HEIG VD

TOPICS FOR THESIS / INTERNSHIPS

ACADEMIC YEAR 2023-24

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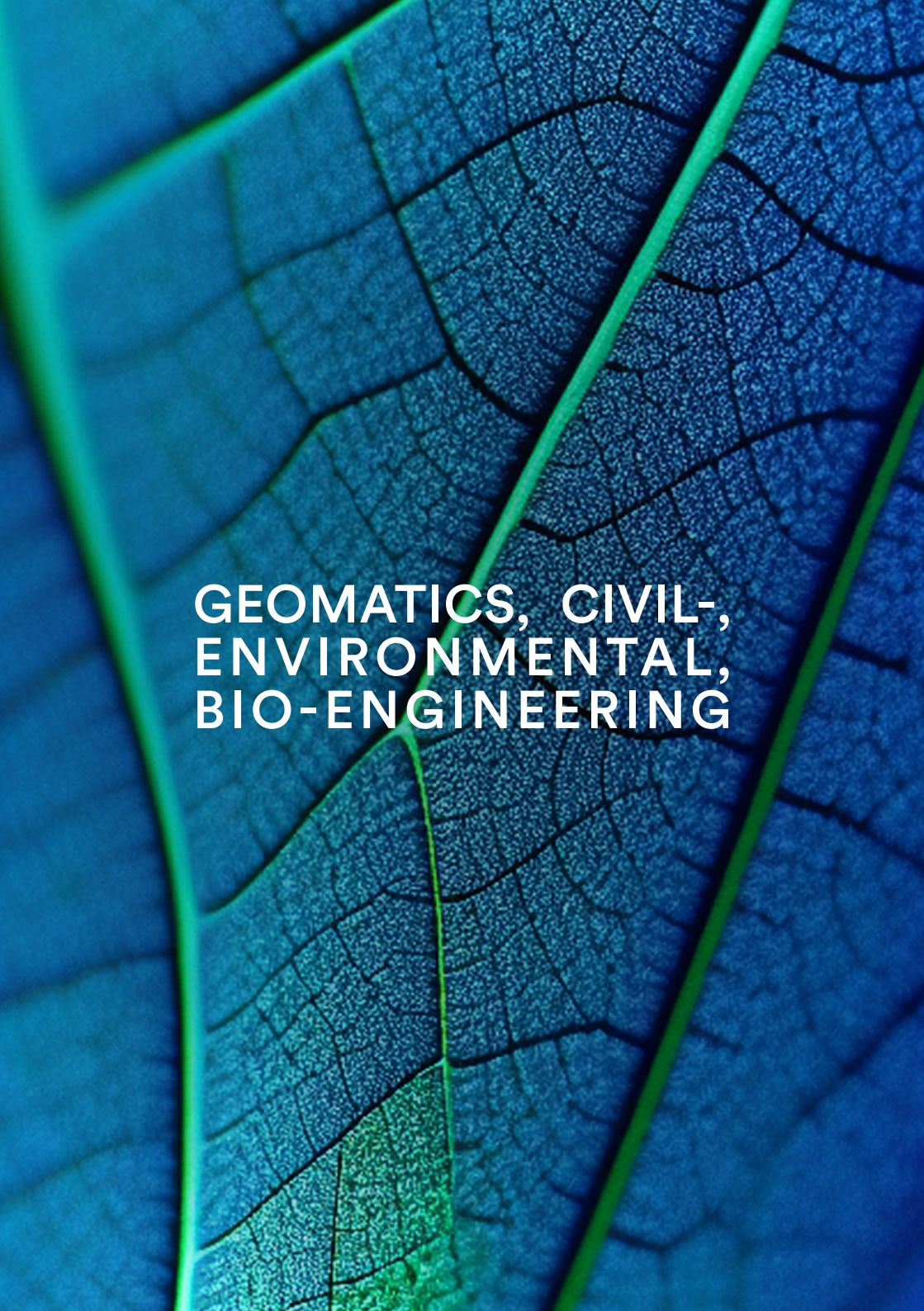
TOPICS FORTHESIS / INTERNSHIPS 2023-24

Applications (CV + transcript of records + cover letter + desired period to begin) must be sent to international@heig-vd.ch Interns will receive a grant to support financial costs: housing (CHF 600.-/month) + basic expenses (CHF 400.-/month). Internships normally last between 5 and 6 months. Some professors may exceptionally accept shorter or longer ones.



GEOMATICS, CIVIL-, ENVIRONMENTAL, BIO-ENGINEERING

VULNERABILITY ASSESSMENT OF BUILDINGS TO DEBRIS FLOW

Prof. E. Prina Howald

Debris flow is considered amongst the most dangerous natural hazards today due to the high velocities and heights it can reach. Climate change and the intensification of land use, not suited to natural hazards, are two factors that significantly increase the risk associated with natural hazards. It is therefore more necessary than ever to understand their behavior and to evaluate the danger they represent for the built environment and thus the population.

The aim of this study is to evaluate the vulnerability of different types of building structures to debris flows. In order to carry out this task, it is first necessary to evaluate the intensity of debris flows according to multiple previously defined parameters. Then, it is necessary to develop a general methodology (adaptation of existing methodologies) needed to assess the vulnerability of predefined types of building structures.

Students in Civil engineering and/or environmental engineering with strong interest in Natural Hazards

PHYSICAL VULNERABILITY ASSESSMENT OF THE BUILT ENVIRONMENT TO ROCKFALL HAZARDS

Prof. E. Prina Howald

Global warming and the escalation of land use not adapted to natural hazards are two drivers that greatly contribute to the elevation of the risk related to natural hazards. Thus, it is necessary now more than ever to analysis and evaluate the danger they represent for the constructed environment and consequently for the population. In the field of rock fall hazards, there are several different methodologies developed to determine the hazard risk and to help create hazard maps (zoning).

This work aims toward analyzing of existing methodologies for rockfall risk assessment and their adaptation in the field of physical vulnerability assessment of the built environment.

Students in Civil engineering and/or environmental engineering with strong interest in Natural Hazards

ADVANTAGES AND DISADVANTAGES OF LOW TEMPERATURE ASPHALT PRODUCTION

Prof. E. Prina Howald

Asphaltic concrete is a mixture of aggregate and bituminous liant, hot-mixed at temperatures generally above 150°C. In order to reduce the energy impact of producing these mixes, it is possible to reduce the production temperature by adding chemical additives. The aim of this project is to analyse the advantages and disadvantages of low temperature asphalt production. The project includes an experimental study and a rheological study, part of which will be carried out in the laboratory in collaboration with a building materials laboratory.

Students in Civil engineering and/or environmental engineering with strong interest in road construction

NUMERICAL MODELLING OF GLACIER MOVEMENTS IN RESPONSE TO CLIMATE CHANGE

Prof. E. Prina Howald

Climate change is the leading cause of glaciers thaw in the Alpine environment. Over the last 30 years, it has led to a drastic increase in rock instabilities, landslides, mudflows, and debris flows in the European Alps.
The project aims to analyse the risks associated with glacier movements due to climate change. In order to carry out this task, a numerical model will be used to assess the temperature rise on glaciers displacements and its consequences.

