

Topics offered to students by other
master's programs

TARGET PROGRAM

Physics Engineering

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

Master : Chemical & Materials engineering - M-IRMAE

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)
Number of topics	1

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

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

Unraveling the degradation of applied brocades in the Van Eyck's brothers' "Adoration of the Mystic Lamb" Altarpiece: synthesis and multi-analytical characterization of Sn(II) metal soaps

Master : Chemical & Materials engineering - M-IRMAE

The iconic "Adoration of the Mystic Lamb" altarpiece, painted by the Van Eyck brothers in the XVth century, presents a severe alteration of its applied brocades, an ancient decorative technique involving a complex superposition of numerous materials. Previous analysis of samples taken from the altarpiece suggest the degradation of the brocades' tin foils occurs through the formation of metal soaps that have not been yet described in the scientific literature. Considering the as-obtained results as well as the materiality of the applied brocades' tin foils, Sn(II)-based soaps are suspected to be one of the main degradation products formed. Nonetheless, the lack of Sn-soap references hinders their identification as well as a refined understanding of the brocades' degradation mechanism. The project currently seeks to clearly identify such mechanisms to propose better conservation-restoration solutions that ensure their preservation.

The project aims to define a reproducible synthetic pathway allowing to obtain a Sn(II) metal soap which will have to be characterized using numerous (micro)analytical techniques (ATR-FTIR, SEM-EDX, Raman, pXRPD, XPS, ToF-SIMS and NMR). Once obtained, a novel reflection FTIR analytical methodology will be developed to identify and localize such soaps in mock-ups and samples taken from the altarpiece, thus improving our understanding of the applied brocade's degradation phenomena.

The work will be carried in collaboration with the Royal Institute for Cultural Heritage in Brussels (KIK-IRPA), more specifically in the Materials Science for Conservation Research (MatCoRe) unit which is dedicated to the study of the molecular phenomena involved in the degradation of historical oil paintings. The main techniques that will be used in this project are: ATR-FTIR, Raman, NMR, SEM-EDX, XPS, ToF-SIMS.

Prerequisites

- Spectroscopy
- Organic Chemistry

Link : <https://www.kikirpa.be/fr/presse/restauration-agneau-mystique>

For more information, please contact Dr. Francisco Mederos-Henry (francisco.mederos@kikirpa.be) or Kristin Bartik (Kristin.bartik@ulb.be).

Language	EN (english)
Number of topics	1

Supervisor : Kristin BARTIK (kristin.bartik@ulb.be)

Co-supervisor : Francisco Mederos-Henry (Francisco.Mederos-Henry@ulb.be)

Efficient computation and optimisation of large-scale computer-generated holograms for physical fabrication

Master : Electrical engineering - M-IRELE

Context

Holographic displays have the potential to become the highest-quality type of 3D display system, as they account for all visual depth cues by reproducing the full wavefield of light, including both amplitude and phase information. Unlike stereoscopic or light field displays, holographic displays can reproduce correct focus cues, occlusion, and motion parallax simultaneously, making them a long-term target for immersive 3D visualization. Computer-generated holograms (CGHs) can reproduce full 3D scenes by encoding a physical interference pattern that reconstructs this complete wavefield. Fabricating such holograms physically imposes strict requirements on the computed fringe pattern: the hologram must be very large (gigapixel scale), encoded in a format compatible with the fabrication process (typically phase-only or binary amplitude), and optically correct across multiple wavelengths for color reproduction. While significant progress has been made in CGH algorithms, efficiently computing and optimizing large-scale holograms that meet these fabrication constraints remains an open challenge. This thesis investigates computational methods for generating high-resolution CGHs optimized for physical fabrication, with the goal of eventual printing in collaboration with external partners.

Research activities and goals

The student will first study wave optics, existing CGH algorithms, and the constraints imposed by physical fabrication processes such as binary quantization and phase-only encoding. Building on the research group's existing hologram generation pipeline, the student will investigate methods for scaling computation to very large hologram sizes, optimizing fringe patterns for binary or phase-only fabrication formats, and reproducing color through multi-wavelength hologram design. Large-scale holographic stereograms may also be explored as a computationally tractable approach to high-resolution 3D content. The work includes literature review, algorithm development and implementation in Python or CUDA, quantitative evaluation of reconstruction quality, and preparation of hologram data for external fabrication.

Expected Student Profile:

- Strong programming skills (MATLAB or Python, C/C++)
- Familiarity with 3D graphics or rendering is a plus, but not strictly required
- Interest in experimental physical research and evaluation (visual and optical testing)

References and further reading

Matsushima, K. and Nakahara, S., "Extremely high-definition full-parallax computer-generated hologram created by the polygon-based method," *Appl. Opt.* 48, H54–H63 (2009).

David Blinder, Tobias Birnbaum, Tomoyoshi Ito, Tomoyoshi Shimobaba. The state-of-the-art in computer generated holography for 3D display[J]. *Light: Advanced Manufacturing* 3, 35(2022). doi: 10.37188/lam.2022.035

Link : <https://www.etrovub.be/education/master/master-thesis-topics-guidelines/thesis-details/overview/2723/>

Language	EN (english)
Number of topics	1

Supervisor : David Blinder (david.blinder@vub.be)

Co-supervisor : Bilal Fares (Bilal.Moussa.Fares@vub.be)

Accelerating autoregressive integrated moving average models using sparse matrix representations

Master : Electrical engineering - M-IRELE

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)
Number of topics	1

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

Quantum light fields with optical fiber cavities

Program : *Physical engineering - M- IRPH*

Description

Quantum light fields and particularly squeezed states are typically generated via nonlinear optical interactions in crystals, waveguides, and cavities.

Fiber cavities are unique as they have length that can be extreme. Unlike laser whose linewidth is typically limited by the stability of the cavity, squeezed vacuum have broader linewidth limited by the cavity. Fiber optical cavities can thus offer

- extremely narrowband photons on a dense frequency comb that find applications in quantum memories.
- narrowband squeezed states with application in quantum sensing.

Both projects include design of experiments, measurements and data analysis.

Interested students can get greater details by setting an appointment with Stéphane Clemmen.

Thesis is in French or English.

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

Supervision

Supervisor : Stéphane Clemmen (stephane.clemmen@ulb.be)

Nonlinear and quantum photonics beyond telecom wavelength

Program : *Physical engineering - M- IRPH*

Description

The maturity of both lasers and single photon detectors now allows exploring nonlinear/quantum optics processes at wavelength beyond 2 μ m close to the mid-infrared.

Two topics are possible:

- photon pair generation via spontaneous four-wave mixing in optical fibers (with application for ghost imaging)
- quantum frequency conversion in silicon nitride photonics integrated circuits

Both projects include design of experiments, measurements and data analysis.

Interested students can get greater details by setting an appointment with Stéphane Clemmen.

Thesis is in French or English.

Language	EN (english) + FR
Open to other master's programs	No
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

Supervisor : Stéphane Clemmen (stephane.clemmen@ulb.be)

Topics offered to students by other
master's programs

TARGET PROGRAM

Physics Engineering

Visibility of quantum dots under solar excitation

Program : EM - Aeronautics - M-IREMR-A

Description

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

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

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

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

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

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

Supervision

Supervisor

Axel Coussement (axel.coussement@ulb.be)

Co-supervisor

Iorio Carlo (carlo.iorio@ulb.be)

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

Master : Chemical & Materials engineering - M-IRMAE

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.

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- 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

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2. Experimental set-up

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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

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Language	EN (english)
Number of topics	1

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

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

Unraveling the degradation of applied brocades in the Van Eyck's brothers' "Adoration of the Mystic Lamb" Altarpiece: synthesis and multi-analytical characterization of Sn(II) metal soaps

Master : Chemical & Materials engineering - M-IRMAE

The iconic "Adoration of the Mystic Lamb" altarpiece, painted by the Van Eyck brothers in the XVth century, presents a severe alteration of its applied brocades, an ancient decorative technique involving a complex superposition of numerous materials. Previous analysis of samples taken from the altarpiece suggest the degradation of the brocades' tin foils occurs through the formation of metal soaps that have not been yet described in the scientific literature. Considering the as-obtained results as well as the materiality of the applied brocades' tin foils, Sn(II)-based soaps are suspected to be one of the main degradation products formed. Nonetheless, the lack of Sn-soap references hinders their identification as well as a refined understanding of the brocades' degradation mechanism. The project currently seeks to clearly identify such mechanisms to propose better conservation-restoration solutions that ensure their preservation.

The project aims to define a reproducible synthetic pathway allowing to obtain a Sn(II) metal soap which will have to be characterized using numerous (micro)analytical techniques (ATR-FTIR, SEM-EDX, Raman, pXRPD, XPS, ToF-SIMS and NMR). Once obtained, a novel reflection FTIR analytical methodology will be developed to identify and localize such soaps in mock-ups and samples taken from the altarpiece, thus improving our understanding of the applied brocade's degradation phenomena.

The work will be carried in collaboration with the Royal Institute for Cultural Heritage in Brussels (KIK-IRPA), more specifically in the Materials Science for Conservation Research (MatCoRe) unit which is dedicated to the study of the molecular phenomena involved in the degradation of historical oil paintings. The main techniques that will be used in this project are: ATR-FTIR, Raman, NMR, SEM-EDX, XPS, ToF-SIMS.

Prerequisites

- Spectroscopy
- Organic Chemistry

Link : <https://www.kikirpa.be/fr/presse/restauration-agneau-mystique>

For more information, please contact Dr. Francisco Mederos-Henry (francisco.mederos@kikirpa.be) or Kristin Bartik (Kristin.bartik@ulb.be).

Language	EN (english)
Number of topics	1

Supervisor : Kristin BARTIK (kristin.bartik@ulb.be)

Co-supervisor : Francisco Mederos-Henry (Francisco.Mederos-Henry@ulb.be)

Efficient computation and optimisation of large-scale computer-generated holograms for physical fabrication

Master : Electrical engineering - M-IRELE

Context

Holographic displays have the potential to become the highest-quality type of 3D display system, as they account for all visual depth cues by reproducing the full wavefield of light, including both amplitude and phase information. Unlike stereoscopic or light field displays, holographic displays can reproduce correct focus cues, occlusion, and motion parallax simultaneously, making them a long-term target for immersive 3D visualization. Computer-generated holograms (CGHs) can reproduce full 3D scenes by encoding a physical interference pattern that reconstructs this complete wavefield. Fabricating such holograms physically imposes strict requirements on the computed fringe pattern: the hologram must be very large (gigapixel scale), encoded in a format compatible with the fabrication process (typically phase-only or binary amplitude), and optically correct across multiple wavelengths for color reproduction. While significant progress has been made in CGH algorithms, efficiently computing and optimizing large-scale holograms that meet these fabrication constraints remains an open challenge. This thesis investigates computational methods for generating high-resolution CGHs optimized for physical fabrication, with the goal of eventual printing in collaboration with external partners.

Research activities and goals

The student will first study wave optics, existing CGH algorithms, and the constraints imposed by physical fabrication processes such as binary quantization and phase-only encoding. Building on the research group's existing hologram generation pipeline, the student will investigate methods for scaling computation to very large hologram sizes, optimizing fringe patterns for binary or phase-only fabrication formats, and reproducing color through multi-wavelength hologram design. Large-scale holographic stereograms may also be explored as a computationally tractable approach to high-resolution 3D content. The work includes literature review, algorithm development and implementation in Python or CUDA, quantitative evaluation of reconstruction quality, and preparation of hologram data for external fabrication.

Expected Student Profile:

- Strong programming skills (MATLAB or Python, C/C++)
- Familiarity with 3D graphics or rendering is a plus, but not strictly required
- Interest in experimental physical research and evaluation (visual and optical testing)

References and further reading

Matsushima, K. and Nakahara, S., "Extremely high-definition full-parallax computer-generated hologram created by the polygon-based method," *Appl. Opt.* 48, H54–H63 (2009).

David Blinder, Tobias Birnbaum, Tomoyoshi Ito, Tomoyoshi Shimobaba. The state-of-the-art in computer generated holography for 3D display[J]. *Light: Advanced Manufacturing* 3, 35(2022). doi: 10.37188/lam.2022.035

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Language	EN (english)
Number of topics	1

Supervisor : David Blinder (david.blinder@vub.be)

Co-supervisor : Bilal Fares (Bilal.Moussa.Fares@vub.be)

Accelerating autoregressive integrated moving average models using sparse matrix representations

Master : Electrical engineering - M-IRELE

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)
Number of topics	1

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

Reliability enhancement for complex systems via AI-based time-dependent reconfiguration

Program : Physical engineering - M- IRPH

Description

Classical reliability techniques, based on Boolean logics, are well established in the treatment of multi-component systems. Yet those methods actually rely on some assumptions: components are assumed to display a binary operation (i.e. they are fully working or fully failed), and the logics of the system is considered static.

