Topics offered to students by other master's programs

TARGET PROGRAM

Biomedical Engineering

Sustainable iron metal production by direct electroreduction of iron ore

Program : Chemical & Materials engineering - M-IRMAE

Description

Steel production accounts for more than 8% of global emissions and sustainable steel production is key to achieve a decarbonized economy. The direct electroreduction of iron oxide to produce metallic iron (ULCOS project) is truly a fascinating field of research and offers a breakthrough alternative to the existing status quo of blast furnace based iron production. The reaction happens in alkaline media and the mechanism of electroreduction -ie, solid state direct reduction is yet to explored in detail. Furthermore, a lot of other sources such as bauxite residue can be directly used to produce metallic iron via this method. The student will work on firstly understanding the fundamental reaction mechanism of direct electroreduction of iron from iron oxide in alkaline media.

Promotor: Prakash Venkatesan (Prakash.venkatesan@ulb.be)

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

Supervision

Supervisor : Prakash Venkatesan (prakash.venkatesan@ulb.be)

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)

Accelerating autoregressive integrated moving average models using sparse matrix representations

Program : Electrical engineering - M-IRELE

Description

Context

Statistical time series models (such as autoregressive integrated moving average, ARIMA) are a staple forecasting method for time series. Even with the advent of more modern forecasting methods (e.g., long-short term memory (LSTM) neural networks and Facebook Prophet), they remain an interesting baseline that has the advantage of being interpretable. Modern ARIMA implementations rely on Kalman filters for fitting and forecasting purposes (notably because Kalman filters and state-space representations are well mastered mathematical tools and support missing observations). This is also the case for seasonal time series models (i.e., seasonal autoregressive integrated moving average, SARIMA) [Brockwell, 2002] [Durbin, 2012].
Interestingly, state-space models of high-order ARIMA models happen to be sparse (which means that the state transition and observation matrices mostly consist of zero coefficients); sparsity levels get even higher in the case of SARIMA models.
However, despite the sparse nature of most of the state-space matrices, it appears that many implementations (e.g., Python statsmodels) do not leverage it and instead rely on standard dense matrix representations for computations.

Objectives and steps

The goal of this master's thesis is to program a custom, high-performance fit-and-forecast program for ARIMA models, relying on sparse matrix representations to reduce computing load. Steps are i) a review of state-space models for ARIMA models and the associated fitting and forecasting methods, ii) implementing a fit-and-forecast program that leverages sparse matrix representations and iii) compare the performance of the developed program to that of Python's statsmodels (in terms of accuracy and computing time), using real and/or synthetic time series. Very motivated students can go further and i) extend the program to SARIMA models, or ii) implement the program in CUDA (for graphical processing unit (GPU) programming) or iii) rely on template meta-programming for implementing compile-time sparse matrices. The BEAMS-EE department possesses various computing platforms (notably a consumer-grade computing tower with a GPU and a rack server with dual Xeon Gold (64 cores in total) and two RTX A6000 GPUs), which are available to Master's thesis students.

Student profile

Ideally, the student has experience in C++ programming and is skilled in mathematics (mostly linear algebra, although basic probability theory and optimization theory are

important as well). Knowledge of BLAS, LAPACK and/or the Eigen library is a plus. Having followed the course “Microprocessor architectures” is also a (minor) plus.

References

[Brockwell, 2002] Brockwell, Peter J., and Richard A. Davis, eds. Introduction to time series and forecasting. New York, NY: Springer New York, 2002.
[Durbin, 2012] Durbin, James, and Siem Jan Koopman. Time series analysis by state space methods. Vol. 38. OUP Oxford, 2012.

Contact

Jean-François Determe, jean-francois.determe@ulb.be

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

Supervision

Supervisor : Jean-François Determe (jean-francois.determe@ulb.be)

Topics offered to students by other master's programs

TARGET PROGRAM

Biomedical Engineering

Master's program offering the topic: Chemical & Materials engineering - M-IRMAE

Development of activable NIR contrast agents for photoacoustic imaging.

Description

Photoacoustic Imaging (PAI), the fastest growing biomedical imaging modality in the last decade, has the potential to significantly impact the field of nanomedicine. It is non-ionizing, non-invasive and uses a nanosecond pulsed laser to generate pressure waves that can be detected by conventional ultrasound transducers. Because PAI uses a light-in-sound-out approach, it has the strengths of ultrasound, i.e. good tissue penetration, real-time monitoring, low cost and high spatial resolution, but also the high contrast, specificity and sensitivity of optical methods. Although endogenous contrast agents such as oxygenated or deoxygenated hemoglobin and melanin can be used, PAI still lacks exogenous contrast agents, which could increase sensitivity and allow targeting of specific cells (such as cancer cells). The EMNS laboratory is involved in the development of such functionalized nanomaterials based on gold nanorods, silver nanoplates and copper sulfide nanoparticles.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS
Nombre de sujets	2

Supervision

Supervisor : Bruylants Gilles (gilles.bruylants@ulb.be)

Master's program offering the topic: Chemical & Materials engineering - M-IRMAE

Designing sustainable covalent adaptable networks from cardanol

Description

The transition to a sustainable chemical industry demands bio-based alternatives to traditional petroleum-based resins. Conventional phenolic resins, widely used in for example adhesives, suffer from poor recyclability due to their permanently crosslinked structure, contributing to plastic waste accumulation. Covalent Adaptable Networks (CANs) present a promising solution by introducing reversible covalent crosslinks that can rearrange in response to an externally applied stimulus. These networks enable improved recyclability, processability, and self-repair, making them an ideal replacement for conventional resins.

The sustainability of such CANs can be further enhanced by investigating new bio-based building blocks such as cardanol, a low-cost agricultural byproduct obtained from cashew nut shell liquid (CNSL). Cardanol is a promising candidate as a starting material for the development of CANs.

This thesis work focuses on the use of functionalized CNSL in Diels-Alder polymer networks for adhesive applications. The synthesized CAN materials will be thoroughly characterized to evaluate their thermal, rheological, and mechanical properties. The most promising formulations will be further assessed for their performance in adhesive applications.

Objective:

The goal of this thesis is to develop innovative adhesive formulations based on cashew nut oil-derived building blocks. Material properties will be systematically characterized and optimized to meet the requirements of targeted adhesive applications.

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

Supervision

Supervisor : Van den Brande Niko (niko.van.den.brande@vub.be)

Master's program offering the topic: Chemical & Materials engineering - M-IRMAE

Investigating the applicability of green solvents in Liquid chromatography (LC)

Description

Liquid chromatography (LC) is a vital analytical technique widely used in various fields, including biotechnology, for separating, identifying, and quantifying components in complex mixtures. Its ability to handle a diverse range of samples—from small molecules to large biomolecules—makes it indispensable for quality control, drug development, and protein analysis. In biotechnology, LC plays a crucial role in monitoring the purity of biologics, identifying impurities, and ensuring product consistency, thereby supporting research and development and regulatory compliance.

The most commonly used LC separation technique, i.e. reversed phase LC (RPLC), uses water as the main component of the mobile phase, but requires an organic co-solvent to tune retention and selectivity. This reliance on organic solvents results in a substantial environmental impact, with an estimated annual global solvent consumption of approximately 150,000 metric tons for RPLC alone. The most frequently used co-solvent in RPLC is acetonitrile, which poses significant environmental and health concerns.
To reduce the environmental impact of HPLC, several strategies have been proposed, such as the use of narrow-bore or capillary columns and the replacement of conventional organic modifiers with greener alternatives. In recent years, ethanol was the primary choice of green co-solvent due to its low toxicity, biodegradability, and potential for production from renewable resources. However, its relatively high viscosity leads to reduced separation performance, increased back pressures, and consequently limits the achievable analysis speed.
Recently, dimethyl carbonate (DMC) has emerged as a potential alternative co-solvent due to its relatively low viscosity, green character, and high elution strength [2]. Nevertheless, its limited miscibility with water restricts its direct application in LC. A possible solution to this is the use of mixtures of DMC with organic solvents to improve water miscibility while enabling fast and greener separation methods. Therefore, this study investigates the possibilities and limitations of using DMC-mixtures as a greener co-solvent for LC by examining all relevant chromatographic parameters and their effects on separation performance. In addition, elution strength is evaluated to quantify the potential reduction in solvent consumption, to quantify the overall improvement in method greenness, and its possibility to obtain unique separation selectivities compared to the traditional co-solvents.