Students in Civil engineering and/or environmental engineering with strong interest in Natural Hazards and modelling

EFFECT OF THAWING ON FROZEN SOIL GEOMECHANICAL PROPERTIES

Prof. E. Prina Howald

Climate change is the leading cause of permafrost thaw in the Alpine environment. Over the last 30 years, it has led to a drastic increase in rock instabilities, landslides, mudflows, and debris flows in the European Alps.
The aims of this project is to quantify exprimentally the effect of thawing on the geomechanical properties of a reconstructed soil samples. The project include the establishment of a test protocol and laboratory tests.

Students in Civil engineering and/or environmental engineering with strong interest in lab tests

PHYSICAL VULNERABILITY ASSESSMENT OF THE BUILT ENVIRONMENT TO DROUGHT

Prof. E. Prina Howald

Climate change is increasing the intensity and duration of soil droughts due to increased evaporation associated with rising temperatures. One of the effects is the swelling and shrinking of clay soils. Although this problem does not directly threaten human life, it causes significant damage to buildings and structures each year.
The aim of this work is to investigate the impact of long periods of heat on the built environment.

Students in Civil engineering and/or environmental engineering with strong interest in Natural Hazards

TERRAIN VULNERABILITY AFTER A PROTECTIVE FOREST FIRE

Prof. E. Prina Howald

Climate change has an important influence on the increasing frequency of events related to natural hazards. Forest fires are intimately linked to this problem. The negative effects of fire on soils include soil erosion and loss of organic matter, nutrient

depletion, changes in soil structure and texture, and increases in soil pH. Severe fires can also cause soil hydrophobicity, which reduces water infiltration and leads to increased runoff and erosion.

The objectives of this study are to characterize the different effects of fire on protective forests and to determine the real impacts of this loss on the development of other natural hazards such as rockfalls. In addition, it will be important to participate in the creation of a comprehensive methodology for short and long term response to these fires.

Students in Civil engineering and/or environmental engineering with strong interest in Natural Hazards

DESIGN OF RECYCLED SOIL STRUCTURES

Prof M. Viviani

Shot-earth is an ecological material made of high percentages of excavated soil. This materials has been tested and mix design methodologies has been prepared. A recent serie s of test have been made in large scale structural element sucha as beams and vault. The aim of this project is to clarify the the procedures and the model that will be used to design shot -earth reinforced structures. A second aim of this project is to control if and how the water uptake might influene the strength of the material.

Keywords: excavation soil, structural engineering, construction fields

Students in Civil engineering and Material sciences with strong interest for lab tests and modelling

TOWARD A MIX-DESIGN STRATEGY FOR EXCAVATED SOIL COMPOSITE CONSTRUCTION MATERIALS

Prof. M. Viviani

The mix-design strategy is fundamental for the acceptance of any new construction material, whether sustainable or not. The objective of this project is to investigate and prepare mix-designs for structural materials made of excavated soil. The project will begin with soil type identification using advanced analytical techniques, such as X-ray diffraction (XRD). This project will provide valuable hands-on experience in the development of sustainable construction materials, including understanding their properties, durability, and their use in building sustainable structures.

Keywords: excavation soil, performace based mix design, construction fields, mix design of composite materials

Students in Civil engineering and Material sciences with strong interest for lab tests and modelling

OPTIMIZATION OF EXISTING MULTI FAMILY BUILDING DECARBONIZATION

Dr. A. Duret

Multi Family Buildings (MFB) remains largely non-retrofitted and use mainly fossil

energy for heating and domestic hot water (DHN) production in Switzerland. This category of building is therefore responsible for a large share of the GreenHouse Gas emission of the swiss building stock. The retrofitting rate of those categories of buildings remains too low to reach the CO2 emission reduction national target. In order to address this issue, an applied R&D project has recently been launched to optimize the decarbonization of existing MFBs by combining limited retrofitting actions with heat distribution and DHW production optimization and switching from fossil based heat producer to Air Source Heat Pump (ASHP).

The proposed internship will directly contribute to the realization of this project. Based on a defined modeling and optimization strategy, the student selected for this internship will be responsible to develop several numerical models: (1) a dynamic model to generate the building heating demand and the DHW production as a function of weather conditions and taking into account various retrofitting actions, (2) model of the heating distribution system to calculate the minimum forward temperature to satisfy the heating demand and (3) a simplified model of an ASHP able to compute the performances as a function of the operating conditions. Those models will then be connected one to each other to evaluate and compare several decarbonization scenarios. The developed method will be tested with at least one case study based on a real MFB.

Keywords: Building retrofitting, building decarbonization, renewable heating, numerical modeling and multi objective optimization

MULTI-OBJECTIVE OPTIMIZATION OF BUILDING ENERGY SYSTEMS

X. Jobard

This internship is part of an applied research project with the objective to develop a multi-objective optimization method to identify the optimal energy concept for the deployment of micro-grids at the neighbourhood's scale. Based on the consumption profiles of buildings and a set of storage and decentralized production technologies (photovoltaic, cogeneration, etc.), the aim is to define optimal solutions that reduce costs while minimizing the environmental footprint. The internship's work plan will follow the following steps:

- Definition of technical, environmental and economic performance models for the different conversion technologies considered.
- Implementation of a multi-objective optimization method including, as performance indicators, costs and environmental impacts (carbon footprint and non-renewable primary energy).
- Application of the method to a case study (theoretical or real according to available data)
- Possibly sensitivity analysis to identify the factors that influence the choice of optimum energy concepts for a given building complex.

minimum duration of this internship is 4 months (preferably 6 months).

Keywords: Multi-objective optimization, renewable energy, microgrids

TWO-PHASE HEAT NETWORKS

Prof E. Da Riva

Latent heat transfer by means of condensation or evaporation requires a considerably lower mass flow rate than sensible heat transfer. As compared to conventional water networks, thermal network exploiting the phase change of a suitable fluid may display a much smaller diameter, thus being competitive especially in applications such as the combined use of a lake as heat-source and heat-sink for heating and cooling in densified city centers.

The Institute of Thermal Engineering (Institut de Génie Thermique, IGT) has developed a thermosiphon CO2 two-phase prototype thermal network which can be used as direct heat-source to the evaporator of a heat pump.

The project proposed may cover the following topics:

- Experimental test and data analysis of the existing prototype network
- Two-phase heat networks modeling and comparison among different fluids
- Energy et technical feasibility assessment of two-phase thermal networks

Students with previous knowledge from courses in refrigeration engineering, heat transfer, hydraulic network design

IDENTIFICATION OF SYNERGIES AND OPTIMIZATION OF DISTRICT HEATING NETWORKS IN URBAN AREAS

Prof. M. Capezzali

District heating networks (DHC) are developing significantly in Switzerland, in particular to replace oil-fired boilers, but also for energy efficiency in the broad sense. Most urban areas in Switzerland have a heterogeneous distribution of buildings in terms of heating demand. of buildings in terms of heating demand, which leads to disparate territorial temperature requirements. requirements. On the one hand, one strategy to implement different technologies and solutions is to build multiple On the one hand, one strategy to implement different technologies and solutions is to build multiple smaller DHNs in urban areas, adapted to existing heat sources or, if necessary, to implement new efficient heat sources for the remaining efficient heat sources for the remaining areas. On the other hand, it is possible to identify synergies between separate networks, in terms of demand dynamics and temporal capacity availability, which On the other hand, it is possible to identify synergies between separate networks in terms of demand dynamics and temporal capacity availability, leading to a de facto multi-injection and multi-temperature network. Load transfer and intermediate reserve strategies can thus be implemented, avoiding oversizing of the network. strategies can be implemented, avoiding oversizing. The project will focus on the development of an approach allowing, on the one hand possible synergies between

DHN networks in an urban area and to understand how best to exploit these to understand the best way to exploit these synergies with respect to the dimensioning of networks and the load curves of the connected buildings.