Complex industrial systems are increasingly designed to tolerate certain failures while maintaining an acceptable level of operational performance. For such systems, reliability can no longer be estimated on the basis of the previous assumptions (binary components and static logics). An alternative is to consider it as a dynamic variable depending on the performance threshold at which the system will be considered to have failed.

Traditionally, improving reliability involves modifying the architecture or adding redundancies, which entails significant costs and constraints. The proposed thesis aims to analyze the approach proposed in a very recent work and to further extend it. It focuses on improving the reliability of specific systems without hardware modifications. Simulation is used to model complex architectures and represent progressive degradation phenomena, depending on the location of components, and common failure modes. Artificial Intelligence is combined with the simulation to treat time-dependent reconfigurations in the allocation of functions between components that are still operational, in order to slow down performance degradation and delay the crossing of a critical failure threshold.

Reference

Cahoreau P., et al. (2026). New approach to improving the reliability of complex systems by combining dynamic simulation and artificial intelligence. Proceedings of the 2025 conference, "Intelligences Artificielles et Humaines : nouvelles synergies pour le Management des Risques", Grenoble, October 2026.

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

Supervision

Supervisor : Pierre-Etienne LABEAU (pierre.etienne.labeau@ulb.be)

Degradation processes with imperfect maintenance: from theoretical models to industrial applications

Program : Physical engineering - M- IRPH

Description

Industrial assets are subject to aging: their performances decrease as a function of time, and this is often revealed by an increasing proneness to fail. In order to monitor and limit the progression of degradation phenomena, these assets are subject to various types of inspections and maintenance actions, in order to (partly) rejuvenate them before considering their replacement. Given the costs associated with these activities, realistic models are necessary as a basis for sound asset management. Those models are required to describe the assets' lifetime and expected lifetime extension, as well as the evolution of their degradation level and the impact of imperfect maintenance.

The thesis will first consist of updating a state of the art of those models and proposing a critical review of their characteristics. Some more realistic features of imperfect maintenance models will be discussed, introduced in models and compared to existing models on various applications.

References

- Doyen, L. and Gaudoin, O. (2004). Classes of imperfect repair models based on reduction of failure intensity or virtual age. *Reliability Engineering and System Safety*, 84, 45-56.
- Wu, S. and Clements-Croome, D. (2005). Preventive maintenance models with random maintenance quality. *Reliability Engineering and System Safety*, 90, 99-105.
- Kahle, W. (2019). Imperfect repair in degradation processes: A Kijima-type approach: Imperfect repair in degradation processes. *Applied Stochastic Models in Business and Industry*, 35. <https://doi.org/10.1002/asmb.2438>
- Kahle, W., Mercier, S., & Paroissin, C. (2016). *Degradation Processes in Reliability* (Inc. John Wiley & Sons, Éd.). <https://doi.org/10.1002/9781119307488>

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

Supervision

Supervisor : Pierre-Etienne LABEAU (pierre.etienne.labeau@ulb.be)

Quantum light fields with optical fiber cavities

Program : *Physical engineering - M- IRPH*

Description

Quantum light fields and particularly squeezed states are typically generated via nonlinear optical interactions in crystals, waveguides, and cavities.

Fiber cavities are unique as they have length that can be extreme. Unlike laser whose linewidth is typically limited by the stability of the cavity, squeezed vacuum have broader linewidth limited by the cavity. Fiber optical cavities can thus offer

- extremely narrowband photons on a dense frequency comb that find applications in quantum memories.
- narrowband squeezed states with application in quantum sensing.

Both projects include design of experiments, measurements and data analysis.

Interested students can get greater details by setting an appointment with Stéphane Clemmen.

Thesis is in French or English.

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

Supervision

Supervisor : Stéphane Clemmen (stephane.clemmen@ulb.be)

Nonlinear and quantum photonics beyond telecom wavelength

Program : *Physical engineering - M- IRPH*

Description

The maturity of both lasers and single photon detectors now allows exploring nonlinear/quantum optics processes at wavelength beyond 2 μ m close to the mid-infrared.

Two topics are possible:

- photon pair generation via spontaneous four-wave mixing in optical fibers (with application for ghost imaging)
- quantum frequency conversion in silicon nitride photonics integrated circuits

Both projects include design of experiments, measurements and data analysis.

Interested students can get greater details by setting an appointment with Stéphane Clemmen.

Thesis is in French or English.

Language	EN (english) + FR
Open to other master's programs	No
Eligible master's programs	M- IRPH
Number of topics	1

Supervision

Supervisor : Stéphane Clemmen (stephane.clemmen@ulb.be)

Physical Engineering

Master Thesis Topics (M-IRPH)

Academic year 2026-2027

Efficient sampling techniques and classification methods in dynamic Probabilistic Safety Analysis (PSA)

Programme : Physical engineering - M- IRPH

Description

Nuclear Reactor Physics and Safety

PSA is used to identify scenarios contributing to the residual risk of the nuclear power plant (NPP) – i.e. the risk once properly dimensioned protection systems and emergency procedures are in function – and possibly suppress those scenarios or reduce their frequency of occurrence.

Passive safety systems and new reactor designs challenge the classical PSA practice (based on the combination of fault trees and event trees), as it does not allow capturing the dynamic response of the plant to the occurrence of an event triggering a transient. Dynamic PSA corresponds to an extended framework, in which allowance is given to the coupling of transient calculations with branching events in an event tree.

Though conceptually more satisfying, dynamic PSA still requires efficient simulation techniques in order to identify “all” significant low-probable, risk-significant scenarios likely to develop in the plant. The proposed topic will review sampling techniques used in dynamic PSA simulations and identify new ones, which would better fit to the specific features of the new nuclear systems. Classification techniques will be considered in order to group similar transients and avoid the repetition of time-consuming computations. More details on the expected outcomes of the work will be discussed with the applicants.

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

Encadrement

Promoteur : PIERRE-ETIENNE LABEAU

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Computational Fluid Dynamics subjects - Liquid metal modelling in CFD

Programme : Physical engineering - M- IRPH

Description

Liquid metal coolants (such as sodium, lead or lead–bismuth eutectic) are key components in several advanced nuclear reactor concepts. Their very low Prandtl number leads to a strong decoupling between momentum and heat transfer, making turbulence modelling and heat transfer prediction particularly challenging for standard CFD approaches. The objective of this subject is to investigate the capability of ANSYS Fluent to model turbulent liquid metal flows, with a specific focus on predicting pressure losses and heat transfer coefficients (HTC) in simple yet representative configurations.

The work will start with a critical literature review of turbulence modelling approaches developed for liquid metals, including adaptations of RANS models (e.g. modified $k-\epsilon$, $k-\omega$ and Reynolds stress models) and the treatment of turbulent thermal diffusivity. Based on this review, a simple validation case (such as fully developed flow in a heated pipe or channel) will be implemented in ANSYS Fluent. Numerical results will be compared against reference correlations or experimental data, and a limited sensitivity study on turbulence model coefficients will be carried out to improve the prediction of pressure drop and HTC. This topic provides hands-on experience in CFD, turbulence modelling and nuclear thermal hydraulics, while addressing practical industrial challenges relevant to Tractebel's activities.

This involves that:

- You will develop competences in the use of ANSYS Fluent software;
- You will develop knowledge on low Prandtl flows;
- You will perform simulations in steady-state mode;
- Writing a scientific report.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Improvement of wave equation solvers in hot magnetised plasmas: the Quasimode approach

Programme : Physical engineering - M- IRPH

Description

Description is available on the U.V.

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

Encadrement

Promoteur : Yves LOUIS

Contact : yves.louis@ulb.be

Co-encadrant : Vincent MAQUET

Contact : vincent.maquet@ulb.be

Calibration en énergie du détecteur JUNO avec des sources à neutrons

Programme : *Physical engineering - M- IRPH*

Description

L'observatoire souterrain de neutrinos de Jiangmen (Jiangmen Underground Neutrino Observatory ou JUNO) est une expérience en Chine destinée à l'étude des neutrinos. Le but principal de JUNO est de mesurer très précisément le spectre en énergie (entre 2 et 10 MeV) des neutrinos provenant de deux centrales nucléaires situées à ~ 53 km de distance. D'autres sources de neutrinos (neutrinos atmosphériques, neutrinos solaires, géoneutrinos, ...) sont aussi étudiées.

Le détecteur est constitué d'une sphère centrale de 35 m de diamètre remplie de 20 kton de scintillateur liquide et entourée de 20000 photomultiplicateurs (PMTs) pour détecter la lumière

produite par les particules créées lors des interactions des neutrinos avec les noyaux d'hydrogène et carbone. Deux systèmes de vetos permettent d'éliminer le bruit de fond venant

des muons cosmiques.

La construction du détecteur s'est terminée fin 2024, suivi du remplissage en eau ultra pure (véto de muon) et en liquide scintillant (détecteur central). La prise des données a commencé le 16 août 2025. Ce veut dire que l'étudiant pourra analyser les toutes premières données de

JUNO acquises en fin 2025 et 2026.

Les muons cosmiques vont représenter une des contributions les plus importantes au bruit de fond sur JUNO, et ils seront détectés avec une grande statistique déjà dans la première phase de l'expérience. Le groupe de JUNO à l'IIHE participe aux activités sur la détection et l'étude des événements atmosphériques (muons et neutrinos) aux énergies du GeV. Le premier

sujet proposé est consacré à l'étude de ces événements.

A basse énergie (MeV), JUNO aura dans un premier temps deux objectifs clés : i) calibrer le détecteur afin de déterminer l'énergie des particules (valeur absolue) au MeV avec une précision

$<1\%$ et ii) sélectionner des coïncidences entre des signaux rapides et retardés produits dans des processus de désintégration beta inverse (IBD), avec une bonne caractérisation des

coïncidences fortuites (bruit de fond) pour ce type d'événements. Les deuxième et troisième sujets proposés vont aider à accomplir ces objectifs.

Calibration en énergie du détecteur JUNO avec des sources à neutrons

- L'étudiant va se familiariser avec les sources à neutrons (AmBe et AmC) utilisées pour la calibration en énergie de JUNO, ainsi qu'avec le format des données de calibration. Il va analyser les données de calibration des sources AmBe et AmC pour obtenir les distributions de la charge.

- L'étudiant va ensuite établir la relation entre l'énergie déposée et la charge détectée (nombre de photoélectrons). Pour cela, l'étudiant va faire la sélection d'événements (coupures en charge, reconstruction du vertex et délais temporels). Il va aussi réaliser une comparaison entre les données et la simulation Monte-Carlo. Les données et les simulations pour cette étude seront fournies à l'étudiant.
- Finalement la résolution en énergie du détecteur sera mesurée. Cette mesure est cruciale pour l'expérience.

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

Encadrement

Promoteur : Nicolas Pauly

Contact : Nicolas.Pauly@ulb.be

Co-encadrant : Barbara Clerbaux

Contact : barbara.clerbaux@ulb.be

Construction of simplified nucleon-nucleon potentials from supersymmetric quantum mechanics

Programme : Physical engineering - M- IRPH

Description

The nucleon–nucleon interaction is intrinsically complex. Owing to the quark substructure of nucleons, it includes central, spin-orbit, and tensor components that depend on spin, parity, and isospin quantum states. This complexity significantly complicates both nuclear structure and scattering calculations. Consequently, the search for a simpler effective interaction could have a profound impact on the field of nuclear physics.

This idea was first explored in 2002 [1] using an inversion technique, i.e., a method that enables the systematic construction of interaction potentials from scattering data. Based on supersymmetric quantum mechanics (SUSYQM) [2, 3], this approach has recently been generalized and simplified, leading to new analytical nucleon-nucleon potentials [4]. However, challenges remain regarding the numerical implementation of these potentials, which currently prevents their direct use in systematic searches for simplified interactions and in revisiting the original ideas of Ref. [1].

The aim of the present work is therefore twofold: first, to develop a numerically tractable version of the potentials derived in [4]; and second, to use these potentials to investigate simplified nucleon-nucleon interactions. To this end, analytic, symbolic, and numerical methods will be employed. The primary programming language will be Python, possibly interfaced with Fortran to leverage existing subroutines, and supplemented by Mathematica if necessary. In addition, a graphical user interface (GUI) for SUSYQM inversion may be developed within the open-source PP (Potential Program) project [5].