Contact: Prof. Ken Broeckhoven (ken.broeckhoven@vub.be) and Msc. Rebecca Gibkes (rebecca.gibkes@vub.be), CHIS department (Chemical Engineering VUB)

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

Supervision

Supervisor : Broeckhoven Ken (ken.broeckhoven@vub.be)

Master's program offering the topic: Chemical & Materials engineering - M-IRMAE

Delivery of anticancer peptides combined to mild-photothermal therapy for improved cancer treatment.

Description

Today, cancer is one of the leading causes of death. Current treatments involve mostly chimio- and radiotherapies but they lack specificity and cause damages to healthy tissues. Anticancer peptides (ACPs) are short polycationic peptide sequences, typically produced by microorganisms, that have anticancer properties via membrane disruption, pore formation or metabolisms disfunction. The efficiency of ACPs can be enhanced when combined to mild photothermal therapy (PTT) using plasmonic nanomaterials. Mild PTT (<45°C) is safer for healthy tissues than traditional PTT (>60°C). Combining ACPs delivery and mild PTT could thus be a promising strategy for specific and safe cancer treatments. Cancer cells overexpress various biomolecules such as enzymes. This dysfunction in their metabolism can be used for targeted therapy.

The goal of this project is to use plasmonic nanomaterials (gold nanorods and/or silver nanoplates) decorated with ACPs for cancer treatments. Gold nanorods and silver nanoplates have absorption in the near-infrared region (700 nm-950 nm) and can thus be used as thermal transducer in vivo. We have developed specific surface modifications of these nanomaterials that allow precise control over the conjugation with peptides. Also, we want to use ACPs that are enzyme-responsive to increase the specificity of the peptide release.

Functionalized gold nanorods and silver nanoplates will be synthesized and then conjugated to ACPs. Various ACPs will be investigated as well as the modification of the nanomaterials with targeting peptides to enhance their selectivity. For every combination of ACPs and targeting peptides, the materials will be characterized using a wide variety of techniques such as UV-Vis, IR, TEM, DLS, … The capacity to release the ACPs form the material surface in the presence of enzyme will be systematically investigated. Promising materials in term of thermal conversion, peptide delivery and colloidal stability will be used in the cytotoxicity study on colorectal cancer and glioblastoma cell lines.

Langue	EN (english)
Ouvert à d'autres masters	Yes

Masters concernés	M-IRCBS
Nombre de sujets	2

Supervision

Supervisor : Bruylants Gilles (gilles.bruylants@ulb.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: Chemical & Materials engineering - M-IRMAE

Nucleotide-peptide complex for the specific delivery of miRNA

Description

MicroRNA have emerged has promising candidates for targeted therapy. They can interact with the cell metabolism and restore (or inhibits) the normal (or abnormal) function at the cellular level. The main challenge to deliver miRNA is the specificity of the distribution and the protection of the nucleotide from degradation by endogenous enzymes. Various strategies have been investigated to carry the nucleotide to the cells such as noble metal nanoparticles or lipidic vesicles, but they have either a poor body clearance or a high toxicity, respectively. Developing new strategies are thus highly necessary.

We have recently developed self-assembled peptide-nucleotide complexes. By using specific peptide sequence, we could produce stable RNA-peptide assembly with interesting optical properties. We want now to demonstrate its potential for miRNA delivery associated to optical imaging modalities. We want to engineer the peptide sequences to ensure appropriate targeting of the RNA delivery, and two applications are currently under investigation: cancer and Alzheimer's disease.

Students will investigate the assembly between peptides and nucleotides with various methods such as UV-Vis, emission, DLS, TEM, ... Various sequences will be studied to understand the mechanism controlling the assembly. Particularly, isothermal calorimetry, that is an original technique for which the EMNS has a top-notch expertise, will be used to determine the affinity constants and the stoichiometry of the RNA-peptide assembly. When the optimal peptide sequence will be determined, studies on cells and animals will be carried out. The student will use an RNA carrying an infrared fluorophore for the tracking of the RNA delivery. The cell internalization will be investigated with confocal microscopy on cell cultures and the biodistribution will be studied by fluorescence imaging on murine model.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS
Nombre de sujets	2

Supervision

Supervisor : Bruylants Gilles (gilles.bruylants@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: 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

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

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

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

Speed adaptive control of an active lower-limb prosthesis

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.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS
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

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

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

Sensor selection for ankle braces

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

Langue	EN (english)
Ouvert à d'autres masters	Yes

Masters concernés	M-IRCBS
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

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

Touch-sensing method for wall reconstruction in Construction

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.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS
Nombre de sujets	2

Supervision

Supervisor : Garone Emanuele (emanuele.garone@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

Design of new didactic devices for teaching control engineering

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

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E
Nombre de sujets	2

Supervision

Supervisor : Garone Emanuele (emanuele.garone@ulb.be)

Master's program offering the topic: EM - Robotics & mechatronics constructions - M-IREMR-M

Virtual Assembly Validation of Complex CAD Systems with Haptic Feedback

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.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS
Nombre de sujets	2

Supervision

Supervisor : Verstraten Tom (Tom.Verstraten@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
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

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

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.

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Prerequisites

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- 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
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

Dynamic Dual-Arm Grabbing and Throwing of Objects

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.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCBS, M-IRIFS
Nombre de sujets	2

Supervision

Supervisor : Garone Emanuele (emanuele.garone@ulb.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
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

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)

Topics offered to students by other master's programs

TARGET PROGRAM

Biomedical Engineering

Sustainable iron metal production by direct electroreduction of iron ore

Program : Chemical & Materials engineering - M-IRMAE

Description

Steel production accounts for more than 8% of global emissions and sustainable steel production is key to achieve a decarbonized economy. The direct electroreduction of iron oxide to produce metallic iron (ULCOS project) is truly a fascinating field of research and offers a breakthrough alternative to the existing status quo of blast furnace based iron production. The reaction happens in alkaline media and the mechanism of electroreduction -ie, solid state direct reduction is yet to explored in detail. Furthermore, a lot of other sources such as bauxite residue can be directly used to produce metallic iron via this method. The student will work on firstly understanding the fundamental reaction mechanism of direct electroreduction of iron from iron oxide in alkaline media.

Promotor: Prakash Venkatesan (Prakash.venkatesan@ulb.be)

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

Supervision

Supervisor : Prakash Venkatesan (prakash.venkatesan@ulb.be)

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)

Accelerating autoregressive integrated moving average models using sparse matrix representations

Program : Electrical engineering - M-IRELE

Description

Context

Statistical time series models (such as autoregressive integrated moving average, ARIMA) are a staple forecasting method for time series. Even with the advent of more modern forecasting methods (e.g., long-short term memory (LSTM) neural networks and Facebook Prophet), they remain an interesting baseline that has the advantage of being interpretable. Modern ARIMA implementations rely on Kalman filters for fitting and forecasting purposes (notably because Kalman filters and state-space representations are well mastered mathematical tools and support missing observations). This is also the case for seasonal time series models (i.e., seasonal autoregressive integrated moving average, SARIMA) [Brockwell, 2002] [Durbin, 2012].
Interestingly, state-space models of high-order ARIMA models happen to be sparse (which means that the state transition and observation matrices mostly consist of zero coefficients); sparsity levels get even higher in the case of SARIMA models.
However, despite the sparse nature of most of the state-space matrices, it appears that many implementations (e.g., Python statsmodels) do not leverage it and instead rely on standard dense matrix representations for computations.

Objectives and steps

The goal of this master's thesis is to program a custom, high-performance fit-and-forecast program for ARIMA models, relying on sparse matrix representations to reduce computing load. Steps are i) a review of state-space models for ARIMA models and the associated fitting and forecasting methods, ii) implementing a fit-and-forecast program that leverages sparse matrix representations and iii) compare the performance of the developed program to that of Python's statsmodels (in terms of accuracy and computing time), using real and/or synthetic time series. Very motivated students can go further and i) extend the program to SARIMA models, or ii) implement the program in CUDA (for graphical processing unit (GPU) programming) or iii) rely on template meta-programming for implementing compile-time sparse matrices. The BEAMS-EE department possesses various computing platforms (notably a consumer-grade computing tower with a GPU and a rack server with dual Xeon Gold (64 cores in total) and two RTX A6000 GPUs), which are available to Master's thesis students.