A concrete case of application of the method will be carried out on the CAD networks of a city in Switzerland, in the framework of a national project coordinated by the HEIG-VD.
The tasks will be the following:

- Development of the method for identifying synergies based on supply technologies supply technologies.
- Coupling with demand data at territorial level.
- Translate the method into a usable code (e.g. Python), in collaboration with an IESE.
- Validation of the developed framework on a test case in French-speaking Switzerland, in the framework of a national project.
- Calculation of indicators to compare different synergy scenarios.

Keywords: District Heating Networks, Control Strategy, Urban Energy Planning, Simulation

Requirements: Interest in Python, knowledge in energy engineering

OPTIMIZATION OF ENERGY PRODUCTION FROM BIOLOGICAL WASTE TROUGH ANAEROBIC DIGESTION

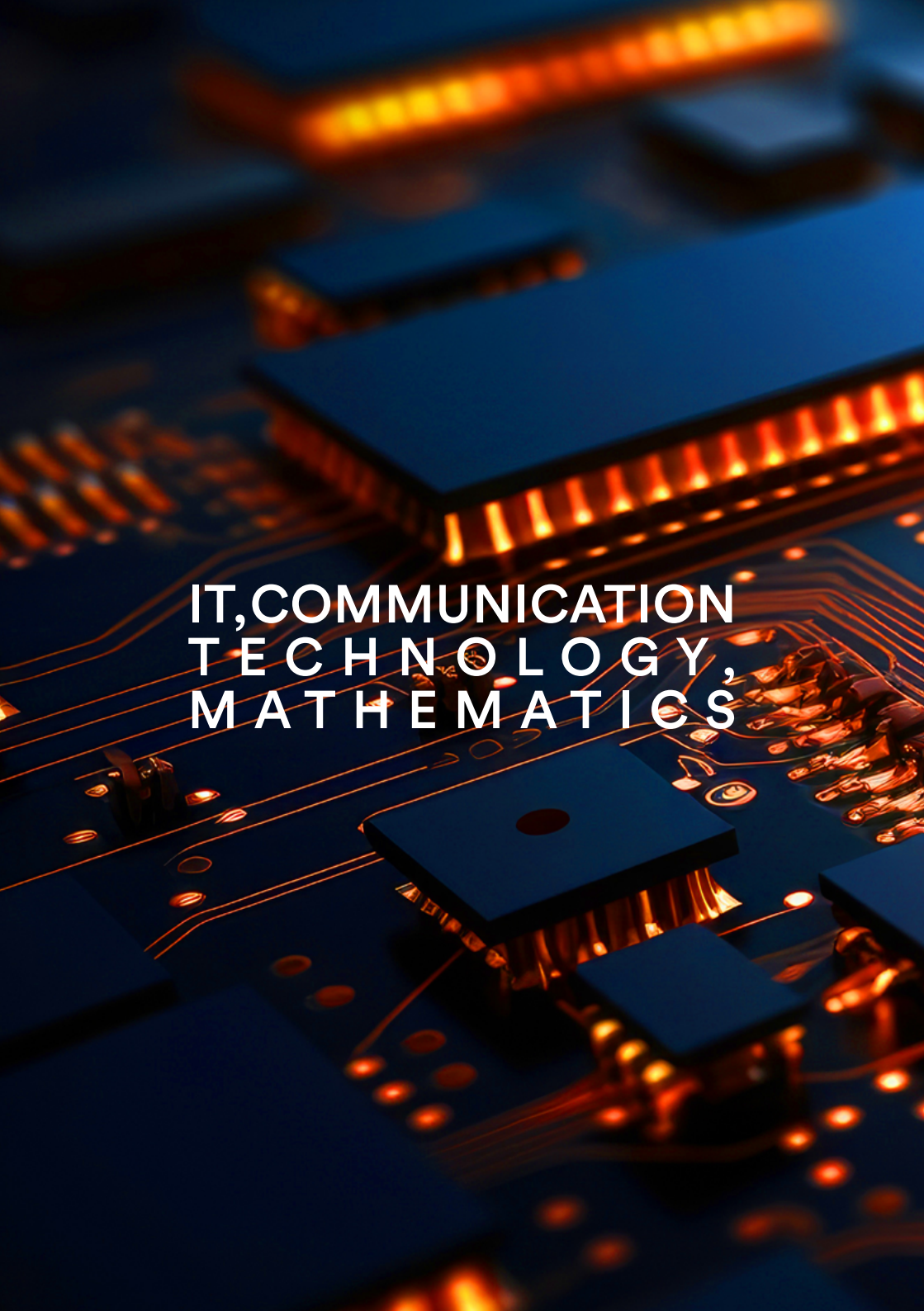
Prof. Dr. R. Roethlisberger

As the world is facing a growing issue with climate change, alternative energy sources are becoming more and more prominent. Among them, anaerobic digestion is a carbon neutral way of converting organic waste into methane, while producing an organic-rich fertilizer. It thus perfectly falls within the concept of a circular economy. The Institute of Thermal Engineering (Institut de Génie Thermique, IGT) is active for several years in this research field. The IGT is particularly active on implementing findings from research laboratories into the field, especially regarding topics like energy and biofuel production from wet and dry biomass, agricultural and food-waste anaerobic digestion, biogas purification technologies and micro-macro algae utilisation for nutrients removal.
The main research activities focus on pre-treatment protocols of fibrous biomass such as manure (using grinding, organic acid and thermal treatments) and PBR (photobioreactor) systems using microalgae to treat water/air waste streams.

If you want to be integrated in one of these research topic, please feel free to contact us.
Minimum duration 4 months, preferentially 6 months.

Keywords: methanization, anaerobic digestion, pre-treatments, microalgae,
biogas upgrade

Students in environmental engineering and/or in biotechnology, with strong interest for laboratory work


IT, COMMUNICATION
TECHNOLOGY,
MATHEMATICS

PLANT ELECTROPHYSIOLOGY ANALYSIS AND MODELING FOR PRECISION AGRICULTURE PURPOSES

Prof. Dr. L. Raileanu

Environmental alterations trigger changes in the underlying plant physiological processes portrayed by distinct variations of the electrical potential. Advanced signal processing and data analysis techniques enabled an automatic recognition of patterns in the electrical response of plants growing under typical production conditions allowing the identification of a plant's health status with high accuracy. However, current developments are based on classical machine learning algorithms requiring the extraction of features from the signal. The proposed project aims to extend the existing modeling approach by developing a classification framework that will extract features in an automated manner, such as applying deep-learning-based algorithms.

Keywords: signal processing, data analysis, deep learning, plants, electrical signal

FRUIT GROWERS ADVISORY SYSTEM BASED ON MACHINE LEARNING EXPLORING FRUIT DIAMETER GROWTH AND MICRO-CLIMATE DATA

Prof. Dr. L. Raileanu

Commercial orchards are increasingly dependent on proper irrigation to ensure the highest yields and optimize production quality. Still, current monitoring tools need greater accuracy that could be achieved by incorporating indicators based directly on the plants. Moreover, tomatoes show difficulty adapting to the water and nutritional contributions provided by automatic systems in the greenhouses, resulting in physiological damage of the fruit, such as skin "cracking" leading to important yield losses. The main objective of the project is to model the growth of the fruits by using intelligent data analysis techniques on data from fruit dendrometer and micro-climate measurements in combination with the expertise of agronomists, to provide a tool for fruit growers that would help them predict physiological damage of the fruits and improve the quality of the crops, while optimizing harvest timing and reducing water usage.

