offshore Wind Turbines." International Conference on Experimental Vibration Analysis for Civil Engineering Structures. Cham: Springer Nature Switzerland, 2025.

- Objectives

§ Review virtual sensing in offshore wind turbines.
§ Identify and review physics-enhanced/hybrid modelling approaches.
§ Generate MDOF systems with varying numbers of degrees and exciting load [both intensity and location] in a Python script.
§ Encode MDOF as a graph, including stiffness, damping and mass matrices.
§ Implement a Graph Neural Network (GNN) virtual senser baseline in Python.
§ Assess and compare the addition of physics knowledge into the baseline with relation to: performance over unseen numbers of nodes [extrapolation and interpolation] and unseen excitations [intensity and location].

- Prerequisites/special skills
· Basic python programming.
· Knowledge of fundamentals of structural mechanics (e.g. equations of motion, etc.).
· Attendance of Prof. Deraemaker's Dynamics of Structures or Mechanical Vibrations course (https://structuraldynamics.ulb.be/dynamics-of-structures-2025-2026/)

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH
Nombre de sujets	1

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Geometric and structural design of flexible joints for deployable scissor grids

Description

Note: if interested, come and discuss the topics with us, to refine the research question based on your skills and interests.

Context:

Deployable structures are fascinating structural mechanisms: they have the ability to transform themselves from a small, closed or stowed configuration to a much larger, open or deployed configuration. Mobile deployable structures have the great advantage of speed and ease of erection and dismantling compared to conventional building forms. They have a wide field of application, from space antennas to festival structures, to adaptable furniture and toys.

At VUB there is 20 years of expertise on these fascinating systems and recently a spin-off company called KONLIGO was created to design and build zero-waste event structures based on our scissor technology.

Because these deployable structures can be used and reused over and over again they are well-suited to support the transition to a zero-waste event industry, where currently the waste problem is huge. Because of the modular construction and high component uniformity, and easy repair and maintenance, they are well-suited for a 'circular business model'.

Topic:
Many new shapes have been developed by us in recent years. Digital models have been made, new shapes have been patented and small-scale models have been realised to test these concepts.
But every new shape has its specific detailing issues to be solved: e new joint that allows the required movement, a new material for the joint or the beams, a modular design that allows reconfiguration, adding stiffening cables or not, etc...

To be able to build our vast library of new and promising shapes for scissor structures, one possible strategy is to develop new joints that are flexible in one direction and stiff in the other. This requires 3D-printing/prototyping and some material engineering. This could potentially unlock very interesting new shapes for expanding the application potential of scissor grids.
Depending on the interest and the profile of the student(s) involved, different accents/directions can be identified, collaboration between students with a different profile is also accepted:
• Emphasis on the exploration of various configurations based on a range of design criteria and application contexts, through scale models and 2D-3D prototyping
• Parametric modelling of scissor geometry in Rhino/Grasshopper and 3D-models/rendered images
• Prototyping a scissor structure at full scale
The aim of this project is the successful experimental exploration and realisation of deployable scissor structures, based on realistic design criteria. Digital and physical design and fabrication tools can be explored and used for the successful realisation of these new shapes.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRARE, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Roels Ellen (ellen.roels@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

World Model for Drone Navigation

Description

Background:

Current VIO pipelines are reactive: they estimate pose from the most recent sensor observations. When those observations suddenly degrade, flying from sunlight into dense fog, or from textured terrain over a featureless lake, the pipeline experiences an abrupt loss of features, often causing tracking failure before any recovery mechanism can act. A predictive approach, inspired by recent advances in world models for robotics (JEPA, Dreamer-V3, diffusion-based latent dynamics), offers a fundamentally different strategy: learn a compressed latent representation of the drone’s multispectral environment and use it to anticipate future sensor states. If the world model predicts that visual features will vanish in 2 seconds (e.g., approaching fog), the navigation system can pre-emptively increase reliance on thermal or IMU channels, or adjust the flight trajectory to stay in feature-rich regions. A multispectral drone platform carrying RGB cameras, a thermal core, an IMU, and a range sensor provides a rich, multi-modal data source for training such a model. This thesis investigates whether a learned world model, trained on multispectral drone data, can improve the robustness of drone state estimation and enable predictive, anticipatory navigation rather than purely reactive recovery.