[1] J.-M. Sparenberg, Eur. Phys. Lett. 59 (2002) 507

[2] D. Baye and J.-M. Sparenberg, J. Phys. A 37 (2004) 10223

[3] D. Baye, J.-M. Sparenberg, A. M. Pupasov, B. F. Samsonov, J. Phys. A 47 (2014) 243001

[4] Q. Bozet and J.-M. Sparenberg, J. Phys. A 59 (2026) 095303

[5] <https://gitlab.ulb.be/jmspar/PP>

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

Encadrement

Promoteur : Jean-Marc Sparenberg

Contact : jmspar@ulb.ac.be

Lien : <https://mycloud.ulb.be/index.php/s/fsFW76RbTg65E4L>

Optimization of vacuum laser acceleration of electrons using structured light

Programme : Physical engineering - M- IRPH

Description

Standard light beams generally cannot impart a net energy on a freely charged particle. The particles will oscillate and displace a small amount, but the net transfer of energy is traditionally zero. However, with vectorial structured light pulses, free electrons can be accelerated to relativistic energies. This result is thought to be promising for a novel source of ultrashort electron bunches, but it also an interesting fundamental test on how to optimize such an interaction using the optical field structure. We have developed a fully arbitrary simulation framework where we seek to globally optimize this interaction. The parameter space is large, so the student would be tasked with refining or expanding the physical model, choosing the fitness function for optimization, testing different optimization algorithms, and finally physically interpreting the found optimum. The documentation link directs you towards a recent experimental result where these simulations provided key physical insights, which is a motivation for this masters project.

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

Encadrement

Promoteur : Spencer Jolly

Contact : spencer.jolly@ulb.be

Lien : <https://doi.org/10.1103/PhysRevLett.133.155001>

CFD & Accident studies description

Programme : Physical engineering - M- IRPH

Description

You will work with the CFD & Accident Studies team. The group performs thermal-hydraulic calculations related to the normal, incidental and accidental functioning of Nuclear Power Plants (NPPs) including Severe Accidents leading to core degradation. The team is composed of about 20 engineers dedicated to design, plant support and licensing activities linked to nuclear applications, i.e. deterministic design basis and beyond basis accidents using TH system codes, deterministic severe accidents, design and root cause analysis using CFD and system codes,...

The studies in these domains require a large set of codes and tools, together with related validation databases. To remain competitive and to diversify its competencies to the new generation of reactors, Tractebel continuously follows the evolution of codes and methods used in such domain of application.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Self-consistent 1D Fokker-Planck and wave equation coupled solvers for hot magnetised plasmas

Programme : Physical engineering - M- IRPH

Description

Description is available on the U.V.

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

Encadrement

Promoteur : Yves LOUIS

Contact : yves.louis@ulb.be

Co-encadrant : Vincent MAQUET

Contact : vincent.maquet@ulb.be

Computational Fluid Dynamics subjects - Improvement of the Reduced Order Model developed to optimize the cask management process

Programme : Physical engineering - M- IRPH

Description

We are looking to develop even further some Reduced Order Model (ROM) created to optimize the storage of the spent fuel within casks – the usual dry spent fuel storage path). Tractebel developed in the past years a ROM allowing to quickly predict the spent fuel cask surface temperature using some CFD evaluations as inputs (considering convection and radiation heat transfer). The work proposed is extend the capability of the ROM by considering Bayesian Optimization to improve the simplified model while using it to optimize the positioning of the casks within the spent fuel storage building.

This involves that:

- You will develop competences in the use of the CFX or Fluent software;
- You will develop competences in the use of Python and the associated pyDOE2 (language used to develop the ROM) ;
- You will develop knowledge on the spent fuel management in Belgium;
- Writing a scientific report.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Rotation-free geometric multigrid for linear elasticity

Programme : Physical engineering - M- IRPH

Description

see link

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

Encadrement

Promoteur : Artem NAPOV

Contact : artem.napov@ulb.be

Co-encadrant : Yvan NOTAY

Lien : http://metronu.ulb.ac.be/anapov/MFE/MFE_GNAMN.pdf

Assessing the constant in Korn's inequality

Programme : *Physical engineering - M- IRPH*

Description

see link

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

Encadrement

Promoteur : Artem NAPOV

Contact : artem.napov@ulb.be

Co-encadrant : Yvan NOTAY

Contact : artem.napov@ulb.be

Lien : http://metronu.ulb.ac.be/anapov/MFE/MFE_GNAMN.pdf

System Thermal hydraulics subjects - ATHLET – ATLAS benchmark

Programme : Physical engineering - M- IRPH

Description

Tractebel is working with the USNRC thermal hydraulics system codes since many years. As such, Tractebel developed multiple in-house methodologies aiming to reproduce as best as possible key physical phenomena considering Separate and Integral Effects Tests.

Tractebel recently acquired ATHLET – the System Thermal hydraulics code developed by GRS – which allow to model systems considering liquid metal and molten salt in addition to the more traditional liquid/steam water systems. In the frame of the OECD/NEA international ATLAS research project, Tractebel received the reference model developed by GRS to reproduce the C2.3 test (Steam line break with PAFS operation) for which Tractebel has a TRACE model. The student will analyse and compare the responses predicted by both codes. If required, model adaptations will be proposed and tested with the aim of improving Tractebel's capabilities to develop ATHLET water based models.

This involves that:

- You will develop competences in the use of the ATHLET and/or TRACE software;
- You will develop knowledge on the functioning of Pressurized Water Reactor;
- You will perform simulations in steady-state and/or in transient modes;
- Writing a scientific report.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Computational Fluid Dynamics subjects - Pressurized Thermal Shock (PTS) validation work

Programme : Physical engineering - M- IRPH

Description

We are looking to develop our capabilities to adequately predict PTS events which is a critical safety concern for nuclear reactors. It involves the rapid cooling of the reactor pressure vessel (RPV) due to emergency cooling water injection, which can lead to thermal stresses and potential cracking.

CFD helps in modeling the complex thermal-hydraulic interactions during a PTS event, including the mixing of hot and cold fluids, heat transfer, and fluid flow dynamics. Tractebel initiated an internal work aiming to reproduce the experimental results obtained on the ROCOM experimental facility dedicated to represent PTS events. As such, the student will take over this initial work with the aim of performing additional parametric and sensitivity analyses trying to improve our internal methodologies.

This involves that:

- You will develop competences in the use of Fluent software;
- You will develop knowledge on the functioning of Pressurized Water Reactor;
- You will perform simulations in transient modes;
- Writing a scientific report.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Interference effect for interface excitations with overlayer systems

Programme : *Physical engineering - M- IRPH*

Description

The inelastic mean free path (IMFP) is the key parameter for Monte Carlo simulations of electron trajectories in solid materials. In most of the cases the IMFP is defined for infinite medium, but for very thin layers as developed today in transistors, this approximation is no more valid. Indeed, interface excitations could play a non-negligible role in energy losses and thus in electron paths. The solution is to use a local IMFP considering interface excitations and thus depending on electron position.

Calculations of this local IMFP was already performed for a bilayer sample and it was shown that interface effect extended to several angstroms on both sides of the interface. If we consider an overlayer systems composed of several layers of a few nanometers, we will have an interference effect between two non-adjacent layers. The goal of this work is to calculate this interference effect.

Up to now, calculations of interference effect have been performed in cylindrical coordinates, which do not completely satisfy energy and momentum conservation laws. In this work, calculations will be performed in spherical coordinates.

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

Encadrement

Promoteur : Nicolas Pauly

Contact : Nicolas.Pauly@ulb.be

Energy and momentum considerations in multimode nonlinear optics

Programme : Physical engineering - M- IRPH

Description

Multimode nonlinear optics has shown significant promise for applications and presents interesting fundamental questions in terms of modal interactions and soliton formation in optical waveguides, among other things. New progress in this field has been primarily pushed by new and powerful simulation algorithms, which will be the focus and the main tool of this project. Firstly, one nuance of optical waveguides is that higher-order modes have a higher energy loss along propagation, which is accentuated further in photonic-integrated circuits by scattering on the waveguide walls. The impact of this fact is not clear on novel nonlinear multimode processes, so it will be modeled and the effect will be quantified. Secondly, when multiple modes of a waveguide are excited in specific ways, different forms of orbital angular momentum (OAM) can be transported in the fiber, but it has not been studied in detail how fiber geometry or type will affect this transport, nor the fundamental explanation for those differences. The project will focus on an area of interest to the student based on initial investigations.

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

Encadrement

Promoteur : Spencer Jolly

Contact : spencer.jolly@ulb.be

Co-encadrant : Pascal Kockaert

Contact : pascal.kockaert@ulb.be

Determinist Severe Accident: Severe Accident Code Benchmarking for Radiological Source Term Assessment (MELCOR / ASTEC)

Programme : Physical engineering - M- IRPH

Description

The assessment of radiological source terms is a key element of nuclear safety analyses, particularly in the context of Design Extension Conditions (DEC) as defined by WENRA. System-level severe accident codes such as MELCOR and ASTEC are widely used to simulate accident progression, including core degradation, fission product release, transport and retention within the reactor coolant system and containment. Despite their maturity, significant uncertainties remain in the modelling of severe accident phenomena, making code-to-code comparisons and benchmark analyses essential.

The objective of this subject is to revisit a reference WENRA DEC-B severe accident analysis by performing simulations with ASTEC, and to compare the results with available MELCOR reference results. The student will analyse and compare the accident sequence evolution (core heat-up, melting, vessel and containment behaviour) and the resulting radiological source term (timing, magnitude and composition of releases). Attention will be paid to identifying differences in modelling assumptions, physical models and numerical treatment between the two codes, and to assessing their impact on the predicted source term. This work contributes directly to Tractebel's expertise in severe accident analysis and regulatory-oriented safety assessments.

The work will involve:

- Learning and using the ASTEC severe accident simulation code
- Understanding WENRA DEC-B scenarios and severe accident phenomenology
- Performing system-level steady-state and transient severe accident simulations
- Conducting a code-to-code comparison (ASTEC vs MELCOR) of accident progression and radiological source terms
- Analysing uncertainties and modelling differences affecting source term predictions
- Writing a scientific report

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

System Thermal hydraulics subjects - ATHLET – Phénix Benchmark

Programme : Physical engineering - M- IRPH

Description

Tractebel has recently acquired ATHLET, the system thermal-hydraulics code developed by GRS, which enables the modelling of reactor systems involving liquid metals and molten salts, in addition to conventional liquid water and steam systems. These working fluids are central to Generation IV reactor concepts, for which system-code validation is still an active topic at the international level. One of the key benchmarks for validating thermal-hydraulic system codes for sodium-cooled fast reactors is the Natural Circulation Test performed during the end-of-life experiments of the Phénix reactor. This experiment was part of an IAEA Coordinated Research Project, aimed at assessing the behaviour of sodium fast reactors under natural circulation conditions. Tractebel has developed its own ATHLET model of the Phénix reactor, calibrated to match Hot Full Power (HFP) operating conditions. Starting from this reference model, the student will implement the Natural Circulation Test transient specifications and analyse the simulation results through comparison with experimental data and/or reference ATHLET or other system-code results available in the literature.

This involves that:

- You will develop competences in the use of the ATHLET software;
- You will develop knowledge on the functioning of GenIV type reactors;
- You will perform simulations in steady-state and/or in transient modes;
- Writing a scientific report.

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Self-consistent study of spontaneous excitation in the ion cyclotron range of frequencies with the hybrid method

Programme : Physical engineering - M- IRPH

Description

Description is available on the U.V.

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

Encadrement

Promoteur : Yves LOUIS

Contact : yves.louis@ulb.be

Co-encadrant : Vincent MAQUET

Contact : vincent.maquet@ulb.be

Détection et étude des neutrinos issus des réacteurs dans les données JUNO, et estimation du taux de bruit de fond dû aux coïncidences fortuites

Programme : *Physical engineering - M- IRPH*

Description

L'observatoire souterrain de neutrinos de Jiangmen (Jiangmen Underground Neutrino Observatory ou JUNO) est une expérience en Chine destinée à l'étude des neutrinos. Le but principal de JUNO est de mesurer très précisément le spectre en énergie (entre 2 et 10 MeV) des neutrinos provenant de deux centrales nucléaires situées à ~53 km de distance.

D'autres sources de neutrinos (neutrinos atmosphériques, neutrinos solaires, géoneutrinos, ...) sont aussi étudiées.

Le détecteur est constitué d'une sphère centrale de 35 m de diamètre remplie de 20 kton de scintillateur liquide et entourée de 20000 photomultiplicateurs (PMTs) pour détecter la lumière produite par les particules créées lors des interactions des neutrinos avec les noyaux d'hydrogène et carbone. Deux systèmes de vetos permettent d'éliminer le bruit de fond venant des muons cosmiques.

La construction du détecteur s'est terminée fin 2024, suivi du remplissage en eau ultra pure (véto de muon) et en liquide scintillant (détecteur central). La prise des données a commencé le 16 août 2025. Ce veut dire que l'étudiant pourra analyser les toutes premières données de JUNO acquises en fin 2025 et 2026.