Keywords: data analysis, machine learning, fruit growth modeling

MALE FERTILITY ASSESSMENT BASED ON SPERM MORPHOLOGY

Prof. Dr. L. Raileanu

Semen analysis is considered the cornerstone of male infertility assessment, whereas spermatozoa morphology is one of the fundamental parameters for evaluating sperm quality. Evaluation of the morphology from microscopic sperm images could help reduce the required time and the observer-based variability of the manual analysis currently used as a clinical gold standard. Moreover, morphological abnormalities represent various forms and shapes on different cell parts, making classification a challenging task. This project aims to use

image processing and machine learning algorithms on spermatozoa images to automatically distinguish abnormal from normal cells and classify different abnormal sperm morphology.

Keywords: image processing and analysis, machine learning, semen analysis

ECG-BASED IDENTIFICATION OF HEART ANOMALIES

Prof. Dr. L. Raileanu

Heart diseases are the leading cause of mortality worldwide. The electrocardiogram (ECG), measuring the heart's electrical activity, is a vital tool in routine clinical practice, assisting in diagnosing cardiovascular diseases. However, the properties of the recorded curve could vary between subjects and anomalies. In fact, the ECG signal could either present different morphological characteristics for the same disease or display similar features for different diseases. We aim to use advanced signal processing and machine learning algorithms on ECG signals to model patterns that identify and automatically discriminate different heart anomalies represented by the ECG curves.

Keywords: signal processing, data analysis, machine learning, heart diseases

DEVELOPMENT OF COMPUTABLE PHENOTYPE ALGORITHM FOR POSTOPERATIVE SURVIVAL PROGNOSIS OF NEONATES

Prof. Dr. L. Raileanu

Patient data are routinely collected day-to-day clinical practice using electronic medical records (EMRs) and/or specialized databases. These data could represent both structured information (specific clinical evaluation parameters, results of a blood test, etc.) and unstructured free-text notes, which provide health care providers with information to convey the nuances of a patient's unique presentation and history. These data could be used to extract facts and specific characteristics of the patients to identify, for example, specific disease cases, treatment, or survival outcomes. Compiling such a large amount of information manually using conventional statistic methods could take months and hundreds of person-hours. Recent advances in computational science allowed integrating more effective and less time-consuming methods into clinical care routine and research, such as computable phenotype algorithms. These algorithms could search across EMR databases to perform case detection. This project aims to develop a computed phenotype algorithm for the prognosis of postoperative survival of children by using data collected and stored at restricted-access database.

The student will develop a computed phenotype algorithm that would predict survival (or death) in newborn children after surgery based on clinical data collected in the pre-, intra- and post-surgery periods and registered in a specialized database. This will facilitate further in-depth processing and analysis of the clinical parameters and developing clinical strategies to increase the chances of a kid's survival.

Keywords: data analysis, machine learning, neonates survival

Secure geolocation solution on mobile
Fabien Dutoit

This internship aims to study, design, implement and evaluate a secure geolocation solution for mobiles. Today, geolocation on smartphones is mainly achieved through GNSS, Wi-Fi positioning, or BLE beacons. Still, none offer a strong guarantee as they can be unavailable or spoofable. After completing a state-of-the-art of existing technologies and their availability on mobile platforms, the trainee will propose a solution and realize a PoC. Several approaches are possible to realize this project; one possibility is the design of a BLE beacon integrating cryptographic features.

Keywords: smartphone, mobile, android, ios, BLE, beacon, geofencing, security, embedded

Serious games and Learning analytics
Prof D. Jaccard

At Media Engineering Institute (MEI), AlbaSim «serious games» research group (www.albasim.ch) develops games and simulations for training purposes in fields such as project management, oncology care or medical management of major events. These serious games are available online and used by thousands of students from different universities. The project aims at studying the possibilities of using usage traces in order to improve the quality of both the games and learning. This study includes conceptual, technical, legal and statistical aspects.

End of Bachelor or Master student in Computer sciences or with a background in user experience.

Serious games: User experience
Prof D. Jaccard

At Media Engineering Institute (MEI), AlbaSim «serious games» research group (www.albasim.ch) develops games and simulations for training purposes in fields such as project management, oncology care or medical management of major events. The UI and UX aspects of games are essential. The aim of the project is to test and evaluate the UI and UX aspects of existing games, define possible improvments, implement and assess the effects of those changes.

End of Bachelor or Master student in Computer sciences or with a background in user experience

Machine translation at the text level
Prof A. Popescu-Belis

The goal of this internship is to study the combination of recent, deep learning approaches to machine translation (MT), with other recent approaches for coreference resolution, i.e. finding the words or phrases in a text that refer to the same entity. Knowledge of coreference

is potentially useful for translating more coherently the referring expressions, but is hard to combine with neural MT. This internship will be devoted to the combination of the two architectures, based on existing systems, for instance by adopting a multi-task learning approach.

Students with previous knowledge from courses in machine learning, neural networks, human language technology or artificial intelligence

Task-oriented chatbots using neural networks

Prof A. Popescu-Belis

Recent neural network approaches to the design of chatbots have resulted in realistic conversational agents - using written, or sometimes spoken language. However, while these agents are trainable through conversations, it is difficult to connect these agents to knowledge bases, so that they perform useful tasks, such as question answering or database transactions. The internship will focus on a hybrid chatbot, which can switch between a conversational, NN-based model for the social aspects of an interaction, and a traditional, knowledge-based model for the task-oriented aspects. The second model could, for instance, perform community question answering, i.e. use existing answers to popular questions to answer new ones, assuming they are variants of existing ones.

Previous knowledge from courses in machine learning, neural networks, human language technology or artificial intelligence

Gamification of Markov Chains

Prof. M. Rubinstein

Gamification is a technique that introduces gaming elements into teaching.

In this project, the student will design and implement a game to teach Markov chains. The game will include competition, collaboration, and a goal to be achieved through the learning and application of Markov chains.

Basic knowledge of Markov Chains. Coding.

Gamification of telecommunications

Prof. M. Rubinstein

Gamification is a technique that introduces gaming elements into teaching.
In this project, the student will design and implement a game to teach Markov chains. The game will include competition, collaboration, and a goal to be achieved through the learning and application of Markov chains.

Knowledge of the OSI Model and telecommunications. Coding.

SDR digital modulator and demodulator

Prof. M. Rubinstein

In this project, the student will create a prototype of a Software-Defined-Radio-based platform to generate, transmit, receive and observe digitally modulated

signals (BPSK, QPSK and possibly QAM) and the effect of the carrier frequency, symbol rate, noise, etc. on the performance.

Telecommunications. Digital modulation

Medical drug dosage adaptation software

Prof. Y. Thoma

Tucuxi (http://www.tucuxi.ch) is a software that has been developed with the aim of helping the pharmacologists with the adaptation of medical drug dosages. The current system supports drugs with single analytes, but some medical drugs require multi-analytes models. The computing engine has been developed in C++, and the GUI in C++, with QML. The goal of this project is to adapt the current GUI to multi-analytes models, with a specific emphasis on the reliability of the system. A psychotropic drug model will be used to validate the system.

Computer science or c. engineering students: C++ software development, expert system..