Research Questions

- Can a latent world model trained on multispectral drone data (RGB, thermal, IMU) predict upcoming visual degradation events before they occur and navigate to a given location?
- What latent representation architecture (JEPA-style, VAE, diffusion) best captures the joint dynamics of RGB and thermal imagery from a drone perspective?
- Can the world model generalise across environments not seen during training?

What the Student Does

- Curate and structure flight datasets into a training corpus with synchronised RGB, thermal, IMU, and range streams
- Implement a latent dynamics model (starting with JEPA or Dreamer-V3 architecture) that learns to predict future latent states from current multi-modal observations and drone actions

- Train the world model to navigate to a given location

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : munteanu adrian (adrian.munteanu@vub.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Multiphysics analysis of oil injection for screw compressors.

Description

This thesis is in collaboration with Atlas Copco Airpower and will be under NDA.
To improve efficiency of the compression phase in a screw compressor, oil is often injected in the compression chamber to cool the compressed air as well as seal the gaps between the different components to minimize leakages. The time-dependency of the heat-transfer between the injected oil droplets and the compressed air, makes the cooling aspect extremely challenging in fast-turning machines. Therefore the goal of this Master Thesis would be to investigate different oil-injection strategies in a Multiphysics-simulation tool in Matlab/Simulink/Simscape to determine design rules for optimal oil-injection parameters. A basic working model will be provided as a starting point of the thesis This model needs to be adapted and extended in function of the needs for the analysis. A specific injection strategy will also be proposed, but this will not be disclosed before the start of the thesis.
The different domains include:

- Mechanical time-of-flight calculation of oil droplets in a compression chamber with dynamic modelling using the equations of motion.
- Heat transfer modelling of an oil droplet in a compressed air environment, using a basic heat transfer model and simplified assumptions on the air flow.
- Basic thermodynamic effects on the compression (isentropic vs. isothermal)

Depending on the initial findings and parallel research, an experimental validation of the injection strategy can be performed with high-speed camera measurements of different injection nozzles. The latter is a topic for another thesis work, thus close collaboration might be relevant.

Before selecting this topic, please contact:
Bjorn Verrelst (Bjorn.verrelst@vub.be)
Jarl Beckers (jarl.beckers@vub.be)

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O

Nombre de sujets	1

Supervision

Supervisor : Verrelst Bjorn (bjorn.verrelst@vub.be)

3D printing of deployable scissor joints

Description

Note: if interested, come and discuss the topics with us, to refine the research question based on your skills and interests.

Context:

Deployable structures are fascinating structural mechanisms: they have the ability to transform themselves from a small, closed or stowed configuration to a much larger, open or deployed configuration. Mobile deployable structures have the great advantage of speed and ease of erection and dismantling compared to conventional building forms. They have a wide field of application, from space antennas to festival structures, to adaptable furniture and toys.

At VUB there is 20 years of expertise on these fascinating systems and recently a spin-off company called KONLIGO was created to design and build zero-waste event structures based on our scissor technology.

Because these deployable structures can be used and reused over and over again they are well-suited to support the transition to a zero-waste event industry, where currently the waste problem is huge. Because of the modular construction and high component uniformity, and easy repair and maintenance, they are well-suited for a 'circular business model'.

Topic:
The deployable bars of a scissor structure are connected by specifically designed joints, that allow the necessary movement. However, there is a specific class of structures that is left out because of the deployment is not possible, or difficult. Unless the joints are designed in such a way that they accommodate this special requirement movement. The projected outcome is an overview of the possibilities for innovative joints for deployable scissor structures that open up the possibilities for new shapes that have never been built before. Physical models (small and medium scale), digital parametric modelling, digital

fabrication and potential full-scale testing belong to the possibilities, depending on the chosen focus.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRARE, M-IRCNE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	2

Supervision

Supervisor : Roels Ellen (ellen.roels@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Instrumented glass gripper: Percipio Robotics’ Tulip gripper revisited (+ internship – to be confirmed by the company Percipio Robotics)