Student profile

Ideally, the student has experience in C++ programming and is skilled in mathematics (mostly linear algebra, although basic probability theory and optimization theory are

important as well). Knowledge of BLAS, LAPACK and/or the Eigen library is a plus. Having followed the course “Microprocessor architectures” is also a (minor) plus.

References

[Brockwell, 2002] Brockwell, Peter J., and Richard A. Davis, eds. Introduction to time series and forecasting. New York, NY: Springer New York, 2002.
[Durbin, 2012] Durbin, James, and Siem Jan Koopman. Time series analysis by state space methods. Vol. 38. OUP Oxford, 2012.

Contact

Jean-François Determe, jean-francois.determe@ulb.be

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

Supervision

Supervisor : Jean-François Determe (jean-francois.determe@ulb.be)

Biomedical Engineering
Master Thesis Topics

Academic year 2026–2027

Analysis of large-scale calcium ima Analysis of large-scale calcium imaging recordings of neuronal activity in the dorsal striatum in relation with naturalistic and acquired behaviors.ging recordings of neuronal activity in the dorsal striatum in relation with naturalistic and acquired behaviors.

Programme : Biomedical engineering - M-IRCBS

Description

Context

The basal ganglia play a key role in the control of both goal-directed behaviors and natural, self-paced behaviors. The proper initiation and execution of these behaviors rely heavily on appropriate functioning within the basal ganglia. Indeed, basal ganglia dysfunction is at the core of various disorders, including Parkinson's disease, autism spectrum disorders, and schizophrenia (Gunaydin and Kreitzer, Annu. Rev. Physiol., 2016). The striatum, which is the main entry nucleus of the basal ganglia, consists of two types of striatal projection neurons (SPNs) that differ based on their expression of either dopamine D1 or D2 receptors and their respective direct or indirect projections to the output nuclei of the basal ganglia (dSPNs or iSPNs). Previous evidence has led to divergent conclusions on the respective engagement of both pathways during the execution of spontaneous actions as well as during the acquisition of new goal-directed instrumental behaviors.
Our team recently proposed an updated model for motor encoding among SPNs in the dorsal striatum that relies on the congruent activation of dSPNs, which encode multiple accessible behaviors in a given context to promote these behaviors, and iSPNs, which encode for and inhibit competing behaviors (Varin et al., Nat. Comm., 2023). As a result, the coactivation of specific subsets of behavior-promoting dSPNs and behavior-suppressing iSPNs alongside specific inhibition of subsets of iSPNs allowing behavior expression would result in the selection and execution of only one motor program.

Project

This work aims at validating and expanding our understanding of the organization of neuronal activity among dSPNs and iSPNs during naturalistic and learned goal-directed operant behaviors using in vivo microendoscopic recordings of neuronal activity recorded through calcium indicators expressed specifically in dSPNs and iSPNs. The project will rely on the analysis of already acquired datasets obtained in mice learning an operant goal-directed task or submitted to a set of behavioral experiments (e.g. self-paced exploration of open fields of different shapes, sizes, proximal cues, elevated plus maze, light-dark room). The goal of the project will be to decipher and compare the encoding of actions between dSPNs and iSPNs and how their respective encoding properties for a given action or a given behavior evolve during learning and when external contingencies are modified.

Langue	**EN (english)**
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

Promoteur : Schiffmann Serge (serge.schiffmann@ulb.be)

Co-Promoteur : Varin Christophe (christophe.varin@ulb.be)

Improved adenoid hypertrophy treatment through nasal replicas

Programme : Biomedical engineering - M-IRCBS

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. 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, 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- IRPH
Nombre de sujets	1

Encadrement

Promoteur : Benoit Haut

Co-Promoteur : Rigaut Clément

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Bistable structures for bronchoscopy

Programme : Biomedical engineering - M-IRCBS

Description

Context: Bistable structures enable multi-equilibrium states without the energy consumption except 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

Encadrement

Promoteur : Pierre Lambert

Co-Promoteur : Berke Péter

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

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

Promoteur : Olivier Debeir

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

Promoteur : Antoine Nonclercq

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Lien : https://www.dropbox.com/scl/fi/fhvdoouhpejo5njxjv5qh/Master-Thesis-Subject-Biomechatronics-Development-of-a-dedicated-affordable-ultrasound-system-for-Automated-Detection-of-Inflammatory-Activity-in-Inflammatory-Bowel-Disease.pdf?rlkey=h93rizecz2mhy8i6rcpjujeeb&dl=0

Implementation of an electrode to stimulate Vagus Nerve

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Lien : https://www.dropbox.com/scl/fi/q56kgaj1xtl2juwdzs9tx/Master-Thesis-Subject-Biomechatronics-Implementation-of-an-electrode-to-stimulate-Vagus-Nerve.pdf?rlkey=053jumhyrq8n9wn33odegcavg&dl=0

Redox-Active Hydrogel Scaffolds for Nanoparticle Encapsulation and Controlled Manganese Release in Postoperative Anticancer Applications

Programme : Biomedical engineering - M-IRCBS

Description

Hydrogel-based biomaterials are increasingly explored as localized platforms for improving postoperative cancer treatment by enabling the encapsulation and sustained release of therapeutic nanomaterials. In this context, manganese dioxide (MnO_2) nanoparticles offer redox-responsive properties and the ability to release manganese ions, which can induce oxidative stress and contribute to cancer cell cytotoxicity. This thesis proposes the development of MnO_2 nanoparticle–embedded photocrosslinkable hydrogels as systems for nanoparticle encapsulation and controlled, sustained manganese release for in vitro anticancer evaluation. Two hydrogel matrices, Gelatin Methacryloyl (GelMA) and Carboxymethyl Cellulose Methacrylate (CMCMA), will be investigated in a comparative study. GelMA provides a biomimetic and biocompatible environment, while CMCMA offers enhanced mechanical stability and potential printability. The study will focus on the fabrication and mechanical characterization of MnO_2-loaded hydrogels, evaluating key properties including rheological behavior, compressive strength, swelling ratio, degradation rate, gel fraction, and porosity. These parameters will be correlated with the hydrogel's ability to encapsulate nanoparticles and regulate their sustained release.

The cumulative release of manganese species will be monitored using UV–Vis spectrophotometry and colorimetric manganese detection assays, enabling analysis of MnO_2 degradation and Mn^{2+} ion release kinetics. The biological effects of released manganese species will be assessed using in vitro cancer cell models, with cell viability evaluated via the CellTiter-Glo® 3D assay (Promega) and Live/Dead staining to visualize cell survival and membrane integrity.

By correlating hydrogel structure, nanoparticle encapsulation, release behavior, and cellular response, this work aims to establish MnO_2-loaded hydrogels as effective platforms for localized and controlled nanomaterial delivery in postoperative anticancer applications.

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

Encadrement

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Lien : https://universitelibrebruxelles-my.sharepoint.com/:b:/r/personal/rezvan_majidi_ulb_be/Documents/Master%20thesis%20abstract%202026.pdf?csf=1&web=1&e=jyk0Yj

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

Promoteur : Antoine Nonclercq

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Lien : https://www.dropbox.com/scl/fi/wiry4smsvvtdc4mrxpx5l/Master-Thesis-Subject-Biomechatronics-Simulation-of-a-biocompatible-and-implantable-optical-fiber-based-flexure-sensor.pdf?rlkey=9524wuax4vitehvr7w5ega1j0&dl=0

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

Programme : Biomedical engineering - M-IRCBS

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. 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 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- IRPH
Nombre de sujets	1

Encadrement

Promoteur : Benoit Haut

Co-Promoteur : Rigaut Clément

Contact : Clement.Rigaut@ulb.be

Dynamically Tunable Hydrogels for Vascular Stiffness Modulation

Programme : Biomedical engineering - M-IRCBS

Description

Hydrogel-based matrices are widely used to model the physical microenvironment of cells in engineered tissues. However, most current systems rely on static materials with fixed mechanical properties, limiting the ability to study how cells respond to mechanical changes over time. In native tissues, extracellular matrix properties such as stiffness evolve dynamically, influencing cell behavior, barrier function, and mechanotransduction.
In this project, you will develop phenol-modified hydrogels with controllable crosslinking and stiffness. Phenol-functionalized polymers enable enzymatic crosslinking reactions that allow the degree of crosslinking, and therefore the mechanical properties of the hydrogel, to be adjusted over time. By tuning crosslinking conditions, the material can undergo controlled stiffening after gel formation, creating a dynamic matrix whose mechanical properties can be programmed during experiments.
Some tasks will involve:
• Tune enzymatic crosslinking conditions to control gelation and stiffness.
• Characterize hydrogel mechanical properties using rheology or mechanical testing.
• Develop protocols for inducing controlled stiffness changes over time.
• Test compatibility of the hydrogels with endothelial cell culture and perfused channel systems.
The resulting platform will enable dynamic control of the mechanical microenvironment, which can be used to study how vascular cells respond to changes in matrix stiffness. Such systems may also serve as in vitro models to investigate processes associated with arterial stiffening, which are difficult to capture using conventional static materials.