Medical drug dosage adaptation smartphone/tablet app

Prof. Y. Thoma

Tucuxi (http://www.tucuxi.ch) is a software that has been developed with the aim of helping the pharmacologists with the adaptation of medical drug dosages. The current system is composed of a computing backend and a GUI running on a PC. The goal of the current project is to develop a smartphone/tablet version of the software. It would take advantage of a remote computing engine already available, and would let the user access data and results in a user-friendly interface.

Computer science or computer engineering students: C++ software development, app design

Drug models validation/addition for drug dosage adaptation software

Prof. Y. Thoma

Tucuxi (http://www.tucuxi.ch) is a software that has been developed with the aim of helping the pharmacologists with the adaptation of medical drug dosages. Models for specific drugs are describes in XML files, and cross-validated against a software called NONMEM. This software is used by pharmacologists to generate models from population data. Currently Monolix seems on the rise to replace NONMEM, and is notably used by our partners at CHUV hospital. This project aims at replacing NONMEM with MONOLIX for the validation of the drug models (the framework uses python scripts), and to implement various new models that will be defined at the beginning of the project. These models will then be offered to the community.

Computer science or computer engineering students: python, interest in discovering pharmacology

Formal verification of digital systems

Prof. Y. Thoma

When designing digital systems for FPGAs or ASICs, developers usually write testbenches. Formal verification is a new technics that offers the possibility to formally check a design againsts properties, and to end up with more realiable systems. Proprietary solutions exist, but are very expensive for our partners. Yosys is an open source initiative that allows to perform some formal verification (https://github.com/YosysHQ/yosys). The goal of the project is to select some already existing interesting VHDL designs, to implement properties and assertions to formally verify their behavior, and to end up with a good comprehension of the possibilities and limitations of the open source option versus the commercial ones.

Computer engineering students or electrical engineering students with background in HDL design

DEEP-INSIGHTS: Extracting Internal Representations from Deep Neural Networks

Prof C. Peña/Xavier Brochet

The proposed project is developed in the frame of our XAI (explainable Artificial Intelligence) research activities. Among other lines, we are exploring the development of novel methods for extracting internal representations from trained Deep Neural Networks. Such methods are able to identify input patterns which are significant for the predictiuons of a given Deep Neural Network and , and that may explain how they make their predictions.
The specific goal of the student's project will be to investigate, implement, and test such an approach for one of the specific deep network architectures that we are using in our research projects. For instance: 1D convolutional or LSTM networks.

Machine learning, Deep learning, Explainable Artificial Intelligence.

RULE-DEEP-EXTRACT: Extraction of Rules from Deep Neural Networks

Prof C. Peña/Xavier Brochet

The proposed project is developed in the frame of our XAI (explainable Artificial Intelligence) research activities. Among other lines, we are exploring the development of novel methods for extracting rules from Deep Neural Networks. Such methods will be able: (1) to extract knowledge in the form of hierarchical rule representations to explain how Deep Neural Networks make their predictions while (2) preserving, as much as possible, the prediction accuracy of the neural network.
The specific goal of the student's project will be to investigate, implement, and test an approach for extracting rules from specific deep network architectures that we are using in our research projects. For instance: 1D convolutional or LSTM networks.

Machine learning, Deep learning, Explainable Artificial Intelligence.

Deep Learning on Genomics using NLP-oriented algorithms

Prof C. Peña/Xavier Brochet

The goal of this project is to apply deep learning techniques that has proven very good at text classification, to deal with genomic data in the context of biological classification. Methods such as LSTM or BERT will be explored and applied to at least 2 different datasets from our group's research projects. Context. In the field of biology, from an information point of view, a DNA sequence can be considered as a sequence of specific characters such as 'A', 'C', 'G' and 'T' called bases. It is generally accepted that the information encoded by the DNA is organized hierarchically in blocks of growing complexity (e.g., domains, genes, chromosomes) related directly with biological characteristics and phenomena. Although different to language, DNA-encoded information has a latent structure that could be exploited by machine-learning algorithms to build predictive models.

Machine learning, Deep learning, Bioinformatics, Genomics.

Machine Learning on Genomics using NLP-inspired approaches

Prof C. Peña/Xavier Brochet

The goal of this project is to apply dna2vec, a computational technique inspired from the NLP method word2vec that has proven very good at text classification, to deal with genomic data in the context of biological classification. More specifically dna2vec (or a similar approach) will be applied to at least 2 different datasets from our group's research projects.
Context. In the field of biology, from an information point of view, a DNA sequence can be considered as a sequence of specific characters such as 'A', 'C', 'G' and 'T' called bases. It is generally accepted that the information encoded by the DNA is organized hierarchically in blocks of growing complexity (e.g., domains, genes, chromosomes) related directly with biological characteristics and phenomena. Although different to language, DNA-encoded information has a latent structure that could be exploited by machine-learning algorithms to build predictive models.

Machine learning, Bioinformatics, Genomics

EVO-PERPHECT Artifical Evolution on Natural Viral Genomes

Prof C. Peña/Xavier Brochet

In the context of developing viral (phage) therapies to fight resistant bacteria, we have developed models able to predict interactions between bacteria and phages based only on their genomic sequences. As a next step, in the PERPHECT project we are exploring the use of Artificial intelligence (AI) to produce genetically-engineered (GE) phages that may provide substantial advantages over natural phages in terms of host range, immune system recognition, and environmental stability. To do so, PERPHECT couples a genome-based interaction predictor with a genome generator that has the potential to create sequences very similar to naturally-occurring ones.

The specific goal of the student's project will be to investigate, implement, and test a generative method based on artificial evolution (e.g., a genetic algorithm) operating virtual modifications (evolution) to existing viral genomes. This method could be integrated/coupled with an existing predictive model in order to search for phage genome editions that improve their therapuetical performance.

Machine learning, Deep learning, Bioinformatics, Genomics

PERPHECT-RL
Modifying viral genomes through Deep Reinforcement Learning

Prof C. Peña/Xavier Brochet

In the context of developing viral (phage) therapies to fight resistant bacteria, we have developed models able to predict interactions between bacteria and phages based only on their genomic sequences. As a next step, in the PERPHECT project we are exploring the use of Artificial intelligence (AI) to produce genetically-engineered (GE) phages that may provide substantial advantages over natural phages in terms of host range, immune system recognition, and environmental stability. To do so, PERPHECT couples a genome-based interaction predictor with a genome generator that has the potential to create sequences very similar to naturally-occurring ones.
The specific goal of the student's project will be to investigate, implement, and test a generative method based on Deep Reinforcement Learning to modify existing viral genomes. This method could be integrated/coupled with an existing predictive model in order to search for phage genome editions that improve their therapuetical performance.

Machine learning, Assisted annotation, Microscopical imaging, Image processing

Deep Learning for Earth observation

Prof A. Perez-Uribe

Deep neural networks have shown to be very good at image classification and object recognition tasks. The objective of this project is to train a custom system to process and analyze satellite images (both from day and night). To achieve this, we will take advantage of pretrained models provided by the major actors in the domain and proceed to fine-tune them with our own data. Potential applications include, forest monitoring, population growth analyses, socio-economic issues, etc.