Les muons cosmiques vont représenter une des contributions les plus importantes au bruit de fond sur JUNO, et ils seront détectés avec une grande statistique déjà dans la première phase de l'expérience. Le groupe de JUNO à l'IIHE participe aux activités sur la détection et l'étude des événements atmosphériques (muons et neutrinos) aux énergies du GeV. Le premier sujet proposé est consacré à l'étude de ces événements.

A basse énergie (MeV), JUNO aura dans un premier temps deux objectifs clés : i) calibrer le détecteur afin de déterminer l'énergie des particules (valeur absolue) au MeV avec une précision <1% et ii) sélectionner des coïncidences entre des signaux rapides et retardés produits dans des processus de désintégration beta inverse (IBD), avec une bonne caractérisation des coïncidences fortuites (bruit de fond) pour ce type d'événements. Les deuxième et troisième sujets proposés vont aider à accomplir ces objectifs.

Détection et étude des neutrinos issus des réacteurs dans les données JUNO, et estimation du taux de bruit de fond dû aux coïncidences fortuites

- L'étudiant va apprendre dans un premier temps la méthode de détection des neutrinos des réacteurs dans JUNO : la physique de l'interaction IBD (Inverse Beta Decay). Il va aussi se familiariser avec les données de JUNO et le détecteur.
- L'étudiant va ensuite analyser les premières données de JUNO. Il va implémenter l'algorithme pour chercher des coïncidences IBD (critères de sélection) et il va l'appliquer aux données. Il va comparer les données avec des simulations des neutrinos de réacteur pour déterminer l'efficacité de la sélection et le taux de coïncidences fortuites.

- Finalement, la toute première mesure de JUNO du spectre en énergie des neutrinos de réacteur sera présentée.

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

Encadrement

Promoteur : Nicolas Pauly

Contact : Nicolas.Pauly@ulb.be

Co-encadrant : Barbara Clerbaux

Contact : barbara.clerbaux@ulb.be

Production of medical isotopes in aqueous homogeneous reactors

Programme : *Physical engineering - M- IRPH*

Description

Nuclear Reactor Physics and Safety

Certain important medical isotopes, such as Tc-99m, are produced via nuclear reactions in centralised nuclear-reactor facilities. Belgium is one of the top-leading suppliers at world scale, from the production of Mo-99 in the BR2 reactor at SCK CEN to its postprocessing into Tc-99m at the Institut des Radioéléments (IRE) in Fleurus. Considering the growing demand in such radioisotopes and the current capacity of limited and aging production infrastructures in the world, an alternative is to develop small, dedicated reactors for local production. For example, aqueous homogeneous reactors are promising since they could provide a high yield per unit power, while allowing to produce the isotopes closer to the demand.

A master-degree thesis is proposed to characterise such a reactor core and optimise it towards medical isotope production, taking into account the timing and method of extraction, and the important safety parameters affected by the optimisation.

The type of thesis is computational. More details (type of software etc) will be discussed with the applicant.

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

Encadrement

Promoteur : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Co-encadrant : PIERRE-ETIENNE LABEAU

Contact : pierre.etienne.labeau@ulb.be

Probabilistic Severe Accident: Dynamic Probabilistic Safety Assessment (PSA) Prototyping Tool

Programme : Physical engineering - M- IRPH

Description

Traditional Probabilistic Safety Assessment (PSA) methods are largely based on static event trees and fault trees, which may face limitations when dealing with complex time-dependent phenomena, operator actions and dynamic system interactions. Dynamic PSA (DPSA) approaches aim to overcome these limitations by coupling system simulations with probabilistic models, allowing a more realistic representation of accident sequences and their evolution over time. In the framework of the potential BE-SAINT project, Tractebel is investigating the applicability and actual implementation of such dynamic approaches for advanced safety assessments.

The objective of this subject is to assess and prototype capabilities for generating dynamic event trees, focusing on key DPSA functionalities such as branch resampling, multi-level simulation assessment, and independent calculation sequence handling. The student will explore existing methodological approaches to DPSA, define a suitable prototype architecture, and implement or adapt simplified tools or workflows to demonstrate these capabilities on representative test cases. Emphasis will be placed on understanding how dynamic tree generation can support safety-relevant analyses, improve scenario coverage, and manage combinatorial complexity. This work will contribute to Tractebel's strategic capability development in next-generation PSA methodologies.

The work will involve:

- Gaining knowledge of classical and dynamic PSA concepts
- Reviewing existing Dynamic PSA methodologies and tools
- Defining requirements for a dynamic event tree prototyping framework
- Implementing and testing key functionalities (e.g. resampling strategies, multi level assessments, sequence handling)
- Applying the prototype to simplified illustrative scenarios
- Analysing strengths, limitations and perspectives of the approach
- Writing a scientific and/or technical report

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Post-Accident Heat Removal (PAHR) in Fast Reactors

Programme : Physical engineering - M- IRPH

Description

Nuclear Reactor Physics and Safety

The safety analysis of nuclear reactors requires to consider scenarios in which damage to the reactor core happens and the coolability of the nuclear fuel, that produces decay heat, is altered. This extends to the relocation of fuel to areas of the reactor vessel that need to be cooled properly to avert thermal damage. Considering the renewed interest in fast reactors, using liquid-metal coolants, modelling and validation of PAHR for this kind of systems becomes an important issue to perform sound safety analysis.

A master-degree thesis is proposed in the framework of nuclear thermo-hydraulics with liquid metals, starting from the reproduction of in-pile experiments performed in the late eighties with sodium coolant with modern computational codes, followed by investigations with other liquid-metal coolants such as molten lead, which is relevant for the Belgian program carried out at SCK CEN to develop a prototype of a fast, lead-cooled SMR (Small Modular Reactor).

The type of thesis is computational. More details (type of software etc) will be discussed with the applicant.

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

Encadrement

Promoteur : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Co-encadrant : PIERRE-ETIENNE LABEAU

Contact : pierre.etienne.labeau@ulb.be

Construction of coupled-channel potentials with threshold difference from supersymmetric quantum mechanics

Programme : Physical engineering - M- IRPH

Description

Supersymmetric quantum mechanics (SUSYQM) is a powerful tool for solving the inverse scattering problem, i.e. for constructing interaction potentials from scattering data [1, 2]. While the method is complete for single-channel systems and for coupled-channel systems with equal thresholds, the case of coupled channels with different thresholds remains challenging. In this situation, only a single potential has been constructed so far, based on a non-conservative SUSYQM transformation [2]. However, more sophisticated potentials exist that are derived from integral equations [3], which are known to be equivalent to SUSYQM in the single-channel case for separable kernels.

The aim of this work is to investigate recent results obtained for coupled-channel systems with threshold differences using integral equations with separable kernels, and to seek a systematic SUSYQM formulation of these results. This study will combine analytical developments with symbolic and numerical calculations. If successful, test potentials could be constructed for applications in nuclear physics [4] and atomic physics [5]. The primary programming language will be Python, possibly interfaced with Fortran to take advantage of existing subroutines, and supplemented by Mathematica if needed. In addition, a graphical user interface (GUI) for coupled-channel SUSYQM inversion may be developed within the framework of the PP (Potential Program) open-source project [6].

- [1] D. Baye and J.-M. Sparenberg, J. Phys. A 37 (2004) 10223
 [2] D. Baye, J.-M. Sparenberg, A. M. Pupasov, B. F. Samsonov, J. Phys. A 47 (2014) 243001
 [3] J. R. Cox, J. Math. Phys. 5 (1964) 1065, J. Math. Phys. 16 (1975) 1402
 [4] N. A. Khokhlov, Phys. Rev. C 111 (2025) 034004
 [5] A. M. Pupasov, B. F. Samsonov and J.-M. Sparenberg, Phys. Rev. A 77 (2008) 012724
 [6] <https://gitlab.ulb.be/jmspar/PP>

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

Encadrement

Promoteur : Jean-Marc Sparenberg

Contact : jmspar@ulb.ac.be

Lien : <https://mycloud.ulb.be/index.php/s/fsFW76RbTg65E4L>

System Thermal hydraulics subjects - Containment Thermal-Hydraulics Benchmarking: COCOSYS / TRAPCON Comparison

Programme : Physical engineering - M- IRPH

Description

The prediction of containment behaviour following a Loss-of-Coolant Accident (LOCA) is a key aspect of nuclear safety analysis, particularly for assessing pressure, temperature and long-term integrity of the containment. Lumped-parameter containment codes such as COCOSYS and TRAPCON are widely used for this purpose, each relying on different modelling assumptions and correlations for heat and mass transfer, condensation and recirculation phenomena.

Tractebel has developed an internal COCOSYS model of a reference reactor containment, which forms the basis of this subject. The objective is to simulate the long-term containment thermal-hydraulic response after a LOCA, with a particular focus on the post-blowdown and recirculation phase. Using the existing COCOSYS model, the student will perform transient simulations covering the evolution of pressure and temperature, and will compare the results with reference calculations performed with TRAPCON (in-house Tractebel software). The analysis will focus on identifying differences in predicted containment response, understanding their physical and modelling origins, and assessing the sensitivity of key safety parameters to containment modelling assumptions. This benchmark-type work contributes directly to code validation and to the robustness of containment safety assessments.

The work will involve:

- Learning and using COCOSYS for containment thermal-hydraulic analysis
- Understanding LOCA phenomenology and long-term containment behaviour
- Performing transient simulations including the containment recirculation phase
- Comparing COCOSYS results with reference TRAPCON calculations
- Analysing discrepancies related to modelling assumptions and correlations
- Synthesizing results into a scientific and technical report

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

Encadrement

Promoteur : Pierre-Etienne Labeau

Contact : pierre.etienne.labeau@ulb.be

Co-encadrant : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Lien : <https://tractebel-engie.com/en-be/>

Microscopic quantum scattering modeling of a schematic 1D quantum measurement apparatus

Programme : Physical engineering - M- IRPH

Description

A possible explanation for the seemingly random outcomes of quantum measurements is that these outcomes are in fact determined by the microscopic state of the measuring device [1]. A well-known example is the so-called Mott problem, i.e. the detection of a spherical wave (as in alpha radioactivity) in an ionization tracking chamber (such as a cloud chamber or wire chamber). The observation of straight tracks, which appears inconsistent with an initially spherical wave emission, may instead be explained by the specific positions of the detector constituents (atoms or molecules).

This hypothesis was recently investigated in a two-dimensional setting using a highly simplified model, in which the particle-atom interaction is represented by a contact term and atomic excitations are neglected [2]. Initial indications of directional behavior were observed in this framework [3].

The present work aims to test this hypothesis in a one-dimensional model of a schematic gaseous detector [4], where atomic excited states, as well as ionization, could be included. This is achieved through a numerical solution (implemented in Python) of the time-independent and/or time-dependent Schrödinger equations, using both Green's function formalism and the transfer-matrix method.

[1] J.-M. Sparenberg, R. Nour and A. Manço, EPJ web of conferences 58 (2013) 01016

[2] D. Gaspard and J.-M. Sparenberg, Phys. Rev. A 109 (2024) 062211

[3] B. Lorent, D. Gaspard and J.-M. Sparenberg, arXiv:2603.12432 [quant-ph]

[4] J.-M. Sparenberg and D. Gaspard, Found. Phys. 48 (2018) 429

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

Encadrement

Promoteur : Jean-Marc Sparenberg

Contact : jmspar@ulb.ac.be

Lien : <https://mycloud.ulb.be/index.php/s/fsFW76RbTg65E4L>

Fast-Reactor Kinetics

Programme : Physical engineering - M- IRPH

Description

Nuclear Reactor Physics and Safety

Considering the renewed interest in fast reactors, their dynamic behaviour is of great impact for operational and safety concerns. These dynamics are governed by the neutron population in the reactor core of which the variation in time (reactor kinetics) is affected by the changes of temperature in the core components following the change in the reactor power that is established by the neutron population.

A master-degree thesis is proposed in the framework of fast-reactor kinetics, first by studying and modelling the transient behaviour in sodium fast reactors built and operated from the seventies to the nineties of the past century, then improving the methodologies or extending the developed modelling to modern designs, such as liquid-lead ones, which is relevant for the Belgian program carried out at SCK CEN.

The type of thesis is computational. More details (type of software etc) will be discussed with the applicant.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IREMR-E
Nombre de sujets	1 - 2

Encadrement

Promoteur : Matteo Zanetti

Contact : matteo.zanetti@ulb.be

Co-encadrant : PIERRE-ETIENNE LABEAU

Contact : pierre.etienne.labeau@ulb.be

Identification des différents types de neutrinos atmosphériques dans JUNO en utilisant des algorithmes de machine learning

Programme : Physical engineering - M- IRPH

Description

L'observatoire souterrain de neutrinos de Jiangmen (Jiangmen Underground Neutrino Observatory ou JUNO) est une expérience en Chine destinée à l'étude des neutrinos. Le but principal de JUNO est de mesurer très précisément le spectre en énergie (entre 2 et 10 MeV) des neutrinos provenant de deux centrales nucléaires situées à ~53 km de distance.