Description

Context: Percipio Robotics is a spin-off from the FEMTO-ST research institute, which has designed the Tulip gripper [1]. This compact, lightweight gripper, weighing less than 30g, is designed for micromanipulation and can grip objects from 50µm to 10mm. It solves the problems of large grippers and fragility frequently encountered in micro-robotics. Parallely, the TIPs department designs and manufactures compliant mechanisms in glass (FemtoPRINT technique), whose deformation is measured with optical/photonics techniques.
Objectives: This thesis aims to design and develop an instrumented version of the Percipio Robotics’ Tulip gripper. The master thesis can be preceded by a 3 months internship in the company (Besançon, France).
Methods: Literature review. Functional analysis and requirements. Design. Fabrication and characterization of the flexure mechanism.
Prerequisites: mechanical design, good command of French

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IRCNE, M-IRMAE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IRPH
Nombre de sujets	2

Supervision

Supervisor : LAMBERT Pierre (pierre.lambert@ulb.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Actuation and control of a clutchable-elastic lower-limb exoskeleton

Description

Context

Many people who have limited mobility (due to age or medical conditions) for example when trying to stand from a seated position, ascend stairs,.... This can heavily limit the quality of life for these people and even result in injuries from falling or other complications that can arise from poor posture and fatigue. These issues can be solved by providing assistance with wearable robotics such as exoskeletons. One of the main challenges with exoskeletons is to limit their weight to allow the user to still perform tasks. To reduce the weight of exoskeletons, we study the use of springs and clutches to capture and store energy during some parts of the motion and release it later when beneficial, thus removing the need for heavy motors and actuators and allowing assistance for motions such as sit-to-stand without external power. This system has already shown its ability to assist tasks such as sit-to-stand, reducing the effort made by the user; however, it requires manual control of the system by the user.

Goal of the thesis

In this thesis, you will improve a clutch and spring-based knee exoskeleton that is currently manually controlled. You will incorporate a semi-active actuation and control system allowing the clutch and spring to be connected and disconnected automatically with the right timing to provide assistance.

This project will be based on the existing exoskeleton but will require designing and building the system controlling the clutch, studying and modeling the system to build an efficient and versatile controller, and finally validating the exoskeleton with experimental results on multiple tasks.

Prerequisites:

It is recommended to have experience with the following aspect:

System identification

Controller design

Actuator design

CAD

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-A, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Verstraten Tom (Tom.Verstraten@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Safety-Aware Coordination for Collaborative Multi-Robot Systems using Explicit Reference Governors

Description

Collaborative robotic systems increasingly rely on multiple robots operating in shared workspaces to perform coordinated tasks such as object transfer, cooperative manipulation, and parallel assembly. While high-level planning methods can generate feasible schedules for multiple robots, ensuring safe execution during runtime remains a critical challenge, particularly when robots operate in close proximity.

This thesis investigates the design of a safety-aware coordination mechanism for multi-robot systems using Explicit Reference Governors (ERG). The ERG framework provides a predictive safety layer that adjusts the robot reference in real time to prevent constraint violations. In a multi-robot context, this mechanism can be extended to account for the motion of neighboring robots and maintain safe coordination during task execution.

The objective of this thesis is to develop and evaluate a coordination-aware ERG capable of enforcing safety constraints between multiple robots while preserving task performance. The work will build upon an existing multi-robot task and motion planning framework and focus on the execution-level safety and coordination problem.

The student will:

Study safety and coordination challenges in multi-robot systems
Implement predictive safety constraints between collaborating robots
Design a coordination-aware reference governor
Integrate the method into a multi-robot execution framework
Evaluate safety and performance in representative collaborative scenarios

The expected outcome is a robust safety mechanism for coordinated multi-robot systems that enables reliable execution of parallel tasks in shared environments.