For more information: http://iict-space.heig-vd.ch/ape

Keywords: Deep Neural Networks, image processing, Machine Learning

Personal mobile coach

Prof A. Perez-Uribe

The increasing availability of wearable sensors embedded in smartphones, watches and physical activity trackers has open the door to original applications, mainly in health and wellness improvement. One typically collects data by means of sensors

like GPS, accelerometers, gyroscopes, barometers, microphones, cameras, depth sensors, etc. To make sense of these data, Machine learning algorithms can be used to establish correlations among the variables under investigation, and as in every attempt to understand high-dimensional data, visualization and dimensionality reduction techniques can suggest new knowledge about the aspects of the person's life being monitored.
The objective of this project is to deal with diverse application domains including self-tracking of physical activity, self-tracking and characterization of style and performance in sport (e.g., racket sports, running), daily-life logging , or 24/7 self-monitoring as a means to enhace our wellbeing.
For more information: http://iict-space.heig-vd.ch/ape

Keywords: wearable sensors, smartphones, smartwatches, time-series, Machine Learning, health, sports

Human-humanoid interaction

Prof A. Perez-Uribe

The current availability of the first humanoid robots at moderate prices opens up a wide range of applications. The objective of this project is to program a humanoid robot or a human-humanoid interface using 3D cameras or smart glasses. Potential applications include the programming of appropriate behaviors that makes the interaction with such robots more human-like with the aim of increasing our trust in them.

For more information: http://iict-space.heig-vd.ch/ape

Keywords: Humanoid robots, human-humanoid interfaces, Kinect, image processing, Machine Learning

Smart rehabilitation

Prof A. Perez-Uribe

Werable sensors open the door to monitoring patients at home. This can provide very valuable data to doctors, that nowadays rely on the observation of their patients when they go to the hospital and on the subjective information provided by the patients themselves or their relatives. Within this project, we will use wearable sensors and egocentric cameras to identify and evaluate the quality of movement of persons suffering from upper-limb neurological disorders. To identify particular movements, we will use machine learning algorithms to exploit both, the video captured by the camera and the time-series captured by the wearable sensors.

Keywords: wearable sensors, Machine Learning, rehabilitation

E-learning to take over geospatial standards from OGC API through an educational scenario on climate change

Prof O. Ertz / J. Ingensand

The Media Engineering Institute (MEI) and the Institute of Territorial Engineering (INSIT) do work since ten years in the field

of geostandardization [1]. Recently the research team is involved in the deployment of a centre of competence in this field [2]. One underpinning purpose is also to produce learning material. Therefore, the proposed intership work participates to the development of an e-learning web app aiming to understand and use the latest Open Geospatial Consortium OGC API standards [3]. The idea is to offer an interactive and gamified way to practice them on the basis of an educational scenario that manipulates climate change geodata [4].

The internship concerns the setup of a simulation platform offering a guided sequence of actions using geospatial APIs (remote sensing, vector and sensor data, custom styling, etc) in order to allow the assessment of the local impact of climate change and to address target measures and indicators to policy makers. It is to put into perspective the usefulness and use of geospatial APIs, all while learning in a practical way how to use these new technologies. The proposed work will be based on some preliminary designed learning objectives and defined didactics extending already existing OGC tutorial modules [5] as well as on an already deployed geodata infrastructure.

The work will follow several phases

1. carry out a state of the art to draw up a panorama of knowledge and techniques
2. specify, design and develop a proof of concept of the intended simulation platform
3. follow an agile process to implement a first release with the web technologies studied during the first phase and
4. deploy and test with multiple learners in order to improve and validate the concept.

software engineering and development with interest in Geographic Information Systems; Interest in e-learning platforms, in educational technologies (EdTech).

BioSentiers augmented reality and occlusion techniques

Prof O. Ertz / J. Ingensand

BioSentiers is a project lead by the Media Engineering Institute and the Institute of Territorial Engineering. The purpose is to offer a way to discover biodiversity through a location-based augmented reality mobile application (see biosentiers.heig-vd.ch). That means, given a predefined pathway marked all along its length with points of biodiversity interest, citizens of Yverdon-les-Bains have the possibility to observe them and virtually interact with nature by getting extra multimedia content about various flora and tree species.

The proposed work is about a new feature for the front-office AR application to allow object occlusion while exploring the area around the user. In other words, the purpose is to find a solution to avoid the display in the AR scene of points of biodiversity interest which may be hidden by a building in the real environment. The swissTLM3D large-scale topographic landscape model and swissBUILDINGS3D vector based dataset which describes buildings as 3D

models may be useful to implement such a feature.

The work will follow three phases

1. carry out a state of the art to draw up a panorama of knowledge and techniques on this theme
2. specify, design and develop a proof of concept of the intended feature
3. integrate the occlusion solution so as to release a new version of the AR front-office BioSentiers application.

Background in software engineering and development with interest in augmented reality or in geographical sciences with focus on interactive mapping techniques

Media Engineering Institute (MEI)
Smapshot Narrative
Prof. D. Rappo

Smapshot is a geolocation tool dedicated to photography. The web platform allows volunteers to position images within a virtual globe in order to locate them in 3D. End users can go back in time, browsing through photographic collections dating from the late 19th century to nowadays.The platform has been in development since 2017, it will soon contain 200'000 images, many software features, and new extensions are being considered.
The following description is one of them.The goal of this project is to create an editor and a viewer for narrative presentation inside smapshot, taking advantage of 3D views for an immersive interactive experience. This new kind of narrative support could be used on the web, or on dedicated devices for examples
You'll have to develop an editor (PoC), with following potential features: select images from georeferenced sources in smapshot via a search engine (keywords, location, owner, collection) or direct selection on a map, rearrange order of images inside the presentations, select info to display with the image (title, description, date, etc.), add additional info (augmented text).
For the conception phase, you'll have to research current similar solutions and extract most common features, must have, etc. and create wireframe of user interface. MEI can help with this phase.Afterwards you'll have to develop the viewer (PoC) whose main features are: display list of narrative presentations, and view a narrative presentation.
The conception step includes the research of current similar solutions and the extraction of most common features, must have, etc. You'll be ask to create wireframe of the user interface. MEI can help with this phase.

Students must be skilled in web development, the technologies used are VueJS, Tailwind, CesiumJS for the frontend, NodeJS for the backend, PostgreSQL for database, Docker and ansible for Sysadmin

Media Engineering Institute (MEI)
My Smapshot
Prof. D. Rapp

Smapshot is a geolocation tool dedicated to photography. The web platform allows volunteers to position images within a virtual

globe in order to locate them in 3D. End users can go back in time, browsing through collections dating from the late 19th century to nowadays.
The platform has been in development since 2017, it will soon contain 200'000 images, many software features, and new extensions are being considered. The following description is one of them.
The goal of this project is to adapt Smapshot for personal usage (uploading trekking pictures, holiday images, etc.). In particular, adapt the backoffice interface to manage import of new images by the user, import location from EXIF, add other metadata, georeference the pictures...
The backoffice main potential features are: user backoffice, admin backoffice / security, deployment.
For the conception phase, you'll have to create wireframe of user interface. MEI can help with this phase.
The development expected is a proof of concept for the fullstack.

Students must be skilled in web development, the technologies used are VueJS, Tailwind, CesiumJS for the frontend, NodeJS for the backend, PostgreSQL for database, Docker and ansible for Sysadmin

High Performance Python

Prof. A. Dassatti

Python is quickly becoming the language of the research community. This is extremely interesting because lowering the entry barrier to science will boost research ideas. On the other and, Python is not the best tool to effectively use the available hardware and obtain the performance usually needed by the researcher. Several attempts do exist to boost Python performances and the scope of this project is exploring the state of the art in the field to quantify benefit and limit of competing solution.