D'autres sources de neutrinos (neutrinos atmosphériques, neutrinos solaires, géoneutrinos, ...) sont aussi étudiées.

Le détecteur est constitué d'une sphère centrale de 35 m de diamètre remplie de 20 kton de scintillateur liquide et entourée de 20000 photomultiplicateurs (PMTs) pour détecter la lumière produite par les particules créées lors des interactions des neutrinos avec les noyaux d'hydrogène et carbone. Deux systèmes de vetos permettent d'éliminer le bruit de fond venant des muons cosmiques.

La construction du détecteur s'est terminée fin 2024, suivi du remplissage en eau ultra pure (véto de muon) et en liquide scintillant (détecteur central). La prise des données a commencé le 16 août 2025. Ce veut dire que l'étudiant pourra analyser les toutes premières données de JUNO acquises en fin 2025 et 2026.

Les muons cosmiques vont représenter une des contributions les plus importantes au bruit de fond sur JUNO, et ils seront détectés avec une grande statistique déjà dans la première phase de l'expérience. Le groupe de JUNO à l'IIHE participe aux activités sur la détection et l'étude des événements atmosphériques (muons et neutrinos) aux énergies du GeV. Le premier sujet proposé est consacré à l'étude de ces événements.

A basse énergie (MeV), JUNO aura dans un premier temps deux objectifs clés : i) calibrer le détecteur afin de déterminer l'énergie des particules (valeur absolue) au MeV avec une précision <1% et ii) sélectionner des coïncidences entre des signaux rapides et retardés produits dans des processus de désintégration beta inverse (IBD), avec une bonne caractérisation des coïncidences fortuites (bruit de fond) pour ce type d'événements. Les deuxième et troisième sujets proposés vont aider à accomplir ces objectifs.

Identification des différents types de neutrinos atmosphériques dans JUNO en utilisant des algorithmes de machine learning:

- L'étudiant va d'abord travailler avec les données et les simulations de JUNO, et va obtenir les distributions des paramètres d'intérêt pour le classement entre les différents types de neutrinos atmosphériques.
- L'étudiant va ensuite se familiariser avec les algorithmes d'intelligence artificielle. Il va implémenter un modèle machine learning pour séparer cinq classes d'interactions pour les

neutrinos atmosphériques : interactions des neutrinos électroniques à courant chargé, interactions des anti-neutrinos électroniques à courant chargé, interactions des neutrinos muoniques à courant chargé, interactions des anti-neutrinos muoniques à courant chargé, et interactions à courant neutre (toutes les saveurs). Le modèle sera entraîné avec une simulation JUNO.

- Enfin l'étudiant appliquera l'algorithme à l'échantillon de neutrinos atmosphériques obtenu avec les premières données de JUNO et effectuera une toute première mesure d'oscillation des neutrinos atmosphériques dans JUNO.

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

Encadrement

Promoteur : Nicolas Pauly

Contact : Nicolas.Pauly@ulb.be

Co-encadrant : Barbara Clerbaux

Contact : barbara.clerbaux@ulb.be

Topics offered to students by other
master's programs

TARGET PROGRAM

Physical Engineering

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

Improved adenoid hypertrophy treatment through nasal replicas

Description

Context: Adenoid hypertrophy is the pathologic enlargement of the tonsils at the back of the nose. It is one of the most common no-infectious ENT affection in children with a prevalence of about over 30%. Nowadays, the first-line treatment of adenoid hypertrophy is corticosteroid nasal sprays. While half of the patients shows improvement with this treatment, it is ineffective for the other half. 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.

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

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

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

Description

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

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

Supervision

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

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

Implementation of an electrode to stimulate Vagus Nerve

Description

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

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

Supervision

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

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

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

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.

Language	EN (english)
Open to other master's programs	Yes
Eligible master's programs	M-IRMAE, M-IRPH

Number of topics	1
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Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

Description

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

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

Supervision

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

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

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

Description

Context: Over the last years, the respiratory drug delivery has drawn a strong interest due to the large surface area of the airway mucosa, providing an easy access to the blood. In particular, nasal sprays intending to treat non-local disorders, like migraine or hypoglycaemia, have appear. Compared to oral medicines, they are easier to use, act faster and can be given to unconscious patients. 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.

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

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

Dynamically Tunable Hydrogels for Vascular Stiffness Modulation

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.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

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)

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 : Dhont Jennifer (jennifer.dhont@ulb.be)

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

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

Description

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

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

Supervision

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

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

Acoustic cough analysis

Description

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

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

Supervision

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

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

Light-Responsive Sacrificial Hydrogels for 3D Bioprinting Applications

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

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

Modular Volumetric Bioprinted Vascular Models to Study Cell–Flow Interactions

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.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

Description

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

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

Supervision

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

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

Master thesis in microfluidics

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 unilamellar vesicles, confined Leidenfrost, coalescence, subretinal injection, blood testing by elastocapilarity, organoid encapsulation, ...

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

Supervision

Supervisor : Scheid Benoit (Benoit.Scheid@ulb.be)

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

Signal quality in intraneural and extraneural electrodes

Description

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

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

Supervision

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

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

Biophysics of Red Blood Cells and Platelets

Description

This project explores the physical behavior of blood, focusing on red blood cells (RBCs) and platelets (PLTs), which play a key role in processes such as thrombosis and hemorrhage. Blood is a complex fluid composed of deformable and electrically charged cells, making its dynamics difficult to model and understand. The project combines experimental and numerical approaches to investigate how cell shape variability and interactions influence blood flow behavior. A particular focus is placed on platelet transport mechanisms, including unconventional dynamics such as Lévy-flight-like motion observed under certain conditions. Additionally, the role of electrical charges on RBC interactions will be studied by applying electric fields in flow experiments. Overall, the work aims to deepen fundamental understanding of blood biophysics with potential implications for medical research and diagnostics.

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

Supervision

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

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

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

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.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

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.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M- IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

Optimized GNNs for Interpretable Brain Connectivity

Description

This project explores the use of Graph Neural Networks (GNNs) to analyze brain connectivity for epilepsy diagnosis. Brain connectivity captures interactions between brain regions and provides richer information than traditional EEG analysis. While previous machine learning approaches showed promising results, more complex GNNs have not yet achieved optimal performance. The objective is to design improved GNN architectures that enhance predictive accuracy. A second key goal is to incorporate explainable AI methods to identify clinically meaningful brain subnetworks. This work bridges advanced machine learning with interpretable neuroscience.

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

Supervision

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

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

Electrical modeling and control of cold atmospheric plasma for endoscopes

Description

This project investigates the use of cold atmospheric plasma (CAP) for disinfecting endoscope channels. CAP shows strong antimicrobial potential but introduces thermal risks that could damage sensitive medical devices. The work aims to build an electrical and electro-thermal model linking plasma operation to temperature effects. Based on this model, control strategies will be developed to regulate temperature while maintaining disinfection efficiency. Experimental validation will compare open-loop and closed-loop performance. The final objective is a safe, optimized plasma-based sterilization approach for medical applications.

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

Supervision

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

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

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

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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRIFS, M-IRPH
Number of topics	1

Supervision

Supervisor : Haut Benoit (Benoit.Haut@ulb.be)

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

Tracing slow relaxation modes in polymer thin films

Description

Relaxation of mechanical stresses is central to many technological applications as it controls a plethora of critical behaviors in polymer materials ranging from polymer dewetting to creep in organic electronics. Controlling and predicting stress relaxations is therefore crucial for material stability and remains an open question which limits our predictive power and force us to keep a trial and error approach in material synthesis. One of the main reasons beyond these limitations is the difficulty of tracking relaxation behavior in polymer films (<10 μm) deep in the glassy state, where microscopic dynamics is extremely slow and responsible microscopic motions are unknown. During this thesis the student will tackle this problem by applying a novel method in dynamical mechanical analysis, namely, static square-wave mechanical spectroscopy (SSWMS), which allows accessing extremely slow relaxation modes in polymer materials in relatively short time. Supported by the research team, the student will:

- 1) Implement the SSWMS procedure on different DMA instruments,
- 2) Develop a script (Python, Matlab,...) to analyse the experimental data,
- 3) Validate the protocol on standard polymer films and extract their ultra-slow mechanical properties.

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

Supervision

Supervisor : Van Assche Guy (Guy.Van.Assche@vub.be)

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

Tailored Hydrochar from Seafood Waste via Microwave-Assisted Hydrothermal Carbonization for Pollutant Removal from Water

Description

Seafood-processing waste, particularly lobster shell residues, represents an abundant and underutilized biomass resource with strong potential for conversion into functional carbon-based materials. Hydrothermal carbonization (HTC), especially when assisted by microwave heating, enables efficient processing of wet biomass without the need for energy-intensive drying. This project aims to develop tailored hydrochar from seafood waste, such as lobster shell waste, via microwave-assisted hydrothermal carbonization (MHTC) and to evaluate its performance in removing pollutants (such as Rhodamine B/ methylene blue) from aqueous systems. Key process parameters, including temperature, residence time, and solid-to-water ratio, will be optimized using a design-of-experiments approach, with the response being pollutant removal under fixed conditions of pH, contact time, and dye concentration. The produced materials will be characterized using CHNS analysis, FTIR spectroscopy, and proximate analysis. Adsorption performance will be evaluated through batch experiments to assess the effects of pH, contact time, dye concentration, and other influential parameters. UV-visible spectroscopy will be used to quantify dye removal. The project will establish relationships between hydrochar production conditions, surface chemistry, and adsorption performance, demonstrating a sustainable approach for converting seafood waste into functional adsorbents.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

Development of PEG/Hydrochar Composite Materials Derived from Seafood Waste for Sustainable Functional Applications

Description

The integration of biomass-derived carbon materials into polymer matrices offers new opportunities for sustainable material development. Hydrochar derived from seafood waste serves as a low-cost, tunable carbon filler, while polyethylene glycol (PEG) provides a versatile, hydrophilic polymer matrix. This project aims to develop PEG/hydrochar composite materials using hydrochar derived from seafood waste, such as lobster shell waste, via microwave-assisted hydrothermal carbonization. Hydrochar will be incorporated into PEG at varying loadings to produce composite materials with tailored properties. The influence of hydrochar incorporation on rheological behavior, mechanical properties, and structural characteristics will be investigated. Rheological testing, mechanical analysis, FTIR spectroscopy, and microscopy will be used to assess material performance and interactions between hydrochar and PEG. The project will explore how hydrochar content and processing conditions affect composite functionality and will demonstrate the feasibility of using seafood-derived carbon materials in sustainable composite systems.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

Enhancing Hydrochar Quality Derived from Seafood Waste via Co-Carbonization with Glucose and Fruit Waste: A Comparative Study

Description

Improving the carbon content and surface functionality of hydrochar remains a key challenge in hydrothermal carbonization, particularly when using mineral-rich marine biomass such as lobster shell waste. Co-carbonization with additional carbon-rich precursors offers a promising strategy to enhance hydrochar properties. This project aims to investigate the effect of adding glucose and fruit waste as co-precursors during microwave-assisted hydrothermal carbonization of lobster shell biomass. The study will compare the influence of pure glucose addition versus natural fruit waste (e.g., citrus or apple residues) on hydrochar yield, carbon content, and surface chemistry. A design-of-experiments approach will be used to optimize process parameters, including temperature, residence time, and additive concentration. The resulting hydrochars will be characterized using CHNS analysis, FTIR spectroscopy, and proximate analysis to assess elemental composition and functional groups. The study will evaluate how different co-carbonization strategies influence hydrochar quality, particularly in terms of carbon enrichment and functionalization. The findings will provide insights into sustainable strategies for upgrading hydrochar properties using low-cost organic additives.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

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

Engineering Nitrogen-Enriched Hydrochar from Seafood Waste Using Microwave-Assisted Hydrothermal Carbonization

Description

The valorization of seafood-processing waste into functional materials presents a valuable chance to advance circular bioeconomy initiatives. Waste such as lobster shells, which contain abundant organic carbon, proteins, and minerals, functions effectively as feedstock for hydrothermal carbonization (HTC). HTC is a thermochemical method that converts moist biomass directly into carbon-rich hydrochar without requiring drying beforehand. This project aims to systematically investigate the production of hydrochar from seafood waste using microwave-assisted hydrothermal carbonization (MHTC) and to establish relationships between processing conditions and material properties. The study will employ a design-of-experiments approach to evaluate the influence of key parameters, including temperature, residence time, and solid-to-water ratio, on hydrochar yield, composition, and physicochemical characteristics. In addition to process optimization, the project will explore the impact of targeted modification strategies, including nitrogen doping via urea and acid treatment for mineral removal. These modifications are expected to influence the elemental composition and surface functionality of the hydrochar, thereby affecting its potential applications. The produced materials will be characterized using CHNS elemental analysis, FTIR spectroscopy, and proximate analysis to determine ash composition. Measurements of pH and electrical conductivity will provide further insight into surface chemistry. The project will focus on understanding how process parameters and modification strategies influence hydrochar structure and composition. The results will provide fundamental knowledge on tailoring hydrochar properties from marine biomass and will contribute to the development of optimized production strategies for sustainable carbon materials.