Langue	EN (english)

Ouvert à d’autres masters	Yes
Masters concernés	M-IREMR-A, M-IREMR-E, M-IREMR-M
Nombre de sujets	1

Supervision

Supervisor : Vanderborght Bram (Bram.Vanderborght@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Unified Range-Multispectral-Inertial Odometry for Autonomous Drone Navigation

Description

Background

Standard Visual-Inertial Odometry (VIO) pipelines fuse RGB imagery with IMU data but degrade in two distinct failure modes: visual degradation (fog, smoke, low light) and scale/altitude ambiguity in featureless terrain. Existing work has addressed these failure modes independently: Multispectral VIO (VTIO) introduces thermal-infrared (TIR) imagery as an alternative visual channel, while Range-Visual-Inertial Odometry (RVIO) incorporates LiDAR altimeter range constraints and coarse-to-fine map registration. No published system currently fuses all four modalities (RGB, Thermal, Range, IMU) in a single tightly-coupled estimation framework for UAV navigation. This thesis fills that gap by designing a unified factor-graph-based odometry system. Range-Visual-Thermal-Inertial Odometry (R-VTIO). The Tarot 990 platform, equipped with two FLIR Blackfly cameras, a thermal core, a radar altimeter, and an IMU, provides the hardware foundation.

Research Questions

- Does a unified R-VTIO framework outperform the individual VTIO and RVIO baselines in trajectory accuracy and robustness across degraded environments?
- What is the marginal contribution of each sensor modality (RGB, Thermal, Range) to overall odometry accuracy, as measured by an ablation study?

What the Student Does

- Implement a unified factor graph (GTSAM or Ceres) that jointly optimises over RGB features, thermal features, IMU pre-integration, and altimeter range factors
- Run a full ablation study: RGB-only, RGB+IMU, RGB+Thermal+IMU (VTIO), RGB+Range+IMU (RVIO), and full R-VTIO — on identical flight logs

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : Munteanu Adrian (adrian.munteanu@vub.be)

Master’s program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Multi-robot localisation

Description

This thesis topic is a broad collection of subtasks that can be undertaken within multi-robot localisation research.
This includes topics such as:
- Multi-agent SLAM.
- UWB Anchored localisaiton
- Relative pose estimation
- Map sharing
- ODometry sensors: IMU, Camera, VIO, LiDAR, LIO.

And this on multiple different robots:
- AGVs
- Humanoids
- Drones.

In case you want to discuss possibilities in this research field please contact yuri.durodie@vub.be for more details.

Langue	EN (english)
Ouvert à d’autres masters	Yes
Masters concernés	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	5

Supervision

Supervisor : Vanderborght Bram (Bram.Vanderborght@vub.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Multispectral Visual Place Recognition for Long-Range Drone Loop Closure for Autonomous Drone Navigation

Description

Visual Place Recognition (VPR) is the ability to recognise a previously visited location from its visual appearance, enabling loop closure in SLAM systems and bounding long-term drift. State-of-the-art VPR methods (NetVLAD, AnyLoc, CosPlace) operate exclusively on RGB images and degrade significantly under appearance changes caused by lighting variation (day vs. dusk), weather (clear vs. fog), or seasonal shifts. From an aerial platform, these appearance changes are even more severe due to altitude-dependent viewpoint variation. Thermal-infrared imagery offers a complementary signal: thermal signatures of buildings, roads, vegetation, and water bodies remain far more stable across illumination and weather changes than their RGB appearance. This thesis develops a multispectral VPR system that learns joint descriptors from RGB and thermal images, producing place signatures that are robust to the appearance variations encountered during long-duration GNSS-denied drone flights. The resulting VPR module is integrated as a loop closure backend into a VTIO or R-VTIO pipeline, correcting accumulated drift on flights of 10 minutes or more.

- Does fusing thermal and RGB features into a joint VPR descriptor significantly improve place recognition recall under appearance changes (day/night, clear/fog) compared to RGB-only baselines?
- Which fusion strategy works best: early fusion (concatenated image input), mid-level fusion (shared backbone with modality-specific heads), or late fusion (separate descriptors combined at retrieval)?
- How much drift reduction does multispectral loop closure provide on flights exceeding 10 minutes, compared to DBoW2 and AnyLoc RGB-only loop closure?