See - R. Schnellmann et al.,Stiffening Matrix Induces Age-Mediated Microvascular Phenotype Through Increased Cell Contractility and Destabilization of Adherens Junctions, Advanced Science, 2026
J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

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

Encadrement

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Estimating physical workload during manual tasks using wearable sensing

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

Promoteur : Ilias El Makrini

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Co-Promoteur : Benoît Haut

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

Prediction of pathological complete response after neo-adjuvant treatment in triple negative breast cancer using multimodal and longitudinal data

Programme : Biomedical engineering - M-IRCBS

Description

Background
Triple-negative breast cancer (TNBC) is an aggressive and heterogeneous subtype of breast cancer that primarily affects young women and lacks targeted therapeutic options. Therefore, chemotherapy—and more recently chemo-immunotherapy—constitutes the standard treatment. The pivotal KEYNOTE-522 (KN522) study established the addition of the immune checkpoint inhibitor (ICI) pembrolizumab to neoadjuvant chemotherapy (NACT) as a new standard for high-risk early-stage TNBC, significantly improving pathological complete response (pCR), event-free survival, and overall survival. However, adding an ICI to NACT also leads to increased toxicity and cost, and not all patients derive the same benefit.
To date, no biomarker analysis has identified a subgroup of patients that clearly derives different levels of benefit from adding an immune checkpoint inhibitor. As a result, pembrolizumab combined with neoadjuvant chemotherapy remains the standard of care for high-risk early-stage (stage II–III) TNBC. Identifying patients who could safely avoid immunotherapy is an important ongoing research goal.
Primary objective: to develop a multimodal predictive tool (integrating longitudinal radiological, pathological, and clinical data and deep learning) capable of predicting pathological complete response (pCR) in patients with stage II/III triple-negative breast cancer treated with neoadjuvant chemotherapy combined with an immune checkpoint inhibitor (ICI) according to the KN-522 regimen.

Contact
Prof. Ir. Jennifer Dhont (jennifer.dhont@ulb.be), Head of Data Science & AI Research Unit at Hopital Universitaire de Bruxelles (Erasme campus)

Note: this master thesis topic requires occasional presence on the Erasme campus (Institut Jules Bordet)

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

Encadrement

Promoteur : Jennifer Dhont

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Lien : https://www.dropbox.com/scl/fi/rpje9mmwg2eff94z4y769/Master-Thesis-Subject-Biomechatronics-An-AI-based-automated-analysis-of-electroencephalographic-EEG-recording-to-aid-in-the-diagnosis-of-epilepsy.pdf?rlkey=7fn95xtoh63iwvp0ctqvu6r3e&dl=0

DEVELOPMENT OF AN AUTOMATIC RESULT GENERATOR FOR EXPERIMENTAL TESTING

Programme : Biomedical engineering - M-IRCBS

Description

DEVELOPMENT OF AN AUTOMATIC RESULT GENERATOR FOR EXPERIMENTAL TESTING

1 Supervising staff

Promoter : Prof. Bernardo Innocenti, PhD ; bernardo.innocenti@ulb.be
Supervisor : Mattia Sisella, PhD Candidate; mattia.sisella@ulb.be

2 Context

Managing the experimental results of a testing session is complex, particularly when this process must be automated during or immediately after the test. The challenge lies in providing a preview of the ongoing experiments, enabling timely evaluation and, if necessary, adjustment of the experimental targets.

3 Work

The objective of this project is to enhance an existing program for the visualization of biomechanical test results. Specifically, the goal is to develop a platform capable of efficiently managing data presentation and automatically generating a comprehensive preliminary report of the entire test.

4. References

1) Sisella M, Maggi L, Allotta B, Innocenti B, Description and Validation of a Portable System for Biomechanical Ex-Vivo Knee Kinematics and Laxity Assessment in Simulated Intra-Operative Scenarios, J Exp Orth. (under review 2026)

Langue	**EN (english)**
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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Finite Element Analysis of Over-the-Top ACL Reconstruction

Programme : Biomedical engineering - M-IRCBS

Description

Supervising Staff

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Context of the project

Anterior cruciate ligament reconstruction (ACLR) is a widely performed surgical procedure for the treatment of anterior cruciate ligament injuries, and the choice of femoral and tibial fixation sites is a key factor influencing postoperative knee stability[1,2].

Over-the-top (OTT) ACLR, as a non-anatomic reconstruction technique that avoids femoral tunnel drilling, has important clinical value in physeal-sparing procedures for skeletally immature patients and in complex revision cases[3].

However, although the clinical outcomes of OTT ACLR are generally comparable to those of conventional anatomic ACLR[4], previous cadaveric biomechanical studies have shown that it does not fully restore normal knee biomechanics[5,6]. At higher flexion angles, reduced graft force may lead to graft slackening and decreased anterior stability, and in some cases graft slippage around the posterior femoral condyle may occur[7].

Finite element analysis enables reproducible comparison of different reconstruction configurations while simultaneously evaluating anterior stability, rotational behavior, graft stress distribution, and tibiofemoral contact stress[8,9].

The aim of this study is to develop finite element models of the intact, ACL-deficient, and reconstructed knee in order to evaluate the effects of different femoral fixation strategies and tibial attachment positions on the biomechanical behavior of over-the-top anterior cruciate ligament reconstruction. This study will compare different OTT ACLR configurations at various flexion angles in terms of anterior stability, rotational behavior, graft stress, and tibiofemoral contact stress, and will seek to identify the configuration that best restores knee stability while avoiding excessive graft loading and abnormal joint contact stress.

Thesis Work Description

- Literature review of the current methodology and biomechanical knowledge related to OTT ACLR, ACLR knee kinematics, and finite element analysis of the knee joint;
- Build a finite element model of the knee joint;
- Development of different OTT ACLR reconstruction configurations based on the knee model;
- Definition of the testing protocol and of the main parameters under investigation;
- Post-processing and comparative analysis of the biomechanical outcomes;
- Writing the Report.

Reference

[1] Fox MA, Engler ID, Zsidai BT, Hughes JD, Musahl V. Anatomic anterior cruciate ligament reconstruction: Freddie Fu's paradigm. J ISAKOS. 2023;8(1):15-22.

[2] Dimitriou D, Wang Z, Zou D, Tsai TY, Helmy N. The Femoral Footprint Position of the Anterior Cruciate Ligament Might Be a Predisposing Factor to a Noncontact Anterior Cruciate Ligament Rupture. Am J Sports Med. 2019;47(14):3365-3372.

[3]Du H, Li L, Qin Z, Guo J, Zhang X. Over-The-Top Technique for ACL Reconstruction:

Advantages, Disadvantages, and Postoperative Complications. Orthop Surg. 2025;17(2):333-347.
[4] Sarraj M, de Sa D, Shanmugaraj A, Musahl V, Lesniak BP. Over-the-top ACL reconstruction yields comparable outcomes to traditional ACL reconstruction in primary and revision settings: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2019;27(2):427-444.
[5] Lertwanich P, Kato Y, Martins CA, et al. A biomechanical comparison of 2 femoral fixation techniques for anterior cruciate ligament reconstruction in skeletally immature patients: over-the-top fixation versus transphyseal technique. Arthroscopy. 2011;27(5):672-680.
[6] McCarthy MM, Tucker S, Nguyen JT, Green DW, Imhauser CW, Cordasco FA. Contact stress and kinematic analysis of all-epiphyseal and over-the-top pediatric reconstruction techniques for the anterior cruciate ligament. Am J Sports Med. 2013;41(6):1330-1339.
[7] Shiwaku K, Suzuki T, Shino K, et al. A Biomechanical Comparison of 2 Over-the-Top Anterior Cruciate Ligament Reconstruction Techniques: A Cadaveric Study Using a Robotic Simulator. Orthop J Sports Med. 2022;10(12):23259671221139876. Published 2022 Dec 14.
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[9] Tampere T, Devriendt W, Cromheecke M, Luyckx T, Verstraete M, Victor J. Tunnel placement in ACL reconstruction surgery: smaller inter-tunnel angles and higher peak forces at the femoral tunnel using anteromedial portal femoral drilling-a 3D and finite element analysis. Knee Surg Sports Traumatol Arthrosc. 2019;27(8):2568-2576.