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

Supervision

Supervisor : Shavandi Armin (armin.shavandi@ulb.be)

Master's program offering the topic: Computer science and engineering - M-IRIFS

Transducer-based quantum algorithms

Description

Transducers are a new framework to design quantum algorithms that has several advantages: it is relatively simple, leads to optimal algorithms in the quantum query complexity model, while also allowing to control quantum time complexity [1], and is inherently error-free which makes it possible to compose subroutines with incurring additional log factors [2].

The goal of this Master Thesis would be to develop new quantum algorithms based on transducers, starting by translating known quantum algorithms in this framework, and potentially leading to new applications.

[1] Aleksandrs Belovs, Stacey Jeffery, and Duyal Yolcu. Taming Quantum Time Complexity. Quantum 8, 1444 (2024). [<https://quantum-journal.org/papers/q-2024-08-23-1444/>]

[2] Aleksandrs Belovs, Stacey Jeffery. Space-Efficient Quantum Error Reduction without log Factors. arXiv:2502.09249. [<https://arxiv.org/abs/2502.09249>]

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

Supervision

Supervisor : Roland Jérémie (Jeremie.Roland@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.

Language	FR (français)
Open to other master's programs	Yes
Eligible master's programs	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Number of topics	1

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@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.

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

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

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

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

Supervision

Supervisor : Sacharidis Dimitris (dimitris.sacharidis@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

[JUNO1] Generative AI for Fast Detector Simulation in Low-Level Trigger Studies

Description

The Jiangmen Underground Neutrino Observatory (JUNO) is a large particle physics experiment whose main goal is to act as a multipurpose observatory for neutrinos produced by artificial and natural sources. JUNO is currently in construction in the Jiangmen underground facility in Southern China.

- **Background:** Accurate simulation of detector response is fundamental for developing and optimizing trigger algorithms in high-energy physics experiments like JUNO. However, traditional Monte Carlo (MC) methods, while precise, are computationally intensive, creating a significant bottleneck for the rapid exploration and tuning of low-level trigger strategies.

- **Objective:** This project aims to develop and validate a fast simulation framework based on Generative AI to produce realistic JUNO detector response data tailored specifically for low-level trigger algorithm research. The goal is to drastically reduce the time needed for data generation compared to full MC simulations, while maintaining sufficient fidelity for trigger-relevant features, thereby accelerating the trigger R&D cycle.

- **Methodology:** The research will leverage JUNO's unique structure (20,000 Photo-Multiplier Tubes (PMTs), representable as a graph) and the availability of high-fidelity MC simulation data for training.

- **Key steps include:**

- Designing and optimizing generative AI models (e.g., Graph Neural Networks combined with GANs, VAEs, or Diffusion Models) capable of capturing the spatio-temporal characteristics of PMT responses.

- Training these models on large datasets generated by the existing, reliable JUNO simulation tools.

- Developing rigorous validation metrics to compare AI-generated data against MC data, focusing on distributions and correlations critical for low-level triggering (e.g., hit times, charge patterns, cluster properties).

- Demonstrating the utility of the fast simulator by integrating it into a typical workflow for trigger algorithm evaluation or optimization.

- **Expected Outcomes:** The primary outcome will be an efficient and validated generative AI model capable of rapidly producing JUNO detector response data. The research will

provide a quantitative assessment of the speed-up factor and the fidelity achieved compared to traditional MC methods.

• Keywords: Generative AI, Deep Learning, Detector Simulation, Fast Simulation, Surrogate Modeling, JUNO, Trigger System, Low-Level Trigger, Monte Carlo Simulation, Graph Neural Networks, High Energy Physics.

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

Supervision

Supervisor : Robert Frederic (frederic.robert@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

DVB-T based passive radar for wide coverage UAV detection

Description

Context:

Low flying Class 1 drones represent a growing threat to critical infrastructures such as airbases, airports, and energy facilities. To mitigate these risks, wide area detection systems capable of providing early alerts are essential.

Passive radars are an attractive solution because they use illuminators of opportunity - such as broadcast television and communication signals - allowing surveillance over a wide area without resorting to dedicated transmitters. Recent research highlights the strong potential of passive radars for UAV detection using continuous, high power, and widely deployed DVB T signals. They enable long range UAV detection, with demonstrations achieving detection distances of up to 5 km, including direction of arrival (DoA) estimation.

Objectives:

The project aims to design, develop, and demonstrate a DVB-T based passive radar system capable of detecting and locating mid size UAVs (approximately 50 cm). The system will be validated using a software defined radio (SDR) receiver, enabling flexible signal acquisition and adaptation to different operational scenarios.

Methodology :

- Investigate the properties of DVB-T signals when used as illuminators of opportunity
- Acquire the DVB-T signal over-the-air with the USRP setup and implement the decoder
- Build the DVB-T-based passive radar and simulate it in Matlab
- Validate the passive radar experimentally for the detection of a mid-size UAV at varying distances from the radar

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

Supervision

Supervisor : Horlin Francois (francois.horlin@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

Integrated Communication and sensing with 5G 28 GHz mm-wave beamsteering arrays

Description

Motivation

The 5G standard dedicated several gigahertz of bandwidth around 28 GHz for high-rate, low-range communications. One main characteristic of 28 GHz wireless propagation channels is that they are very sparse and deterministic: there are only a few multipath components, but those multipath are very deterministic and reliable. This makes 28 GHz wireless systems an interesting candidate for Integrated Communication and Sensing (ISAC) systems, where the communication signals are also used to perform sensing of the environment, in a radar-like fashion.

Another advantage of 28 GHz wireless systems is that to overcome the large path loss at millimeter-wave frequencies, large antenna arrays are required. This allows for very directional beamsteering, providing angular information for both communication and sensing operations.

Our previous research has demonstrated the feasibility of 28 GHz ISAC for determining the position and the trajectory of pedestrians in indoor environments, both theoretically and experimentally. The objective of this master thesis will be to determine whether this concept is also feasible in practical deployments.

Objective

This Master's thesis will investigate the ability of a 28 GHz beamsteering system to identify and track obstacles moving through the field of view of a 28 GHz communication system in a practical deployment. The student will need to:

- Propose several scenarios of practical deployments for 28 GHz communication systems, and determine the sensing capabilities for each deployment;
- Learn how to use the 28 GHz software-defined radio setup at the lab for practical experimentations;
- Validate the theoretical predictions of sensing capabilities for various deployments through experimental measurements.

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

Supervision

Supervisor : Quitin Francois (francois.quitin@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

[JUNO2] An Intelligent Agent System for Automated Monitoring and Debugging Support of the JUNO Electronics system

Description

The Jiangmen Underground Neutrino Observatory (JUNO) is a large particle physics experiment whose main goal is to act as a multipurpose observatory for neutrinos produced by artificial and natural sources. JUNO is currently in construction in the Jiangmen underground facility in Southern China.

- **Background:** The JUNO Electronics system is a complex, distributed system responsible for processing signals from 20,000 PMTs (photomultipliers). Ensuring its stable operation requires continuous monitoring of performance metrics, analysis of large data volumes, and timely diagnosis of potential hardware faults. Current approaches often rely heavily on manual inspection and expert intervention, which can be time-consuming and difficult to scale, especially with evolving personnel.
- **Objective:** This project aims to develop an Intelligent Agent system designed to automate the monitoring, analysis, and debugging support workflow for the JUNO Electronics system. The agent will act as an "intelligent assistant," proactively analyzing operational data, identifying anomalies, providing contextual information, and streamlining the troubleshooting process for human experts.
- **Methodology:** The research will focus on integrating modern AI agent frameworks with existing analysis tools and domain knowledge.

Key steps include:

- Designing the agent architecture using a framework like AutoGen or LangChain, enabling it to perceive system status, plan analysis steps, and execute actions.
- Implementing automated workflow execution, allowing the agent to orchestrate existing data analysis scripts and algorithms (developed by previous researchers) as callable "tools."
- Developing data-driven anomaly detection modules to continuously monitor key performance indicators and flag statistically significant deviations potentially indicative of hardware issues.
- Building a local JUNO Electronics system knowledge base (from design documents, historical logs, expert notes) and integrating it using Retrieval-Augmented Generation (RAG) with Large Language Models (LLMs) and vector databases. This allows the agent to query the knowledge base to provide context for anomalies or answer expert queries.
- Designing the system with modularity and extensibility in mind, allowing easy integration of new tools, data sources, or diagnostic capabilities.

- **Expected Outcomes:** The project will deliver a functional prototype of the Intelligent Agent system for JUNO Electronics system monitoring and debugging support, including demonstrated automation of routine analysis tasks, successful identification of predefined anomaly types, effective knowledge retrieval via RAG, and a well- documented, extensible framework. This system aims to significantly enhance operational efficiency, accelerate problem resolution, and preserve critical expert knowledge for the JUNO experiment.
- **Keywords:** Intelligent Agents, AI Agent, Automation, System Monitoring, Fault Diagnosis, Debugging Support, JUNO, Backend Electronics , Workflow Automation, Knowledge Base, RAG (Retrieval-Augmented Generation), Large Language Models (LLM), Anomaly Detection, High Energy Physics Operations, Extensible Framework.

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

Supervision

Supervisor : Robert Frederic (frederic.robert@ulb.be)

Master's program offering the topic: Electrical engineering - M-IRELE

Device localization with 5G 28 GHz mm-wave beamsteering arrays

Description

Motivation

The 5G standard dedicated several gigahertz of bandwidth around 28 GHz for high-rate, low-range communications. To overcome the large path loss at millimeter-wave frequencies, large antenna arrays are required. We developed a pair of 28 GHz software-defined radios (SDRs), using conventional SDRs for generating the baseband signals, and a 16-antenna array for beamsteering. With our setup, signals with bandwidths up to 100 MHz can be generated, and the transmitter and receiver beams can be steered in azimuthal and elevation space through a digital control link.

Since the transceiver's beams are quite narrow, it is possible to identify the angle-of-arrival and angle-of-departure of the signal, which eventually allows to locate the transmitter node. High-accuracy localization of transmitters in 28 GHz is one of the many benefits of 28 GHz communications in 5G.

Objective

This Master's thesis will investigate the localization of a 28 GHz Tx in a beamsteering 28 GHz system. The main problem is that the process of changing the beam's direction is not instantaneous, but rather takes between 1 and 10 milliseconds. Performing a full scan of all Tx and Rx directions is not a feasible option in practice. A better approach is to rely on a theory called Design of Experiments, which is an information-theoretic approach to determine future beam directions based on past experiments to allow for real-time tracking of moving transmitters. The algorithm could use only the array at the Rx side, or both Tx and Rx arrays. The proposed algorithms will be implemented and evaluated experimentally using the 28 GHz testbed, and the localization accuracy will be investigated.

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

Supervision

Supervisor : Quitin Francois (francois.quitin@ulb.be)

Master’s program offering the topic: Electrical engineering - M-IRELE

[JUNO3] Nanosecond-Scale Clock Distribution in the Base-Edge-Core Architecture for Particle Physics Experiments

Description

The Jiangmen Underground Neutrino Observatory (JUNO) is a large particle physics experiment whose main goal is to act as a multipurpose observatory for neutrinos produced by artificial and natural sources. JUNO is currently in construction in the Jiangmen underground facility in Southern China.

- The Base-Edge-Core (BEC) architecture is a hierarchical framework developed at IIHE for cost-effective multichannel data aggregation in particle physics experiments. A key design principle of BEC is the decoupling of functional layers: Base, Edge, and Core can evolve independently, minimizing adaptation cost when requirements change.
- In its current deployment within the JUNO experiment, the BEC system uses 125 Mbps GPIO links between back-end and front-end electronics, with IEEE 1588 Precision Time Protocol providing clock synchronization at 8 ns precision. Recent tests have demonstrated that the Edge layer can be upgraded to optical links operating at up to 1 Gbps, with an asymmetric physical layer: SelectIO (GPIO) on the BEC side and a Multi-Gigabit Transceiver (GTX) on the front-end side.
- The objective of this thesis is to study clock distribution and synchronization techniques under this asymmetric link architecture. The student will analyze the existing PTP implementation, investigate how state-of-the-art approaches — such as the White Rabbit protocol — can be adapted to the deterministic, point-to-point BEC context, and evaluate the achievable timing precision. If time permits, a prototype implementation on the optical BEC platform will be carried out.