What the Student Does

- Collect a multispectral place recognition dataset: fly repeated trajectories over the same area at different times of day, weather conditions, and altitudes, recording synchronised RGB and thermal imagery with GNSS RTK ground truth for place identity labels
- Implement and compare three fusion architectures: (a) early fusion — 4-channel

input (RGB+T) to a modified NetVLAD/AnyLoc backbone, (b) mid-level fusion — dual-encoder with cross-attention, (c) late fusion — separate RGB and thermal descriptors combined via learned weighting

- Train on the collected dataset and evaluate recall@1, recall@5 against RGB-only AnyLoc and NetVLAD baselines under matched and cross-condition (day-query/night-database) retrieval
- Integrate the best-performing model as a loop closure module in the VTIO or R-VTIO pipeline (replacing DBoW2 in VINS-Fusion or equivalent)

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M-IRELE, M-IREMR-M
Nombre de sujets	2

Supervision

Supervisor : Munteanu Adrian (adrian.munteanu@vub.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Biomechanics-based optimization of bike drivetrain

Description

Context

When cycling, the cyclist applies a force on the back wheel through the pedals, chainwheel, chain, and pinion. The force and speed of the wheel depend on the ratio between the size of the chainwheel and pinion, as well as on the force applied by the user. However, for a given force applied by the user, the torque transmitted to the chainwheel varies based on the position of the pedals. Indeed, the rotation of the pedals changes the lever arm between the foot and the center of rotation, as well as the angle of application of the force. This leads to an uneven effort during the motion and wasted effort.

Goal of the thesis

Previously, the issue of uneven torque transmission was studied, and it was proposed to use a non-circular chainwheel to even the torque transmission. This project aims to propose an alternative non-circular chainwheel that, instead of trying to even the torque, will optimize its shape to maximize power transmission by optimizing the shape of the chainwheel and pinion.

Based on biomechanics studies, such as an available Biodex dataset (measurement of the torque capability of each joint of the leg), it can be observed that strength is highly dependent on the leg joint angle and speed. This project aims to combine this knowledge of biomechanics and the use of a non-circular chainwheel to allow the user to apply their maximum force at all points in the pedaling motion.

In this thesis, the student will analyze the biomechanics of the leg when cycling based on an existing Biodex dataset and then will design a bike drivetrain with a non-circular chainwheel to optimize power output. Finally, a prototype will be built and tested to assess the ability to increase performance.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O
Nombre de sujets	1

Supervision

Supervisor : Tom Verstraten (Tom.Verstraten@vub.be)

Master's program offering the topic: EM - Sustainable transport and automotive M-IREMR-O

Electrical motors for EV traction, design and control --- internships and Master theses, at/in collaboration with Punch Powertrain (Sint-Truiden)

Description

Internship subjects (see also the document with Dropbox link):

1) In-house Multi-disciplinary emotor design toolchain maintenance
2) Torque ripple requirements definition in electric machine pre-design
3) Harmonics limits definition in electric machine pre-design
4) Emotor design towards short circuit protection

Master thesis subject (and more coming):

Title: DC and AC Harmonics reductions techniques in electric machine design
Promoter: Dr. Ilja Siera
Contact person: ilja.siera@punchpowertrain.com
Description:
A critical design challenge in electric machines for the automotive market is the presence of electromagnetic harmonics, which can lead to undesirable effects such as torque ripple, increased losses, noise, vibration, reduced efficiency or inverter over-currents. In the current multi-disciplinary design methods applied at Punch powertrain, the potential issues often lay hidden until the latter stages of the design process.
This thesis proposes to investigate and implement advanced methods to reduce harmonic distortion early during the optimisation process of electric machines. The goal is to develop a multi-objective optimisation framework that explicitly includes harmonic reduction as a design target.
The current optimisation approach for electric machines focusses on objectives such as torque density, efficiency, and thermal performance. While torque ripple is considered, Current harmonic mitigation is only considered as a constraint, and then treated in the post design. This research aims to integrate harmonic reduction directly into the optimisation loop, allowing for a more balanced and robust design process.
The goals are to:

(a) Review harmonic generation mechanisms in electric machines (with a focus on slot/pole combinations, winding distribution, and magnetic saturation).
(b) Evaluate methods for harmonic analysis, including Fast Fourier Transform (FFT), Space Vector analysis, and Total Harmonic Distortion (THD) metrics.
(c) Evaluating methods for detecting the presence or vulnerability of a design to harmonics (e.g. through flux map analysis).
(d) Implement harmonic minimisation techniques in the design optimisation loop
(e) Evaluate performance and the trade-offs in a design optimisation study.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI
Nombre de sujets	1

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)