Topics offered to students by other master's programs

TARGET PROGRAM

EM - Management Engineering

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

Program : Chemical & Materials engineering - M-IRMAE

Description

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

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

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

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

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

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

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

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

Methodology

1. Literature survey

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

2. Experimental set-up

The student will work with the existing electrolysis cell, Mach Zehnder interferometer, and high-speed imaging system available at the TIPS laboratory. This phase will involve hands-on training with laser alignment, optical adjustments, electrode handling, and system calibration. The student

will also participate in test runs to optimise measurement conditions and gain confidence in operating the setup independently.

3. Measurement campaign and data analysis

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

4. Reporting

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

References

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

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

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

Supervision

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

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

Topics offered to students by other master's programs

TARGET PROGRAM

EM - Management Engineering

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 □□25 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)

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

Program : Chemical & Materials engineering - M-IRMAE

Description

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

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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].

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1. Literature survey

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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

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4. Reporting

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References

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

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

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

Supervision

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

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

Topics offered to students by other master's programs

TARGET PROGRAM

EM - Management engineering

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

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

Description

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

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

Supervision

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

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

Construction of a multiple-criteria evaluation process for student engineering projects

Description

Every bachelor student at Ecole Polytechnique de Bruxelles (EPB) must realize at least two projects during their first two years of study. These projects involve multiple different aspects, namely the construction of some model, the realization of a prototype implementing the model, the writing of a technical report, an oral presentation of the work, and in the case of the second project, an overview of the project management.
Currently, the evaluations of these points are performed separately by different parties using predefined evaluation grids. Such grids are great to objectivize the expectations of the teaching staff and tend to uniformize the grading if performed by different people. They are however based on natural language values (e.g.: "The slides are overall clear and allow the transfer of information") and translating these to a numerical grade is not trivial. Moreover, combining the different grids also involve subjective choice that is not clear to pre-define, such as a weight associated to each grid.
In this master thesis, the student is expected to apply concepts from multiple criteria decision aid and natural language preference learning to develop a realistic and applicable evaluation process for bachelor projects. Ideally, the method(s) developed by the student could be compared with existing approaches and eventually applied in the following years.
Concerning the supervision, I would be available for weekly meetings (at the student's demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentations skills.
In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be interested in didactics and will be confronted to an open applied problem with many possible leads to try. Moreover, this subject lies between multiple fields, some of which I do not master (at all). The student should thus be able to take initiatives, remain curious and be independent in its research.

Langue	FR (français)
Ouvert à d'autres masters	Yes

Masters concernés	M-IRCBS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	1

Supervision

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

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

On intransitive indifference relations and PROMETHEE methods

Description

When a problem involves multiple (conflicting) criteria, the notion of an "optimal" solution is ill-defined. Consider for example the problem of choosing the best place to host a conference, i.e. the least expensive, fanciest, and most accessible. It seems very unlikely that one place is the best on all these criteria.

The field of Multiple Criteria Decision Aid (MCDA) emerged in the 1960s to help decision makers who face such problems. In this context, the PROMETHEE I and PROMETHEE II methods rely on pairwise comparisons and preference functions to construct rankings of the available alternatives. In PROMETHEE, decision makers begin by describing their preferences regarding each criterion. When these preferences are crisp (strict), the procedure yields, for each criterion, a binary relation between alternatives that generally satisfies transitivity of strict preference (if $a > b$ and $b > c$ then $a > c$) but not transitivity of indifference ($a \sim b$ and $b \sim c$ but $a > c$).

However, the PROMETHEE I and II aggregation procedure produce rankings, and hence a form of global indifference that is transitive, since alternatives with identical net flows are considered indifferent. This raises several theoretical and practical questions: how does the aggregation process "repair" the non-transitive local indifference into a globally transitive indifference? To what extent is the global indifference meaningful when the underlying unidimensional relations exhibit cycles of indifference? Can alternative aggregation procedures or variants of PROMETHEE preserve or reflect the structure of local indifference more faithfully?

In this master thesis, the student is expected to investigate the contrast between non-transitive indifference at the criterion level and transitive indifference in the final ranking, both from a theoretical and methodological perspective. This could include revisiting the formal properties of PROMETHEE preference functions and the binary relations they generate; studying the structure of local indifference cycles and their propagation during aggregation; exploring alternative formulations or extensions that preserve local structures (e.g., partial orders, forest orders, interval-based flows, robust PROMETHEE approaches); or evaluating whether modified procedures could yield rankings that better reflect decision makers' intent.