Langue	**EN (english)**
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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Acoustic cough analysis

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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BIOMECHANICAL ANALYSIS OF CEMENT-SCREW REPAIR OF TIBIAL DEFECTS IN TOTAL KNEE ARTHROPLASTY

Programme : Biomedical engineering - M-IRCBS

Description

BIOMECHANICAL ANALYSIS OF CEMENT-SCREW REPAIR OF TIBIAL DEFECTS IN TOTAL KNEE ARTHROPLASTY

1 Supervising staff

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Mattia Sisella, PhD Candidate; mattia.sisella@ulb.be

2 Context

The knee joint plays a vital role in daily activities and physical exercise, such as standing, walking, and ascending or descending stairs, and is one of the key joints responsible for lower-limb weight-bearing, mobility, and stability. Because the knee is subjected to substantial mechanical loading over a prolonged period, knee osteoarthritis has become a common joint disorder. For patients with severe pain or deformity, total knee arthroplasty (TKA) is often required as an effective treatment.

Tibial plateau bone defects are a common condition encountered during TKA. Depending on the size and depth of the defect, surgeons typically choose among several reconstructive options, including bone cement filling, bone cement combined with screws, metal augments, and metaphyseal cones, with the aim of improving prosthetic stability, prolonging implant survival, and reducing the likelihood of future revision surgery.

For small bone defects , most surgeons prefer to use bone cement alone for filling. In contrast, larger bone defects often require reconstruction with metal augments or metaphyseal cones, and in some cases, more constrained prostheses or stem extensions are also needed to enhance stability. However, for medium bone defect, there is currently no unified clinical consensus. Most surgeons tend to adopt a cement-and-screw construct for reconstruction. Nevertheless, the number of screws used and their insertion angles are often determined according to individual surgical experience, and no standardized guideline has yet been established.

To investigate whether the biomechanical performance of cement-and-screw reconstruction for tibial defects differs between osteoporotic patients and patients with normal bone quality, and to determine whether increasing the number of screws could improve stability in osteoporotic patients, this study plans to employ finite element analysis (FEA). Specifically, tibial bone defects in these two patient populations will be simulated, and the stress distribution in different region of interests will be evaluated. The findings are expected to provide biomechanical evidence to support the selection of reconstruction strategies in clinical practice.

3 Work

- Review the literature on tibial bone defect reconstruction in TKA, with a focus on the cement-screw technique.
- Develop a finite element model in Abaqus using laboratory-provided data.
- Define the material properties, boundary conditions, and loading conditions for normal and osteoporotic bone.
- Simulate different screw numbers and configurations for medium tibial bone defects.
- Compare biomechanical performance in different regions of interest.
- Prepare the final report

4. References

1) Liu D, Lu Q, Li X, Du L, Sun H, Liu P. Biomechanical Analysis of Cement-Screw Technique for Tibial Bone Defects in Total Knee Arthroplasty. J Arthroplasty. Published online August 12, 2025.
2) Zheng C, Ma HY, Du YQ, et al. Finite Element Assessment of the Screw and Cement Technique in Total Knee Arthroplasty. Biomed Res Int. 2020;2020:3718705. Published 2020 Oct 15.
3) Liu Y, Zhang A, Wang C, et al. Biomechanical comparison between metal block and cement-screw techniques for the treatment of tibial bone defects in total knee arthroplasty based on finite element analysis. Comput Biol Med. 2020;125:104006.
4) Nourishirazi R, Firoozabadi MA, Hassanzadeh M, Toofan H, Karimpour M, Mortazavi SMJ. Biomechanical study of effect of tibial posteromedial defect depth and area on primary TKA implant stability. Knee. 2024;49:249-256.
5) Zhao G, Yao S, Ma J, Wang J. The optimal angle of screw for using cement-screw technique to repair tibial defect in total knee arthroplasty: a finite element analysis. J Orthop Surg Res. 2022;17(1):363. Published 2022 Jul 26.

Langue	EN (english)
Ouvert à d'autres masters	no
Masters concernés	
Nombre de sujets	1

Encadrement

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Light-Responsive Sacrificial Hydrogels for 3D Bioprinting Applications

Programme : Biomedical engineering - M-IRCBS

Description

Three-dimensional (3D) bioprinting enables the fabrication of complex biological structures with spatial control over materials and cells. However, creating perfusable channel networks within these constructs remains a major challenge. Sacrificial hydrogels offer a promising solution by acting as temporary templates that can be removed after printing to form hollow structures.

This project focuses on the development of light-responsive sacrificial hydrogels that can be processed under mild conditions and selectively dissolved upon external stimulation. The material system can be tuned to function either as a support bath for embedded printing or as a printable sacrificial filament, enabling flexible fabrication strategies. The student will investigate how formulation and processing affect mechanical properties, printability, and removal behavior, and will demonstrate the fabrication of simple perfusable structures.

The objective of this project is to design and evaluate a tunable hydrogel system for use as a sacrificial material in 3D bioprinting. This includes understanding how material composition influences gel formation, mechanical behavior, and responsiveness to light-based triggering, as well as demonstrating its applicability in creating defined structures and channels.

Tasks

- Chemical preparation and modification of polymer-based hydrogels
- Formulation optimization to tune mechanical properties (soft vs. structured gels)
- Rheological characterization (viscosity, gel strength, recovery behavior)
- Development of support bath systems for embedded 3D printing
- Extrusion-based 3D printing experiments (filaments, simple structures)
- Evaluation of light-triggered material removal
- Fabrication of hollow channels and perfusion testing
- Basic biocompatibility assessment (cell viability assays) Methods & Techniques
- Hydrogel synthesis and preparation
- Rheometry and mechanical testing
- 3D bioprinting (extrusion-based)
- Optical/light-based triggering experiments
- Microscopy and image analysis
- Cell culture and viability assays

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

Encadrement

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Lien : https://universitelibrebruxelles-my.sharepoint.com/:b:/r/personal/rezvan_majidi_ulb_be/Documents/Master%20topic-Sacrifical%20Biomaterial-%20Hafez.pdf?csf=1&web=1&e=aWcXLE

Exploitation de signaux hémodynamiques continus pour la détection précoce de profils à risque ischémique après hémorragie méningée

Programme : Biomedical engineering - M-IRCBS

Description

Contexte :
Chez les patients présentant une hémorragie méningée, l'un des enjeux majeurs en réanimation est d'identifier précocement ceux qui risquent de développer un phénomène ischémique secondaire. Ce problème est particulièrement important, car il conditionne la prévention, la surveillance et la prise en charge ultérieure. D'après les échanges avec le service concerné, ce besoin est aujourd'hui peu couvert, alors même que de nombreuses données sont déjà disponibles en pratique : ECG, onde de pouls invasive ou non invasive, pression veineuse centrale, et autres paramètres monitorés en continu. Le contexte est donc particulièrement intéressant, car il combine un besoin clinique réel, un manque de solution satisfaisante, et un accès à des données riches déjà présentes.
Objectif :
L'objectif de ce mémoire est d'étudier si les signaux hémodynamiques disponibles en routine peuvent aider à mieux caractériser les patients à risque d'évolution ischémique après une hémorragie méningée. Le travail pourra porter sur l'exploration de jeux de données existants, l'analyse de tendances ou de profils de signaux, et l'identification d'indices potentiellement utiles pour une détection plus précoce. Ce mémoire vise avant tout à évaluer la faisabilité et la pertinence d'une telle approche, dans un contexte où les données sont abondantes mais encore peu exploitées à cette fin.