Keywords: Python High Perfornace Computing
Requirements: Python, C/C++, GPU, computer architecture.

Smart Storage

Prof. A. Dassatti

Data centres demand more and more computation efficiency. Standard CPU are unable to cope with the demand and GPU can only serve specific computation patterns. FPGAs are an attractive technology in this field, but its integration in the data centre infrastructure is not trivial. Smart Storage solutions based on the NVMe protocol are the most promising path in this scenario. In our lab we have developed a first prototype of the technology and this project will focus on extending its functionalities and benchmark it extensively.

Keywords: Storage, NVMe
Requirements: computer architecture, C/C++, basic FPGA a plus, Operating systems

DVBS2x LDPC decoder

Prof. A. Dassatti

LDPC are powerful error correction codes

adopted by many modern communication standards. In satellite communication, for instance, DVBS2x use a specific LDPC to protect video transmission from and to space. In our lab we have a complete Software Defined Radio system implementing the system in software, but the performance of the LDPC decoder are unable to cope with the required data rate for a real-time system. In this project we will develop a FPGA based LDPC decoder and we will test it in a complete radio communication chain.

Keywords: LDPC, SDR
Requirements: C/C++, FPGA design experience

Smart Network

Prof. A. Dassatti

Data centres demand more and more computation efficiency. Standard CPU are unable to cope with the demand and GPU can only serve specific computation patterns. FPGAs are an attractive technology in this field, but its integration in the data centre infrastructure is not trivial. Smart Network interface (NICs) solutions are attractive for offloading many filtering and computation directly at the network attachment point relieving the CPU of many tasks. This project will be based on our 100Gb research prototype and explore the state of the art in the domain with the aim at developing and benchmarking off-loading tasks to an FPGA.

Keywords: Networking, Hardware
Requirements: computer architecture, C/C++ programming, basic FPGA knowledge a plus, Operating systems

Portable gait analysis system in natural conditions for the diagnosis of neurological disorders

Prof. R. Mosqueron

- Background: Walking is a complex motor task performed automatically by healthy adults. In the elderly and in patients with various neurological conditions (e.g. Parkinson's disease), the automaticity of walking decreases or disappears. Several studies have identified changes in certain gait parameters as independent predictors of fall risk and disease severity.
- Problem: These gait changes are often too subtle to be detected by clinical observation alone. Objective quantification of these gait changes is necessary to determine the risk of falling or the progression of the disease, and to enable, where possible, the prevention of falls. Current technologies for studying gait involve either a vision laboratory or fitting the patient with a series of sensors on both sides, and take place in specific environments, in an ad hoc manner, which do not reproduce normal living conditions.
- We propose to develop a rechargeable, unilateral, daily wearable device, such as a bracelet, including the necessary sensors to analyse a limited group of parameters to characterise gait and identify patients at high risk of falling.

– This group of parameters includes: (1) cadence with left-right discrimination and its variability, (2) difficulty in initiating and maintaining gait, and (3) festination (gait rush). These narrow parameters are characteristic of different conditions and are potentially measurable with a simple device.

Health, embedded systems

Design of an embedded system for wheelchair vibration acquisition

Prof. R. Mosqueron

As part of the Walio project, which consists of designing a new generation of electric wheelchairs, we wish to obtain data on the vibrations generated by existing wheelchairs in order to

Prove/motivate the interest of a more stable and technologically advanced solution.
Establish a set of reference data for the design of the solution (level of vibration to be damped etc.)
The project consists here in improving and designing elements of the compact and mobile measurement system, easily usable for the acquisition of these data.

The project includes :

Development and optimisation of the electronic system
Design of an electronic board (ideally with EMC validation) and the 3D case
Energy sizing of the system (recharge, battery size etc.)
Establish an interface for data interpretation, representation and modelling
Project management: ensure documentation in relation to the design (SysML modelling)

Health, embedded systems

Virtual SIM for 5G stand-alone network

Prof. R. Mosqueron

As part of these projects, REDS is studying the implementation of a 5G Standalone network (5G SA). To do this, it has a 5G Base Station and various User Equipment (UE -modem connected to Raspberry PI, mobile phone, road, etc.).
These UEs currently use basic SIM cards (USIM), the same as those used by operators. The use of these USIMs is not optimal: It requires individual programming, physical access to the EU, ...
The aim of the project is to study the new generations of cards that are / will be available. These include eSIM (electronic SIM), iSIM (integrated SIM), SW SIM. Once the study has been completed, it will first be a matter of selecting the most suitable type of card. The selection criteria will also be defined during the project
Once the type of card has been selected, a solution, SW and HW, will have to be set up for the use of this type of SIM within the 5G network.

– Progress of the project:
– Study of the different types of SIM card
– Selecting a SIM card type
– SIM deployment

Telecom, embedded systems, 5G

Virtual Implementation of cloud

framework into edge computer
Prof. R. Mosqueron

As part of the development of agriculture in African countries, a distributed edge computer network system could be developed to allow a group of farmers to have access to an intelligent and shared data processing service.

This network would be a private 5G-type base station network where the management would not be done by the mobile telephone operators.

AWS and Microsoft have some frameworks include in their cloud functionalities dedicated to agricultural concern. It is possible to integrate this system into edge (cloud) computing to design an architecture capable of operating without having access to the cloud. Internet access is not guaranteed in these countries, it is necessary that access to these computing power can be done anyway.
Specifications:

- System definition
- Implementation of farmbeats in an edge computer
- Development of communications with sensors and user equipment
- Tests and validation

Cloud computing, Network

Seat tilt control for wheelchair users
Prof. R. Mosqueron

Within the framework of the Walio project, which consists in designing a new generation of electric wheelchair, we are studying the integration of a stabilisation system for the user of the chair to maintain him/her in an adapted position on a steep slope.
Indeed, in the event of a steep slope or descent/climb of stairs, a person in a wheelchair is in a dangerous situation, it is necessary to guarantee a stable and correctly oriented sitting position to limit the risks to health and safety.

The work consists of :

- Design a system that measures the angular position of the user in real time.
- Detect and display the position and critical tilt points to ensure user safety and anticipate tipping
- Adjust the position in real time according to the tilt and speed of the device.
- Combine this system with an anti-tilt detection system.
- Manage this system with the addition of acceleration and centre of gravity management.

Health, embedded systems

Automous drone flying using accelerated deep neural networks
Prof. M. Zapater

Today's embedded systems are deployed in edge devices able to run artificial intelligence applications based on deep neural network algorithms. One such example is the usage of nanodrones able to fly autonomously by executing continuously

in a very efficient way a deep neural network (DNN). The goal of this project is to create a framework able to accelerate and deploy neural networks (such as DroNet) is the RISC-V based accelerator of a nanodrone (AI deck of the Crazyflie 2.1) allowing it to fly autonomously. For this purpose, the student will have to create a framework (in C++ or Python) that takes a DNN as input and generates optimized code for the RISC-V accelerator of the drone. This work might start from open-source projects like the DORY framework (from ETH Zurich) or the GreenWaves NNtool.

Background on embedded Systems.
Knowledge of C/C++.
Python and DNNs would be a plus.