Concerning the supervision, I would be available for weekly meetings (at the student's

demand), and the student would be expected to give a ten-minute presentation of their work every six to eight weeks in order to receive regular feedback on their presentation skills. In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be ready to work on theoretical mathematics, in particular on binary relations on sets and orders representations.

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

Supervision

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

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

Explainability of decisions from PROMETHEE based models

Description

In many real-world decision problems — selecting candidates for a position, ranking infrastructure projects, or allocating research funding — stakeholders are not only interested in the outcome of a decision process, but also in understanding why a particular alternative was preferred over another. This need for transparency is both ethical, as decisions may significantly affect individuals or organizations, and practical, as trust in a decision support tool should be constructed.

The PROMETHEE I and PROMETHEE II methods, developed in the 1980s, are widely used outranking methods in multiple-criteria decision aid (MCDA). They rely on pairwise comparisons across criteria, weighted preference functions, and the aggregation of these into net flow scores that induce a ranking of alternatives. While the mathematical structure of PROMETHEE is relatively transparent compared to black-box approaches such as neural networks, translating its outputs into natural language justifications that are meaningful to a non-expert decision maker remains an open challenge. For instance, stating that alternative a outranks alternative b because its net flow is higher offers little intuitive value without further context about which criteria drove that difference, how decisive those differences were, and whether the conclusion is robust to small changes in the model parameters.

In this master thesis, the student is expected to investigate explainability in the context of PROMETHEE-based decision models, drawing on concepts from both MCDA and the broader literature on explainable artificial intelligence (XAI). This could include formalizing notions of explanation suited to outranking methods (e.g., criterion-level contribution decompositions, contrastive or counterfactual explanations of the form "alternative a would have been preferred if criterion k had been weighted differently"); studying the relationship between robustness analysis tools already available in PROMETHEE and the production of explanations; or developing a prototype explanation module that generates human-readable justifications for a given ranking. The practical applicability of the proposed approach should be evaluated, ideally on a real or realistic decision problem.

Concerning the supervision, I would be available for weekly meetings (at the student's demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentation skills.

In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.
Expected profile: the student should be interested in didactics and will be confronted to an open problem with many possible leads to try. The student should be comfortable with discrete mathematics and logic. Familiarity with probability and statistics is a plus.

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

Supervision

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

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

Learning preferences of students towards course practices

Description

University courses are composed of a wide variety of teaching and assessment practices: lectures, exercise sessions, project work, oral examinations, written tests, flipped classroom approaches, peer feedback, and many others. While instructors often choose these practices based on experience or tradition, little is typically known about how students themselves perceive and value different combinations of course activities. Understanding student preferences is non-trivial. A student may prefer oral exams over written ones in general, yet that preference may weaken or reverse when the course involves heavy mathematical content. Such context-dependent and potentially inconsistent preferences are difficult to capture with simple questionnaires or Likert scales. The field of preference learning, at the intersection of machine learning and multiple-criteria decision aid (MCDA), offers structured methods to elicit, represent, and reason about such preferences from observed data or pairwise comparisons.

In this master thesis, the student is expected to design and apply a preference learning methodology to model how students rank or evaluate different course practice profiles. This includes identifying relevant course attributes (e.g., type of assessment, frequency of feedback, degree of autonomy), collecting preference data through an appropriate elicitation protocol, and fitting a preference model - such as a utility function, a sorting rule, or an outranking relation - to the collected data. The work should also address the robustness of the inferred preferences and discuss the practical implications for course design. Ideally, the methodology could be piloted within one or more courses at Ecole polytechnique de Bruxelles and the results compared across student profiles (year of study, discipline, prior academic performance).

Concerning the supervision, I would be available for weekly meetings (at the student's demand) and the student would be expected to give a ten minutes presentation of their work every six to eight weeks in order to have regular feedback on their presentation skills. In case of questions or interest, feel free to contact me at alexandre.flachs@ulb.be with Dimitris Sacharidis (dimitris.sacharidis@ulb.be) in CC.

Expected profile: the student should be interested in didactics and will be confronted to an open problem with many possible leads to try. The student should be ready for data-driven

approaches. Ideally, the student would propose an end-to-end pipeline to apply on courses or cohorts.

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

Supervision

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

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

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

Description

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

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

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

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

• Key steps include:

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

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

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

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

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

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

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

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

Supervision

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

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

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

Description

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

• Background: The JUNO Electronics system is a complex, distributed system responsible for processing signals from 20,000 PMTs (photomultipliers). Ensuring its stable operation requires continuous monitoring of performance metrics, analysis of large data volumes, and timely diagnosis of potential hardware faults. Current approaches often rely heavily on manual inspection and expert intervention, which can be time-consuming and difficult to scale, especially with evolving personnel.