Langue	**FR (français)**
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Food and house dust mite allergens

Programme : Biomedical engineering - M-IRCBS

Description

Allergy represents an important public health problem. On the one hand, we are developing bioinformatics tools to predict whether a protein corresponds to a food allergen. Such tools are very important for the development of new food products. On the other hand, we are studying certain structural and dynamic properties of house dust mite allergens.

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

Encadrement

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Génération de signaux physiologiques synthétiques plausibles pour la validation de pipelines d'analyse

Programme : Biomedical engineering - M-IRCBS

Description

Contexte : Le développement de nouvelles méthodes d'analyse de signaux physiologiques est souvent limité par l'absence de données parfaitement annotées et par la difficulté d'explorer systématiquement l'impact de certaines variations physiologiques ou de certains artefacts. La génération de signaux synthétiques plausibles constitue alors un outil méthodologique précieux : elle permet de contrôler explicitement les paramètres du système simulé, de reproduire certaines dynamiques physiologiques, et de tester la robustesse de méthodes d'analyse dans un cadre maîtrisé. Objectif : L'objectif de ce mémoire est de développer un cadre simple de simulation de signaux physiologiques plausibles, avec la possibilité d'introduire des variations contrôlées et des perturbations réalistes. L'étudiant travaillera sur la définition des caractéristiques essentielles du signal, la génération de formes d'onde synthétiques et l'utilisation de ces signaux pour tester la robustesse de pipelines d'analyse. Le sujet convient particulièrement à un étudiant intéressé par la modélisation et la validation méthodologique.

Langue	FR (français)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Utilisation de Physics-Informed Neural Networks pour l'estimation d'états physiologiques à partir de signaux continus

Programme : Biomedical engineering - M-IRCBS

Description

Contexte : Les approches d'apprentissage automatique classiques offrent une grande flexibilité, mais elles sont souvent peu interprétables et fortement dépendantes de la quantité et de la qualité des données disponibles. À l'inverse, les modèles physiologiques offrent un cadre interprétable, mais leur identification peut être difficile lorsqu'ils sont confrontés à des données bruitées ou incomplètes. Les Physics-Informed Neural Networks (PINNs) proposent une voie intermédiaire, en intégrant des contraintes physiques ou physiologiques dans l'apprentissage. Ils constituent ainsi une approche prometteuse pour relier des signaux continus à des états latents ou paramètres non directement observables. Objectif : L'objectif de ce mémoire est d'explorer l'intérêt des PINNs pour l'estimation de variables physiologiques à partir de signaux continus, dans un cadre simple mais rigoureusement défini. Le travail pourra inclure une revue méthodologique des PINNs, la mise en place d'un cas d'étude pilote, puis une comparaison avec des approches plus classiques de modélisation ou d'apprentissage supervisé. Le mémoire visera à évaluer ce que ces approches hybrides apportent réellement en termes d'identifiabilité, de robustesse et d'interprétabilité dans un contexte biomédical.

Langue	**FR (français)**
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Évaluation du potentiel des signaux PPG dans une approche de modélisation physiologique simplifiée

Programme : Biomedical engineering - M-IRCBS

Description

Contexte : Les signaux de photopléthysmographie (PPG) sont particulièrement attractifs en raison de leur caractère non invasif et de leur facilité d'acquisition. En pratique, ils sont toutefois principalement utilisés pour des usages simples, comme l'estimation de la fréquence cardiaque ou de la saturation en oxygène. La question scientifique sous-jacente est de savoir dans quelle mesure ces signaux peuvent être interprétés comme des observations indirectes du système cardiovasculaire, et s'ils peuvent être intégrés à une approche fondée sur la modélisation afin d'en extraire des informations hémodynamiques plus riches. Objectif : L'objectif de ce mémoire est d'évaluer, de manière critique, le potentiel des signaux PPG pour une exploitation modèle-guidée. Il s'agira d'identifier quelles composantes du signal semblent plausiblement reliées à des variables physiologiques d'intérêt, quelles hypothèses de modélisation peuvent être formulées, et dans quelles limites ces approches restent scientifiquement crédibles. Le travail pourra combiner revue de la littérature, analyse exploratoire de données et discussion structurée sur les perspectives et verrous de cette modalité.

Langue	**FR (français)**
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Improved adenoid hypertrophy treatment through nasal replicas

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Experimental platform for human–exoskeleton collaboration in construction tasks

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Modular Volumetric Bioprinted Vascular Models to Study Cell–Flow Interactions

Programme : Biomedical engineering - M-IRCBS

Description

Understanding how geometry and flow conditions influence cellular behavior is crucial for studying vascular biology, disease development, and tissue engineering. Recent advances in volumetric bioprinting enable the rapid fabrication of complex hydrogel structures with precisely defined internal geometries. These structures can be used as model systems to investigate how physical cues affect cell responses in engineered microenvironments.
In this project, you will develop modular hydrogel building blocks containing internal channel geometries that can be linked together to form artificial vessel-like networks. Using volumetric printing, these building blocks will be fabricated with features such as constrictions, angles, and porous regions that create distinct flow regimes (e.g., altered shear stress, recirculation zones, or diffusion-dominated regions).
Some tasks will involve:

- Design and volumetrically print modular hydrogel blocks with embedded channels.
- Assemble these blocks into customizable artificial vascular systems.
- Introduce cells into the channels and apply controlled perfusion flow.
- Investigate how channel geometry, flow patterns, and shear stress influence cell behavior such as adhesion, morphology, migration, and proliferation.
- Analyze how porous or structured regions affect diffusion and cell–material interactions.

The project combines advanced biofabrication, microfluidics, and cell biology, providing a platform to systematically study how physical microenvironmental parameters regulate cellular responses. It will help to uncover fundamental principles governing cell behavior in vascular-like environments.

See - J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.

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

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

Programme : Biomedical engineering - M-IRCBS

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

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

Promoteur : Olivier Debeir

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Master thesis in microfluidics

Programme : Biomedical engineering - M-IRCBS

Description

Several research topics related to microfluidics and lab-on-a-chip: droplets, bubbles, capsules, antibubbles, double emulsions, flow crystallisation, cell encapsulation, cell sorting, giant unilamelar vesicles, confined Leidenfrost, coalescence, subretinal injection, blood testing by elastocapilarity, organoid encapsulation, ...

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRMAE, M- IRPH
Nombre de sujets	2

Encadrement

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Automated Detection and Classification of Breast Tumor Morphology in 3D MRI Using Deep Learning

Programme : Biomedical engineering - M-IRCBS

Description

The accurate characterization of breast tumors on MRI depends on the identification of subtle morphological features, including spiculated margins, irregular contours, and heterogeneous internal structure, that are strongly associated with malignancy but difficult to assess consistently across readers and institutions. This thesis builds a deep learning system that processes 3D breast MRI volumes to automatically detect, segment, and classify tumor lesions based on their morphological and textural properties. Starting from raw volumetric acquisitions, the pipeline isolates lesion regions, computes clinically grounded shape descriptors aligned with BI-RADS criteria, and produces a structured classification output indicating the likelihood and type of malignancy. The system is designed to function as a decision support tool for radiologists, reducing inter-reader variability and providing a reproducible, quantitative basis for diagnostic reporting.

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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Deep Learning-Based Segmentation and Classification of Pediatric Brain Tumors from Multi-Sequence MRI

Programme : Biomedical engineering - M-IRCBS

Description

Pediatric brain tumors represent the most common solid malignancy in children and encompass a heterogeneous spectrum of histological entities whose accurate characterization is critical for treatment planning and prognosis. Unlike adult gliomas, pediatric tumors exhibit distinct spatial distributions, growth patterns, and MRI signal characteristics that limit the direct transferability of adult-trained segmentation and classification models. This thesis develops a deep learning pipeline specifically designed for the segmentation and classification of pediatric brain tumors from multi-sequence MRI acquisitions including T1, T1 post-contrast, T2, and FLAIR. The system is trained on pediatric-specific annotated MRI datasets including contributions from the BraTS-PEDs challenge and validated against neuropathological ground truth.