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

Supervision

Supervisor : Robert Frederic (frederic.robert@ulb.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Parameter study for laser ablation of metal 3D-printed surfaces for patterning and roughness reduction.

Description

Context of the master thesis:

Metal 3D-printing or Additive Manufacturing (AM) of metallic structures is an emerging technology for making solid 3D object from a digital file. The design, fabrication, distribution of products and the use of components made with AM techniques are low carbon consuming and highly efficient in their use of virgin material [1]. Airbus and other aerospace companies have denoted AM as a game changing technology for 21 century. An article by The Economist [2] details "The third industrial revolution". Additive manufacturing is highlighted as the production technology of the future, enabling mass customization instead of mass production. One of the remaining key challenges is to eliminate and control the roughness level in the produced parts. The reduction of the roughness level is a crucial element to support the application of AM components in the aeronautical industry for critical applications. The objective of the thesis is to study the different parameter sets of a nano-second pulsed laser system available at the Additive Manufacturing Research Lab (AMRL) at the VUB. The tasks listed below are for information and depending on the student interest can be adapted. For more information don't hesitate to contact the contact person below.

Tasks:

- Literature study of surface roughness reduction and laser patterning with nano-second lasers.
- Definition of evaluation framework of the parameter study.
- Definition of parameter sets to be evaluated.
- Development of an experimental set-up
- Performance of experimental study with developed experimental set-up.

See also external link

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

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Machine-learning prediction of flow properties for space vehicles during atmospheric reentry

Description

In the present research project, machine-learning methods will be explored to accurately predict the thermodynamic and transport properties of carbon-phenolic mixtures for atmospheric re-entry applications. The objective is to develop a reliable methodology to calculate the properties of new ablative materials or mixtures for which the physical properties are not reported in the current literature. When spacecraft re-enter the atmosphere, small particles originating from the ablative heat shield are injected in the plasma flow developed in front of the vehicle. These ablation species change the thermodynamic and transport properties of the mixture and contribute to the total heat flux developed during the re-entry phase. However, the calculation of these properties is a burdensome task as it involves computations at a molecular level for each collision pair.

In the current research project, we will develop a machine-learning framework to bypass these complex computations and offer a fast prediction of the missing properties. The strategy is based on the training of an artificial neural network (ANN) using physical data of ablation mixtures that are well known in the community. Some examples are the ablation of carbon-phenolic shields made out of new materials (carbon grid with phenolic resin) developed by NASA and ESA.

The first part of the project is centered around the training of the neural network to predict documented properties. Once the methodology is verified and validated, we will use the machine-learning framework to predict the properties of new materials. For instance, we will predict the properties for cork, which is used for the protection of CubeSats during re-entry.

This project builds on a previous master thesis project and is in collaboration with the aeronautics and aerospace department at the von Karman Institute for Fluid Dynamics (Prof. Thierry Magin).

The candidate should have an interest in reacting flows (chemistry, plasma flows, combustion) and comfortable with programming (python / matlab).

Contact: Prof. Aurélie Bellemans (aurelie.bellemans@vub.be)

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

Supervision

Supervisor : Bellemans Aurelie (aurelie.bellemans@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Temperature estimation methods study for metal 3D-printing.

Description

Context of the master thesis:

Metal 3D-printing or Additive Manufacturing (AM) of metallic structures is an emerging technology for making solid 3D object from a digital file. The design, fabrication, distribution of products and the use of components made with AM techniques are low carbon consuming and highly efficient in their use of virgin material [1]. Airbus and other aerospace companies have denoted AM as a game changing technology for 21 century. An article by The Economist [2] details "The third industrial revolution". Additive manufacturing is highlighted as the production technology of the future, enabling mass customization instead of mass production. To obtain good quality manufactured parts in AM, temperature control of the printing process is required. Therefore, one of key challenges resides on the temperature estimation method. The objective of the master thesis is to get acquainted with different temperature estimation methods, identify the advantages and disadvantages of each method, and define what methods are suitable for monitoring the AM process.

Tasks:

- Literature review of different temperature estimation methods
- Understanding of hyperspectral cameras
- Development of temperature estimation algorithms
- Temperature estimation methods assessment

See also external link

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

Supervision

Supervisor : De Baere Dieter (dieter.de.baere@vub.be)

Master's program offering the topic: EM - Aeronautics - M-IREMR-A

Modelling atmospheric mass deposition from space debris re-entry

Description

This master thesis aims to develop a simplified yet robust modelling framework to quantify the contribution of space debris re-entry to atmospheric mass deposition, focusing on a bottom-up approach from single-object physics to global annual estimates. The student will first model the aerothermal ablation of a single spherical debris object composed of one representative material (e.g., aluminum), deriving altitude-resolved mass loss and emission profiles during atmospheric entry using simplified heat transfer and ablation laws. Based on this single-object analysis, the work will then scale up to annual global estimates by compiling and critically assessing literature data on debris re-entry frequency and mass distributions, allowing the derivation of total yearly injected mass and its vertical distribution in the atmosphere. The objective is to produce a first-order model of mass deposition as a function of altitude, suitable for integration into atmospheric simulations. In a second phase, the results will be prepared for coupling with atmospheric chemistry and transport models, in collaboration with prof. Irene Dedoussi (Cambridge), to assess the impact of such emissions at different atmospheric layers. The project sits at the interface between aerospace engineering and atmospheric science and will provide a scalable methodology to estimate the growing anthropogenic contribution of space debris to the upper atmosphere, addressing an emerging gap in current literature.

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

Supervision

Supervisor : Bellemans Aurelie (aurelie.bellemans@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Clean energy & sustainable propulsion: Adjoint optimization for LES of hydrogen flames

Description

- Hard-to-abate industries and heavy-duty transportation will keep relying on combustion-based applications due to the high required energy densities and high process temperatures. Hydrogen-based fuels are a viable option to decarbonize these sectors.
- Hydrogen and ammonia flames dynamics are entirely different to conventional fuels and burner geometries need to be adapted.
- The goal is to couple an adjoint based optimization algorithm with an existing LES framework, which models hydrogen combustion.
- The goal is to apply the developed framework to a particular burner geometry and optimize it, e.g. such that minimal emissions are obtained.

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Cybersecurity of electric power systems

Description

Modern power systems have evolved into complex Cyber-Physical Power Systems (CPPS) due to the rapid integration of advanced sensors, communication networks, and computing technologies, which are needed to manage the energy transition (e.g., management of the variability of renewable energy sources). Ensuring the cybersecurity of CPPS has thus become of utmost importance for maintaining the stability and reliability of future electricity grids. This MSc will aim at analyzing the cybersecurity either of a microgrid (option 1) or of a transmission system (option 2), and at proposing solutions to improve it.

Regarding option 1, the idea will be to study experimentally cyber-attacks towards pieces of equipment that are typical of microgrids gathering a few households: smart meters, solar PV systems, batteries, EV chargers, smart loads, etc. based on the smart electric energy systems lab under development within BEAMS.

Option 2 is expected to focus on False Data Injection Attacks (FDIAs). They stealthily manipulate measurement data, potentially bypassing traditional bad data detection mechanisms. A successful FDIA can mislead the State Estimation (SE) process — as a grid monitoring tool — thereby causing incorrect operational decisions and potentially causing serious physical and economic impacts on the power system. The MSc thesis will then aim to conduct a probabilistic cybersecurity assessment of Remote Terminal Units (RTUs) and the State Estimation function under FDIA scenarios. The student will begin by identifying potential vulnerabilities in RTUs and SE through established threat modeling techniques. Building on this analysis, a probabilistic framework will be developed—using methods such as attack trees and attack graphs—to estimate the likelihood of different attack scenarios. In a more advanced phase, the project will involve constructing attack impact assessment models, potentially exploring injection vectors and attacker-defender bi-level optimization approaches to quantify the effects of successful FDIAs on key power system reliability indices.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Inertia Estimation in Inverter-Dominated Distribution Systems: A Simulation and Machine Learning Perspective

Description

This MSc thesis will address the challenge of inertia estimation in inverter-dominated electric power systems, a growing concern as power systems transition toward renewable energy sources such as solar PV and wind. Traditional power systems rely on the physical inertia of synchronous generators to stabilize frequency during disturbances. In contrast, inverter-based resources lack inherent inertia, leading to faster frequency deviations, reduced stability margins, and higher sensitivity to disturbances.

In modern autonomous distribution systems, inertia is no longer a constant physical parameter but a dynamic, operating-point-dependent characteristic influenced by control delays, power electronics, and load behavior. Classical inertia estimation techniques based on the swing equation are shown to be inadequate, as their assumptions do not reflect inverter-based system dynamics. The objective of this MSc thesis is to analyze and compare inertia estimation approaches and to investigate whether machine learning (ML) can more effectively capture system behavior. A structured review of model-based, measurement-based, and data-driven methods will be conducted to assess their applicability and limitations. The methodology will involve simulating an autonomous distribution system in MATLAB/Simulink, including inverter-based generation, virtual inertia control, response delays, and dynamic loads. Disturbance scenarios will be applied to study frequency response. An ML-based approach will then be implemented using simulation data to estimate inertia-related behavior, and its performance is compared with conventional methods.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Clean energy & sustainable propulsion: Machine learning methods in LES of hydrogen flames

Description

- Hard-to-abate industries and heavy-duty transportation will keep relying on combustion-based applications due to the high required energy densities and high process temperatures. Hydrogen-based fuels are a viable option to decarbonize these sectors.
- Hydrogen and ammonia flames dynamics are entirely different to conventional fuels and local flame propagation, which is a key design parameter, is challenging to predict. However, validated simulation tools are indispensable for technology development nowadays
- The goal is to learn the flame propagation from direct numerical simulation (DNS) with machine learning methods
- Apply data-driven model to industrial-relevant large-eddy simulations (LES)

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Quantum computing for power system reliability assessment

Description

Power system reliability is a general concept describing its ability to deliver electricity to all points of utilization within acceptable standards and in the amount desired. The predictive assessment of power system reliability is of paramount importance to ensure beforehand that it will meet desired standards. Due to intrinsic uncertainties arising within electric power systems (e.g., failures of pieces of equipment, variability of renewable energy resources, ...), power system reliability is characterized by probabilistic indicators such as the Loss Of Load Probability (LOLP, the probability that the system is not able to supply all the load while fulfilling operational constraints) and the Expected Energy Not Served (EENS, the energy that the system is not able to supply but should have supplied). These indicators are currently estimated mainly through Monte Carlo simulation for real power systems. Although the implementation of Monte Carlo is straightforward, it leads to significant computation times to obtain results with the desired statistical accuracy. In that context, quantum computing could help to estimate in an efficient way power system reliability indicators. The purpose of this MSc thesis will be to develop a methodology based on quantum computing to tackle a specific problem related to power system reliability assessment (e.g., adequacy of the generation system) and to compare its performances with a Monte Carlo simulation.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Digital twin simulations of offshore wind turbines

Description

At the Vrije Universiteit Brussel (VUB) we are heavily involved in monitoring the structural health of offshore wind turbines (OWT) in the Belgian North Sea. We are currently monitoring wind turbines on all Belgian offshore wind farms for fatigue life, structural integrity and their overall dynamic behaviour. Digital twin are more and more used in the wind industry to predict remaining lifetime, predictive maintenance, and structural integrity. Commonly differentiated in data-driven digital twins, which represents the structure completely based measured inputs, and physics based digital twins, which are build based on existing physical relations. Through their rooting in known physical relations, physics-based digital twins often provide better transparency of their behaviour.

- Objective:

In this Master Thesis you will validate the physics-based digital twin of an offshore wind turbine in the Belgian North Sea with real-world data using the aeroelastic simulation software ASHES.

- Prerequisites/special skills (optional)

An interest in structural dynamics and programming is desired. A good knowledge of numerical methods such as the finite element method as well as prior experience with aeroelastic software such as OpenFast can be advantageous. This master thesis gives you the opportunity to learn about the modelling and dynamic behaviour of Offshore Wind Turbines as well as the work of OWI-lab in the structural health monitoring of wind turbines.

- Other information:

This topic is an umbrella topic in which direction can be given aligned with the student's interests and skillset. E.g. the focus can be put on the control of the turbine, the soil-structure interaction, the performance under anomalous behaviour, the automatic integration between database and simulation, ...

Your thesis work builds on past master thesis's and starts from their latest findings.