• Objective: This project aims to develop an Intelligent Agent system designed to automate the monitoring, analysis, and debugging support workflow for the JUNO Electronics system. The agent will act as an "intelligent assistant," proactively analyzing operational data, identifying anomalies, providing contextual information, and streamlining the troubleshooting process for human experts.

• Methodology: The research will focus on integrating modern AI agent frameworks with existing analysis tools and domain knowledge.

Key steps include:

-Designing the agent architecture using a framework like AutoGen or LangChain, enabling it to perceive system status, plan analysis steps, and execute actions.

-Implementing automated workflow execution, allowing the agent to orchestrate existing data analysis scripts and algorithms (developed by previous researchers) as callable "tools."

-Developing data-driven anomaly detection modules to continuously monitor key performance indicators and flag statistically significant deviations potentially indicative of hardware issues.

-Building a local JUNO Electronics system knowledge base (from design documents, historical logs, expert notes) and integrating it using Retrieval-Augmented Generation (RAG) with Large Language Models (LLMs) and vector databases. This allows the agent to query the knowledge base to provide context for anomalies or answer expert queries.

-Designing the system with modularity and extensibility in mind, allowing easy integration of new tools, data sources, or diagnostic capabilities.

• Expected Outcomes: The project will deliver a functional prototype of the Intelligent Agent system for JUNO Electronics system monitoring and debugging support, including demonstrated automation of routine analysis tasks, successful identification of predefined anomaly types, effective knowledge retrieval via RAG, and a well- documented, extensible framework. This system aims to significantly enhance operational efficiency, accelerate problem resolution, and preserve critical expert knowledge for the JUNO experiment.

• Keywords: Intelligent Agents, AI Agent, Automation, System Monitoring, Fault Diagnosis, Debugging Support, JUNO, Backend Electronics , Workflow Automation, Knowledge Base, RAG (Retrieval-Augmented Generation), Large Language Models (LLM), Anomaly Detection, High Energy Physics Operations, Extensible Framework.

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

Supervision

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

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

Grid-Forming Droop Control with Seamless Islanding Transition for a Battery-Based Vehicle-To-Grid Unit

Description

The ability of a vehicle-to-grid (V2G) unit to transition seamlessly between grid-connected and islanded operation is critical for microgrid resilience. This thesis will design a droop-based grid-forming controller that detects islanding and autonomously reconfigures its control loops, validated experimentally using the battery-connected inverter as the grid-forming source and a machine as a local load.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

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

Digital twin simulations of offshore wind turbines

Description

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

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

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

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

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

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

Supervision

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

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

Three-phase Active Power Filter for Vehicle-To-Grid Applications

Description

Harmonic pollution injected into the grid by nonlinear loads is a well-known power quality issue, and V2G inverters can be leveraged to actively suppress these harmonics without relying on heavy and expensive passive filters. Building directly on experience already acquired with single-phase proportional-resonant (PR) controllers for active filtering, this thesis extends the concept to the three-phase case using the existing bench inverter and MicroLabBox II platform. The student will implement selective harmonic compensation using parallel resonant controllers tuned to the 5th, 7th, and 11th harmonics in a synchronous reference frame, and validate the results experimentally with a nonlinear load.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

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

Finite-Control-Set Model-Predictive Control for a Vehicle-To-Grid Bidirectional Inverter

Description

Classical PI current controllers with PWM are the industry standard for grid-connected inverters, but finite-control-set model-predictive control (FCS-MPC) has emerged as an attractive alternative that eliminates the modulator and offers intuitive multi-objective tuning. This thesis will implement both control strategies in Simulink on the MicroLabBox II for the same two-level inverter and battery setup, and compare them experimentally in terms of current THD, dynamic response, and ease of tuning. The FCS-MPC implementation will use a single prediction step (horizon = 1) as a baseline, with extension to longer horizons left as an option for motivated students.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

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

Real-Time State-of-Charge-Aware V ehicle-To-Grid Power Scheduling with Grid Frequency Support

Description

Effective vehicle-to-grid (V2G) participation requires the inverter controller to be aware of the battery's state of charge and to respond to grid frequency deviations in a coordinated way. This thesis will develop a supervisory layer combining a real-time SoC estimator (e.g. extended Kalman filter or adaptive observer) for the LiFePO4 pack with a primary frequency droop response, dynamically modulating injected/absorbed power according to SoC constraints. The MicroLabBox II will run both the SoC estimator and the power reference generator in real time, enabling full closed-loop V2G frequency support experiments.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