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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Signal quality in intraneural and extraneural electrodes

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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DESIGN OF A FRAME SIMULATING LEG WEIGHT FOR EXPERIMENTAL TESTING: A PROOF OF CONCEPT STUDY

Programme : Biomedical engineering - M-IRCBS

Description

DESIGN OF A FRAME SIMULATING LEG WEIGHT FOR EXPERIMENTAL TESTING: A PROOF OF CONCEPT STUDY

1 Supervising staff

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Supervisor : Mattia Sisella, PhD Candidate; mattia.sisella@ulb.be

2 Context

In a common experimental setup, for practical reasons usually only knee joint is tested. However, it's important not to ignore the effect of the leg+foot weight during analysis. Moreover, Finite Element Analysis (FEA) is a powerful tool to support the validation process.

3 Work

The goal of this project is to design a frame that can be attached to the tibia to simulate the weight of the leg by adding external masses. A Finite Element Model (FEM) will also be created to verify the prototype.

4. References

1) Sisella M, Maggi L, Allotta B, Innocenti B, Description and Validation of a Portable System for Biomechanical Ex-Vivo Knee Kinematics and Laxity Assessment in Simulated Intra-Operative Scenarios, J Exp Orth. (under review 2026)

Langue	**EN (english)**
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Évaluation de la qualité de signaux physiologiques pulsés en vue d'analyses hémodynamiques avancées

Programme : Biomedical engineering - M-IRCBS

Description

Contexte : L'exploitation quantitative de signaux physiologiques pulsés suppose que ceux-ci soient suffisamment fiables pour refléter la dynamique du système cardiovasculaire. En pratique, ces signaux peuvent être altérés par de nombreux facteurs : artefacts de mouvement, bruit instrumental, saturation du capteur, mauvais couplage capteur-sujet, amortissement, dérive ou pertes de contact. La question de la qualité du signal constitue donc un verrou méthodologique fondamental, car toute inférence physiologique ultérieure dépend de la validité du signal analysé. Objectif : L'objectif de ce mémoire est de développer une méthodologie d'évaluation de la qualité de signaux physiologiques pulsés, afin de distinguer automatiquement les segments exploitables de ceux qui ne le sont pas. Le travail pourra comprendre une revue critique des approches existantes, l'identification de critères objectifs de qualité, l'analyse de signaux réels, puis la mise en place d'un outil de scoring ou de classification. L'enjeu est de produire un cadre méthodologique réutilisable pour des analyses ultérieures de signaux hémodynamiques.

Langue	**FR (français)**
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Biophysics of Red Blood Cells and Platelets

Programme : Biomedical engineering - M-IRCBS

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

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Construction of Bacterially in Situ Generated Cellulose-Based Tannic Acid Nanozyme and Investigation of Its Enzymatic Performance Study

Programme : Biomedical engineering - M-IRCBS

Description

Nanozymes, as synthetic nanomaterials with enzyme-like catalytic activities, have attracted significant attention in biosensing, catalysis, and antibacterial applications. Among them, metal–polyphenol networks (MPNs), especially tannic acid (TA)-based nanozymes, exhibit excellent catalytic efficiency, biocompatibility, and drug-loading capacity due to the inherent antioxidant and anti-inflammatory properties of polyphenols. Bacterial cellulose (BC), biosynthesized by microorganisms such as Komagataeibacter xylinus, is a highly pure, mechanically robust, and biocompatible nanofibrous material, making it a promising candidate for tissue engineering and functional materials. Integrating nanozymes with BC can impart multifunctionality to the composite system. However, conventional approaches typically rely on in vitro incorporation of nanozymes into preformed BC, which often results in uneven distribution and weak interfacial interactions. To address these limitations, this study proposes an in-situ biosynthesis strategy, in which TA-based nanozymes are directly introduced into the bacterial fermentation system, enabling the simultaneous formation of BC and nanozymes. This approach is expected to achieve uniform distribution and strong interfacial integration. Furthermore, the interaction mechanisms between nanozymes, BC fibers, and bacterial behavior will be systematically investigated, providing fundamental insights into the bio-fabrication of engineered living materials (ELMs).

Research points:
A) Construction of in situ BC complexes by co-culturing bacteria with TA nanozymes
B) Investigation of the interaction mechanisms between nanozymes and BC fibers through comprehensive material characterization.
C) Evaluation of multi-enzyme activities in the composite system and investigation of the effects of BC matrix on catalytic activity stability, reaction kinetics, and pH adaptability.

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

Encadrement

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Development of a Bioactive HAMA/GelMA Hydrogel for Volumetric Printing of Biomimetic Structures

Programme : Biomedical engineering - M-IRCBS

Description

Volumetric 3D printing is an emerging approach in biofabrication that enables the rapid production of complex three-dimensional structures. Unlike layer-by-layer printing techniques, this method allows an entire volume of photosensitive resin to be polymerized in a matter of seconds. However, its use in tissue engineering remains limited by the small number of compatible bioinks, which must both possess suitable optical properties for printing and maintain a biologically favorable environment for cells.

This project aims to develop and characterize a new bioactive hydrogel formulation based on a GelMA (gelatin methacryloyl) and HAMA (hyaluronic acid methacrylate) mixture for volumetric printing. The goal is to design a resin that enables both efficient polymerization during printing and a supportive environment for cell viability. The potential addition of PEGDA may also be explored to fine-tune mechanical properties and crosslinking kinetics.

The first work axis will focus on material formulation and characterization. HAMA will be synthesized, and different molecular weights may be investigated. Methacrylation will be analyzed (by NMR if possible, or by FTIR for qualitative estimation). These polymers will then be incorporated into GelMA/HAMA hydrogel formulations at various ratios, optionally complemented with polyethylene glycol diacrylate (PEGDA) to adjust mechanical properties and crosslinking. Simple UV photopolymerization tests will be conducted to assess the reactivity of the formulations, followed by mechanical characterization of the resulting hydrogels (Young's modulus and storage modulus).

The second project axis will address the compatibility of the formulations with volumetric printing. The optical properties of the resin (refractive index, absorbance) will be measured to verify their suitability for the printing technique. Volumetric printing polymerization tests and light-dose adjustments will be carried out to determine the conditions required to produce stable and well-defined hydrogel structures, with the ultimate goal of creating more complex structures, such as those containing microchannels.

Finally, in parallel, a third axis will focus on evaluating the biological activity of the hydrogels. Cell viability assays (MTT or Alamar Blue) will be performed using fibroblasts or endothelial cells. Cell morphology will also be studied using fluorescent labeling to assess the interactions between cells and the different formulations (HAMA molecular weight and ratios). These tests can be conducted on hydrogel discs.

This project will thus explore the potential of HAMA/GelMA hydrogels as bioinks for volumetric printing and provide insights into how formulation affects the mechanical, optical, and biological properties of the material.

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

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Artificial intelligence methods to design ligands for olfactory receptors

Programme : Biomedical engineering - M-IRCBS

Description

The olfactory system relies on protein receptors expressed by olfactory neurons. These olfactory receptors belong to the family of G protein-coupled membrane receptors (GPCR). The relationships between odorant molecules, targeted olfactory receptors and odour perception are complex and not yet well understood. In addition, it has been shown that some olfactory receptors are expressed in tissues other than the olfactory epithelium and may have a physiological or potentially therapeutic role.
This project consists in developing artificial intelligence approaches, allowing (1) to predict the olfactory receptor(s) targeted by an odorant molecule, and (2) to design de novo a molecule able to activate a given olfactory receptor. It is carried out in collaboration with the group of Prof. I. Langer (Faculty of Medicine), which experimentally characterises these systems.
The master thesis topics related to this project can be entirely bioinformatics or include an experimental part.