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

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Consideration of probabilistic security constraints in electricity market coupling

Description

Nowadays, the European internal electricity market is organized on a zonal basis. Europe is divided into different bidding zones, that are geographical areas within which market participants can exchange energy without transmission capacity allocation (i.e., each bidding zone is implicitly considered as a “copper plate” from the market point of view). On the contrary, the exchange of energy between different bidding zones require transmission capacity allocation. The preferred approach to calculate and allocate transmission capacity to the electricity market is the so-called “flow-based approach”. This flow-based approach tries to model in an explicit way power flow constraints on transmission elements. Nevertheless, the current modelling is based on deterministic security criteria (following the N-1 security criterion) and does not take into account the possible outages of components and the variability of renewable energy sources (i.e., the uncertainties of load, wind power and transmission line failures). The objective of this MSc thesis will be twofold: (i) to integrate probabilistic criteria (LOLE, LOLP, EENS,...) and uncertainties (forecast errors) in the flow-based market algorithm, and (ii) to assess the impact of such integration on the different stakeholders (producers, consumers, TSOs) involved in the market. The effectiveness of the proposed methodology will be validated through different case studies on IEEE RTS.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Sustainable Aviation Fuels: Controlling Soot Emissions in Aircraft Engines

Description

- Sustainable Aviation Fuels (SAF) are key to decarbonize the aviation sector
- The reduction of soot and other emissions is critical to reduce the environmental impact of the aviation sector
- Soot formation is strongly sensitive to the local flow conditions and combustion process in an aircraft engine
- The goal is to analyze the effect of the flow field on soot formation in laminar well controlled counterflow flames
- In a second step, soot formation in turbulent flames is simulated using LES and a comparison to experimental reference data is performed
- the development of a validated LES framework for industrial applications is key to enable the design of future aircraft engines

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Dynamic probabilistic security assessment of power systems

Description

The security of a power system is its ability to withstand disturbances arising from faults and unscheduled removal of bulk power supply equipment without further loss of facilities or cascading outages. The security analysis of the transmission grid requires both deterministic and probabilistic approaches. The "N-1 security rule" is the deterministic approach classically used by Transmission System Operators for network planning and real-time operation. This rule relies on the assumption that an electrical grid will be secure if it stays electrically stable after any single failure among the N initially active network elements. Probabilistic studies can then complement (or replace?) this deterministic approach to assess the residual risk of cascading outages leading to an important amount of loss of load and to identify corresponding accidental scenarios. Their importance is increasing with the massive integration of renewable energy resources in the grid. Because cascading phenomena are not only static but also dynamic (e.g., loss of stability), probabilistic studies should be coupled with dynamic simulations to estimate accurately the security level of power systems, leading to dynamic probabilistic security assessment methodologies. This MSc thesis will explore the use of such methodologies for decarbonized power systems and/or power systems dominated by renewable energy resources, and their use as a tool in planning and/or in operation.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Risk-based planning and operation of meshed offshore HVDC grids to moderate the risk of blackout in power systems

Description

A blackout is a collapse of the electrical grid on a large area, leading to a power cutoff, and is due to a cascading failure. The occurrence of such a situation entails major direct and indirect societal and economical consequences and should be moderated as much as possible. Some recent events worldwide underline the fact that the residual risk of blackout or undesired load shedding in critical zones remains. Even if such an event is not plausible for single contingency situations, it is for an unfortunate set of strategic (not even necessarily close-by) outages and incidents, combined with unexpected generation and consumption patterns. This means that the risk of cascading incidents needs to be taken into account through the development of risk functions. These functions describe the risk of post-contingency component overloads by considering the probability as well as the impact of contingencies. Moreover, the radical changes experienced by the power systems in recent decades, along with the fast increase of renewable power generation, have triggered interest for offshore wind connections and more specifically for meshed offshore HVDC grids that are seen as a natural target. It could then be of interest to study the optimal planning and operation of these HVDC grids and to what extent they can support the blackout risk reduction, including through the use of corrective security approaches. This is the general purpose of this MSc thesis.

More specifically, this MSc thesis is expected to combine 2-3 of the following activities:

- The development of risk functions that describe the risk of blackout or load shedding for mixed AC/DC grids.
- The development of optimal approaches to operate and to control HVDC grids (including with corrective security with automatic systems) such that the risk of blackout or load shedding is limited through prevention and/or mitigation of cascading outages. Indeed, during cascading events (such as slow voltage collapse), multiple actions are required within a very short time. The converters can provide very fast response (with the appropriate control schemes) to support the frequency, and they can provide, if well controlled, a dynamic support through their power oscillation damping capability. The effectiveness of these approaches will be demonstrated by simulation.
- The development of an approach to plan in an optimal way HVDC grids (e.g., number of converters, lines, and installed GW) with appropriate control schemes such that the risk of blackout or load shedding is limited. The security level of these HVDC grids will be

evaluated by simulation.

- The experimental test of automatic corrective security schemes through Control-Hardware-in-the-Loop (combination of the Real-Time Digital Simulator (RTDS) available within BEAMS Electric Energy with an Intelligent Electronic Device (IED) implemented by the student on a Raspberry Pi or equivalent).

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

PEM fuel cells to decarbonize aviation: Modeling liquid water transport

Description

- PEM fuel cells are considered a viable option for emission free flying (see e.g. ZEROe from Airbus or the Flying Fuel Cell by MTU Aero Engines AG etc.) using hydrogen as a fuel
- operation of PEM fuel cells is challenging and requires in-depth understanding of the small-scale processes in the porous media, e.g. liquid water transport
- the goal is to model liquid water transport in macro-homogeneous models and validate the simulations against experimental reference data
- Particular focus lies on the modeling of the channel/GDL interface

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Clean energy & sustainable propulsion: Modeling hydrogen/ammonia flames in LES

Description

- Hard-to-abate industries and heavy-duty transportation will keep relying on combustion-based applications due to the high required energy densities and high process temperatures. Hydrogen-based fuels are a viable option to decarbonize these sectors.
- Hydrogen and ammonia flames dynamics are entirely different to conventional fuels and predictive combustion models for LES are yet not available
- The goal is to analyze detailed data-heavy DNS data, where all turbulent fluctuations are resolved, and to extract the underlying physics regarding the interactions of the flame and turbulence
- The goal is to develop models for unclosed terms in LES and then apply the newly developed models in an LES to show its improvements
- The analysis will be done for different hydrogen/ammonia blends

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

PEM fuel cells to decarbonize aviation: Pore-resolved simulations in porous media

Description

- PEM fuel cells are considered a viable option for emission free flying (see e.g. ZEROe from Airbus or the Flying Fuel Cell by MTU Aero Engines AG etc.) using hydrogen as a fuel
- operation of PEM fuel cells is challenging and requires in-depth understanding of the small-scale processes in the porous media, e.g. liquid water transport
- the goal is to establish a modeling framework for pore-resolved simulations of liquid water transport in PEM fuel cells
- the goal is to apply this framework to relevant questions in flow field and stack design

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Experimental testing of a monitoring hardware for application in floating offshore wind turbines.

Description

At the Vrije Universiteit Brussel (VUB) we are heavily involved in monitoring the structural health of offshore wind turbines (OWT) in the Belgian North Sea. We are currently monitoring wind turbines on all Belgian offshore wind farms for fatigue life, structural integrity and their overall dynamic behavior. Floating Offshore Wind Turbines (FOWT) refer to offshore wind turbines mounted on floating platforms, allowing them to be deployed in deeper waters where fixed-bottom turbines are not feasible.

- Objectives of the master thesis;

This master's thesis focuses on building and testing a small-scale experimental setup to evaluate a monitoring hardware system (GNSS/IMU). The objective is to assess the hardware's ability to provide accurate position for an instrumented device—such as a scaled FOWT. When combined with other sensor types, this data will help us better understand the motion characteristics of FOWTs and how they relate to mooring line tensions and overall system dynamics. This project is conducted in collaboration with 24SEA, a company specializing in monitoring solutions for offshore wind turbines.

- Prerequisites/special skills (optional)

An interest in structural dynamics, experimental work and programming is desired. The thesis also includes working with sensors and hardware, and doing experimental validation of the sensor setups. A thesis suitable for someone with a strong 'MacGyver'/'Maker' - spirit.

- Other information

This thesis might require you to travel occasionally to 24SEA, situated just outside Brussels.

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

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

PEM fuel cells to decarbonize aviation: Modeling degradation in PEM fuel cells

Description

- PEM fuel cells are considered a viable option for emission free flying (see e.g. ZEROe from Airbus or the Flying Fuel Cell by MTU Aero Engines AG etc.) using hydrogen as a fuel
- operation of PEM fuel cells is challenging and handling cell degradation is a key challenge for future technologies
- the goal is to develop a simulation framework to model degradation mechanisms in PEM fuel cells
- the new library will be coupled to CFD solvers to enable predictions of degradation in a 3D realistic cell

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

Supervision

Supervisor : Berger Lukas (lukas.berger@vub.be)

Master's program offering the topic: EM - Energy - M-IREMR-E

Risk-Aware Flexibility Procurement for Congestion Management in Distribution Systems under Uncertainty

Description

This MSc thesis will aim to study how to use distributed flexibility—such as flexible loads, batteries, EV charging, and renewable curtailment—to relieve congestion in distribution networks. The work will start with a deterministic market-clearing model that selects cost-effective flexibility actions while respecting network limits (using a simplified power flow model). It is then extended to account for uncertainty in renewable generation, demand, and flexibility availability using a scenario-based approach. In this context, a two-stage stochastic perspective can be used, where decisions are taken ahead of time and evaluated under different possible system conditions. To ensure that the solution remains reliable, the modeling framework will adopt a risk-aware formulation. The goal will not be only to minimize cost, but also to limit the risk of congestion after market clearing. This will be done by tracking how often and how severely network constraints are violated across scenarios, and by incorporating these effects either as constraints or in the objective function. The proposed methods will be tested on representative distribution networks. The results will be evaluated in terms of cost, ability to relieve congestion, and sensitivity to uncertainty. If time allows, the impact of imperfect flexibility activation (e.g., delays or partial delivery) can also be analyzed. In addition, this MSc thesis might explore simple market design choices, such as how flexibility bids are defined (price, quantity, location), how they are selected (e.g., pay-as-bid vs uniform pricing), and how non-delivery is penalized. The focus will remain on understanding how these choices affect congestion management outcomes.

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

Supervision

Supervisor : Henneaux Pierre (pierre.henneaux@ulb.be)

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

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

Description

- Context of the master thesis

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

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

- References

§ Haywood-Alexander, Marcus, et al. "Discussing the spectrum of physics-enhanced machine learning: a survey on structural mechanics applications." *Data-Centric Engineering* 5 (2024): e30.

§ Cicirello, Alice. "Physics-Enhanced Machine Learning: a position paper for dynamical

systems investigations." Journal of Physics: Conference Series. Vol. 2909. No. 1. IOP Publishing, 2024.

§ Mehrjoo, Azin, Eleonora M. Tronci, and Babak Moaveni. "A Physics-Informed Framework for Input Load Estimation in Offshore Wind Turbines." International Conference on Experimental Vibration Analysis for Civil Engineering Structures. Cham: Springer Nature Switzerland, 2025.

- Objectives

§ Review virtual sensing in offshore wind turbines.

§ Identify and review physics-enhanced/hybrid modelling approaches.

§ Generate MDOF systems with varying numbers of degrees and exciting load [both intensity and location] in a Python script.

§ Encode MDOF as a graph, including stiffness, damping and mass matrices.

§ Implement a Graph Neural Network (GNN) virtual sensor baseline in Python.

§ Assess and compare the addition of physics knowledge into the baseline with relation to: performance over unseen numbers of nodes [extrapolation and interpolation] and unseen excitations [intensity and location].

- Prerequisites/special skills

· Basic python programming.

· Knowledge of fundamentals of structural mechanics (e.g. equations of motion, etc.).

· Attendance of Prof. Deraemaker's Dynamics of Structures or Mechanical Vibrations course (<https://structuraldynamics.ulb.be/dynamics-of-structures-2025-2026/>)

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

Supervision

Supervisor : Weijtjens Wout (wout.weijtjens@vub.be)

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

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

Description

1) The objectives of the project

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

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

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

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

2) Methodology

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

- (i) A literature study on vacuum gripping of flexible materials and thin films.
- (ii) Design optimization of self-closing suction cups and gripper configurations for handling thin elastic films.
- (iii) Manufacturing of prototypes using molding or additive manufacturing methods such as FFF 3D printing.
- (iv) Experimental evaluation of gripping reliability, deformation behavior of thin films, and performance comparison with conventional suction cups.

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

3) Prerequisites needed to succeed in this project

We are looking for students who have interests in:

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

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

Supervision

Supervisor : Wang Zhanwei (Zhanwei.Wang@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

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

Supervision

Supervisor : LAMBERT Pierre (pierre.lambert@ulb.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 localisation
- Relative pose estimation
- Map sharing
- ODOMetry sensors: IMU, Camera, VIO, LiDAR, LIO.

And this on multiple different robots:

- AGVs
- Humanoids
- Drones.

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

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

Supervision

Supervisor : Vanderborght Bram (Bram.Vanderborght@vub.be)