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

Virtual-Synchronous-Machine Control of a Vehicle-To-Grid Bidirectional Inverter Using a LiFePO4 Battery Pack

Description

Grid-forming control via Virtual Synchronous Machine (VSM) emulation is one of the most active research areas in power electronics, as inverter-dominated grids increasingly lack the natural inertia of synchronous generators. This Master thesis will build upon previous work and implement a VSM algorithm on the MicroLabBox II to make the battery-side inverter behave like a synchronous generator, providing synthetic inertia and voltage support. The student will tune the virtual inertia and damping coefficients and validate the frequency response experimentally.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)

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

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

Description

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

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

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

- Other information
This thesis might require you to travel occassionally to 24SEA, situated just outside Brussels.

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRCNE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M- IRPH

Nombre de sujets	1

Supervision

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

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

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

Description

- Context of the master thesis

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

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

- References

§ Haywood-Alexander, Marcus, et al. "Discussing the spectrum of physics-enhanced machine learning: a survey on structural mechanics applications." Data-Centric

Engineering 5 (2024): e30.
§ Cicirello, Alice. "Physics-Enhanced Machine Learning: a position paper for dynamical systems investigations." Journal of Physics: Conference Series. Vol. 2909. No. 1. IOP Publishing, 2024.
§ Mehrjoo, Azin, Eleonora M. Tronci, and Babak Moaveni. "A Physics-Informed Framework for Input Load Estimation in Offshore Wind Turbines." International Conference on Experimental Vibration Analysis for Civil Engineering Structures. Cham: Springer Nature Switzerland, 2025.

- Objectives

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

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

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

Supervision

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

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

Multi-robot localisation

Description

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

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

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

Langue	EN (english)
Ouvert à d'autres masters	Yes
Masters concernés	M-IRARE, M-IRCBS, M-IRCNE, M-IRMAE, M-IRIFS, M-IRELE, M-IREMR-A, M-IREMR-E, M-IREMR-M, M-IREMR-O, M-IREMI, M-IRPH
Nombre de sujets	5

Supervision

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

Master's program offering the topic: EM - Sustainable transport and automotive M-IREMR-O

Electrical motors for EV traction, design and control --- internships and Master theses, at/in collaboration with Punch Powertrain (Sint-Truiden)

Description

Internship subjects (see also the document with Dropbox link):

1) In-house Multi-disciplinary emotor design toolchain maintenance
2) Torque ripple requirements definition in electric machine pre-design
3) Harmonics limits definition in electric machine pre-design
4) Emotor design towards short circuit protection

Master thesis subject (and more coming):

Title: DC and AC Harmonics reductions techniques in electric machine design
Promoter: Dr. Ilja Siera
Contact person: ilja.siera@punchpowertrain.com
Description:
A critical design challenge in electric machines for the automotive market is the presence of electromagnetic harmonics, which can lead to undesirable effects such as torque ripple, increased losses, noise, vibration, reduced efficiency or inverter over-currents. In the current multi-disciplinary design methods applied at Punch powertrain, the potential issues often lay hidden until the latter stages of the design process.
This thesis proposes to investigate and implement advanced methods to reduce harmonic distortion early during the optimisation process of electric machines. The goal is to develop a multi-objective optimisation framework that explicitly includes harmonic reduction as a design target.
The current optimisation approach for electric machines focusses on objectives such as torque density, efficiency, and thermal performance. While torque ripple is considered, Current harmonic mitigation is only considered as a constraint, and then treated in the post design. This research aims to integrate harmonic reduction directly into the optimisation loop, allowing for a more balanced and robust design process.
The goals are to:

(a) Review harmonic generation mechanisms in electric machines (with a focus on slot/pole combinations, winding distribution, and magnetic saturation).
(b) Evaluate methods for harmonic analysis, including Fast Fourier Transform (FFT), Space Vector analysis, and Total Harmonic Distortion (THD) metrics.
(c) Evaluating methods for detecting the presence or vulnerability of a design to harmonics (e.g. through flux map analysis).
(d) Implement harmonic minimisation techniques in the design optimisation loop
(e) Evaluate performance and the trade-offs in a design optimisation study.

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

Supervision

Supervisor : Gyselinck Johan (johan.gyselinck@ulb.be)