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

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Analyse de signaux cardiovasculaires continus pour aider à l'identification étiologique des AVC ischémiques

Programme : Biomedical engineering - M-IRCBS

Description

Contexte :
Après un AVC ischémique, l'une des questions majeures est de mieux comprendre l'origine de l'événement, en particulier lorsqu'un trouble du rythme ou un mécanisme cardiovasculaire sous-jacent est suspecté. En pratique, cette démarche repose souvent sur des enregistrements prolongés, comme le Holter, et sur des analyses qui peuvent être longues et consommatrices de ressources. La discussion menée avec le service de neurologie suggère qu'il pourrait exister, dans des signaux déjà disponibles comme l'ECG ou certaines ondes de pouls, des informations utiles pour accélérer ou faciliter cette identification, avec un intérêt à la fois clinique et organisationnel .
Objectif :
L'objectif de ce mémoire est d'explorer si des signaux cardiovasculaires déjà acquis en routine chez des patients en stroke unit peuvent apporter une aide supplémentaire pour orienter l'identification étiologique d'un AVC ischémique. Le travail pourra inclure une revue de la littérature, l'analyse exploratoire de signaux disponibles, l'étude de marqueurs ou de patterns potentiellement pertinents, ainsi qu'une réflexion critique sur leur utilité réelle dans ce contexte. Le but n'est pas de remplacer la démarche diagnostique actuelle, mais d'évaluer si une exploitation plus fine de signaux déjà mesurés pourrait contribuer à rendre cette démarche plus rapide, plus objective ou plus efficace.

Langue	**FR (français)**
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Variable stiffness catheter for lung cancer diagnosis

Programme : Biomedical engineering - M-IRCBS

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

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Depth Camera-Based Person Tracking for Quantitative Balance Assessment

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Evaluation and Benchmarking of Feature-Based Registration Pipelines Under Challenging Initial Conditions for Whole-Slide Images

Programme : Biomedical engineering - M-IRCBS

Description

This project focuses on the evaluation of various configurations of a feature-based registration pipeline, with particular attention to their robustness under varying initial conditions in the domain of *Whole-Slide Image* (WSI) registration.

Context

In digital pathology, the integration of information from multiple WSIs is often required to obtain a comprehensive understanding of complex biological processes, such as cancer development and progression. This integration requires accurate spatial alignment of corresponding tissue regions across WSIs, a process referred to as WSI registration. Due to challenges such as image artefacts, varying staining, and large tissue deformations, WSI registration remains a difficult problem in computer vision.

Recent challenges, such as ANHIR [[Borovec2020](https://doi.org/10.1109/TMI.2020.2986331)] and ACROBAT [[Weitz2024](https://doi.org/10.1016/j.media.2024.103257)], have brought attention to the state-of-the-art in WSI registration. These challenges evaluate the performance of registration algorithms on real-world datasets comprising multi-stained slides, such as Hematoxylin & Eosin and Immunohistochemistry. Successful approaches generally follow a two-stage process: an initial low-resolution rigid or affine alignment, followed by a high-resolution non-rigid (deformable) registration. This two-step approach effectively constrains the parameter space within which the non-linear elastic transformation is subsequently estimated, thereby significantly improving the quality of the final alignment.

Among the strategies for estimating initial alignment, feature-based methods have emerged as the most widely used, with six out of eight top-performing teams in the ACROBAT challenge employing such techniques [[Weitz2024](https://doi.org/10.1016/j.media.2024.103257)]. Feature-based registration typically involves three key stages: (i) pre-processing, (ii) local feature extraction, and (iii) robust matching. Each of these stages can be performed using a variety of algorithms, ranging from traditional approaches to deep learning-based methods [[Marzahl2021](https://proceedings.mlr.press/v156/marzahl21a.html), [Gatenbee2023](https://doi.org/10.1038/s41467-023-40218-9), [Elskens2023](https://doi.org/10.1109/SIPAIM56729.2023.10373514), [Wodzinski2024](https://doi.org/10.1016/j.cmpb.2024.108187), [Elskens2025](http://dx.doi.org/10.13140/RG.2.2.29399.79521)].

Objectives

The main objective of this project is to systematically evaluate and benchmark feature-based registration pipelines with respect to their robustness to challenging initial conditions.

More specifically, the project aims to:

- Quantify the limits of different pipelines in handling:
  - Large translations and rotations
  - Scale variations and geometric distortions
  - Imaging artefacts and staining differences
- Determine failure thresholds, i.e., the maximum level of perturbation beyond which registration performance significantly degrades.
- Propose a novel method to better handle the initial conditions (as a pre-registration step)

Methods

The project will involve a comparative study of several state-of-the-art feature detection and matching algorithms found in recent literature. These may include: SuperPoint [[DeTone2018](https://doi.org/10.1109/CVPRW.2018.00060)], LightGlue [[Lindenberger2023](https://doi.org/10.1109/ICCV51070.2023.01616)], LoFTR [[Sun2021](https://doi.org/10.48550/arXiv.2104.00680)] and OmniGlue [[Jiang2024](https://doi.org/10.1109/CVPR52733.2024.01878)]. Each algorithm will be implemented and evaluated under controlled experimental settings.

A novel evaluation protocol will be developed, grounded in existing metrics from the literature while integrating innovative criteria specifically tailored to the tasks explored in this project. The evaluation will include, but not be limited to, assessments of robustness to large displacements (e.g., rotation, translation, and shear) as well as the ability of each pipeline configuration to effectively filter outliers during robust matching. The goal is to design a comprehensive and reproducible benchmarking approach focused on critical aspects of feature-based registration pipelines within the context of digital pathology.

Prerequisites

Candidates should have:

- A solid foundation in Python programming
- A willingness to work with containerization tools such as Docker (prior experience is a plus but not mandatory)
- Successfully completed INFO-H500 or an equivalent course in image processing, computer vision, or machine learning

Contact person

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Langue	FR (français)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS
Nombre de sujets	1

Encadrement

Promoteur : Olivier Debeir

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Optimized GNNs for Interpretable Brain Connectivity

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Lien : https://www.dropbox.com/scl/fi/mjrq2vihssyp4xo704kkm/Master-Thesis-Subject-Biomechatronics-Optimized-GNNs-for-Interpretable-Brain-Connectivity.pdf?rlkey=pie0kze0xd72gg37qicquimyv&dl=0

Electrical modeling and control of cold atmospheric plasma for endoscopes

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Lien : https://www.dropbox.com/scl/fi/ehch822zev3dn6isf90j7/Master-Thesis-Subject-Biomechatronics-Electrical-modeling-and-control-of-cold-atmospheric-plasma-for-endoscopes.pdf?rlkey=lbpuz90jap1x1fsixpzc77394&dl=0

Biopsies in the periphery of the lung: shape sensing catheter tip

Programme : Biomedical engineering - M-IRCBS

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

Encadrement

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Investigating resistance mechanisms to monoclonal antibody therapies in cancer

Programme : Biomedical engineering - M-IRCBS

Description

Monoclonal antibodies (mAbs) are one of the largest classes of therapeutics in cancer. However, their efficacy is often limited by the ability of cancer cells to evolve and escape their effects. In this project, we aim to analyze in detail the mechanisms underlying this escape. By better understanding these resistance processes, we seek to (re)design new monoclonal antibodies or combination that minimize the likelihood of tumor escape.

Langue	EN (english)
Ouvert à d'autres masters	No
Masters concernés	
Nombre de sujets	1

Encadrement

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Analyse comparative des signaux ICG et SCG dans une logique d'inférence de variables cardiovasculaires latentes

Programme : Biomedical engineering - M-IRCBS

Description

Contexte : L'impédancemétrie thoracique (ICG) et la seismocardiographie (SCG) représentent deux modalités non invasives permettant d'observer indirectement des phénomènes liés à l'activité cardiovasculaire. Bien que ces signaux soient régulièrement proposés pour l'estimation de variables telles que le débit cardiaque ou certains temps caractéristiques du cycle cardiaque, leur interprétation reste délicate et fortement dépendante du contexte expérimental et de la qualité des mesures. Une question importante est donc de déterminer si ces signaux peuvent raisonnablement être reliés à un modèle cardiovasculaire simplifié permettant l'inférence d'états ou paramètres latents. Objectif : L'objectif de ce mémoire est de comparer l'ICG et la SCG dans une perspective de modélisation physiologique, afin d'évaluer leur capacité potentielle à informer sur des états internes du système cardiovasculaire. Le travail pourra inclure une analyse comparative de la littérature, une exploration de signaux disponibles, ainsi qu'une réflexion structurée sur les relations possibles entre ces mesures et un modèle simplifié du système. L'enjeu est moins de produire une méthode finale que d'identifier, de manière rigoureuse, les hypothèses les plus plausibles et les limites structurelles de ces modalités.

Langue	FR (français)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRIFS, M- IRPH
Nombre de sujets	1

Encadrement

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Depth Camera-Based Person Tracking for Quantitative Balance Assessment

Programme : Biomedical engineering - M-IRCBS

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

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