Federated and collaborative learning for nanodrone swarms

Prof. M. Zapater

The nanodrone Crazyflie 2.1 is a very agile, stable, 27-gram nanodrone. Within our research institute we have worked on the creation and deployment of Artificial Intelligence (AI) algorithms that enable the drone to fly autonomously by using Convolutional Neural Networks (CNNs). The goal of this project is to put together a system for federated and collaborative learning, enabling several Crazyflie drones to fly together coordinately and autonomously. This project will use the Light House localisation system together with our internal platform for edge-to-cloud communication, to enable each drone to calculate its position and share it to the others, navigating altogether thanks to AI algorithms. The student will have to put in place the proposed system and create the algorithms for federated and collaborative intelligence that will be deployed into the edge-to-cloud platform (provided by the institute).

Knowledge of C/C++ and Python.
Basic knowledge on AI and CNNs.

Implementing RISC-V vector extensions for artificial intelligence on the Rocket chip

Prof. M. Zapater

RISC-V is a modern and simple open-hardware processor architecture which is becoming widely used today by researchers, but also in industry. The Rocket chip, created by UC Berkeley, is an open platforms that allows to improve both the hardware architecture and the software around RISC-V processors for low-power embedded systems by synthethesing a processor on FPGA to emulate its behavior. The goal of this project is to propose new vector extensions on RISC-V that will be tested on the Rocket chip on FPGA. For this purpose the intern will need to get familiarised with the Rocket platform and development workflow, extending the core and proposing novel extension that will be tested on FPGA.

Background on VHDL/Verilog, FPGAs and computer architecture.
Chisel would be a plus.

Versatile GUI for OpenCN

Prof. D. Rossier

OpenCN is an open, flexible and powerful solution for system control with embedded path planning algorithms and hard realtime control.
It has been used to control different kind of machine like 3 or 5 axes milling machines, laser engraver, Pick & Place robot.
It can be deployed on different targets (x86, ARM / Raspberry PI 4).

The user can control OpenCN though applications running on a distant PC connected through a network connection (Ethernet)

The goal of this project consists of developing a new GUI which has the following features:

- Ability to adapt to different machines.
- Can run on multi-platforms
- Clean interface with OpenCN target

Background on C, C++
Embedded systems
Qt and Motion control would be a plus.

OpenCN - integration of a PLC

Prof. D. Rossier

OpenCN is an open, flexible,and powerful solution for system control with embedded path planning algorithms and hard realtime control.
It has been used to control different kind of machine like 3 or 5 axes milling machines, laser engraver, Pick & Place robot.
It can can be deployed on different targets (x86, ARM / Raspberry PI 4).

The goal of this project consists of t adding the support of a Programmable Logic Controller (PLC), IEC 61131-3 standard, to the OpenCN framework. This will allow very high versatility and customization for the user to reach his need.
It consists in adding the support for at least one of the languages defined in the standard. It means the possibility to write code, compile it and execute it in OpenCN target.

LinuxCNC, OpenPLC open source project can be used as starting point.

Strong C programming knowledge
Motion control would be a plus.

OpenCN - Virtual machine

Prof. D. Rossier

OpenCN - Virtual machine

OpenCN is an open, flexible,and powerful solution for system control with embedded path planning algorithms and hard realtime control. It is used to control different kind of machine like 3 or 5 axes milling machines, laser engraver, Pick & Place robot.
This framework can be deployed on real targets (x86, ARM / Raspberry PI 4) and virtual targets, QEMU based for development / debug activities.
It controls different kind of machine like 3 or 5 axes milling machines, laser engraver, Pick & Place robot.
The goal of this project is to develop an interface to simulate comportment of real machines in a virtualization environment.
The initial use-case is to implement the

numerical twin of the micro-milling micro5 available in the school.

The use of virtual machine provides the ability to:

- Exploration of new path-planning algorithms
- Simplification of testing of new components
- Demonstrate OpenCN capabilities

We propose to use Gazebo (https://gazebosim.org) as simulator

C programming, simulation, motion control

Polymorphic Operating System, with SO3

Prof. D. Rossier

The SO3 Operating System has been developed in the REDS Institute from HEIG-VD for >10Y and is intended to be used in IoT products or embedded systems based on ARM CPU family as well as in academic environment. It is a compact, powerful and full featured operating system which can be configured to run as a standalone OS, an hypervisor (AVZ), or a guest OS running on the hypervisor (AVZ). Furthermore, SO3 can be used as “mobile entitiy” (ME) in the Smart Object Oriented framework enabling the migration of entities between embedded devices.
This project proposes to investigate various security aspects in SO3 to make the execution environment more robust, and also to investigate ARM TrustZone technology in this context. A security audit could be made at the beginning of the project to drive the objectives.
An important aspect will be to study the impact of security measures on the overall performance of the execution environment.

Background in C and ARM assembly programming, security and operating systems

Simulation of the Smart Object Oriented (SOO) ecosystem

Prof. M. Zapater

We propose to develop a simulation based on Omnet++ for the study of behaviour of an ecosystem composed SOO (Smart Object Oriented) devices and various mobile entities (ME). The SOO technology has been developed in the REDS Institute since 2014 and has led to a sound framework that can be deployed on Raspberry Pi 4 with mobile entities to manage home automation with different devices (blinds, weather stations, heating systems, etc.).
The project aims at studying different migration patterns by means of a simulator which can be partly connected to a real environment, in particular to an infrastructure currently developed inside the School to host various connected devices (using Home Assistant among other things).

Python, C/C++, simulation


INDUSTRIAL
ENGINEERING

Integration of smart meter data in distribution system state estimation with respect to privacy constraints

Prof. M. Bozorg

Domain: Energy and Smart Grids

Context and objective: The recent increase of intermittent and stochastic renewable sources such as photovoltaic generation connected to the distribution networks as well as changes in power demand profiles (e.g., due to electrical vehicle charging) raised the need for better network monitoring and control solutions. The monitoring and observability of distribution networks has been improved in recent years thanks to the ongoing digitalization of the electric grid infrastructure through installation of smart meters (SMs) and grid monitoring systems such as GridEye of Depsys [1]. State estimation methods could be applied to integrate data from smart meters and grid measurement infrastructure to enhance the observability of the distribution network. However, due to the privacy issues, the measurements coming from grid monitoring systems installed on the grid and those from the smart meters at customer level are not always available with the same sampling time and recuperation delay. In particular, in Switzerland the SMs data (i.e., the active/ reactive power consumptions of end-user clients at every 15-minutes interval) are not always available in real-time and can only be recuperated once every 24 hours. Few SMs data can be requested in near real-time.

Within this context, the aim of this project is to study and analyze the number of smart meter real-time data request necessary to satisfy a desired level of observability at each time step as well as to find an appropriate allocation of smart meter data request among the costumers over time to ensure data privacy constraints. [1] https://www.depsys.com/solutions/grideye/

Activities:

1. Preparatory works:
   - Study state estimation methods and in particular distribution system state estimation (DSSE) methods in the literature
   - Hands on training in a DSSE method based developed at IESE institute of HEIG-VD (codes available in MATLAB and Python)
2. Design and development of two case studies based on 1) synthesized data of SMs and grid measurement (synthesized data can be obtained from a distribution grid simulator developed at IESE institute), and 2 real data of a Swiss distribution system operator (partner of the project).
3. Analyse the impact of the number of SMs where real-time data are available on the accuracy of DSSE results in terms of voltages/Currents estimations
4. Implement an algorithm for allocating the minimum number of requests for real-time SM data among the customers in a way that no customer has been requested more than two times a day (each time data includes active and reactive power consumption within the last 15 minutes)
5. Test and validate the effectiveness

of the proposed algorithms on the designed case studies

Basic competences in power systems, programming, and data analysis

Optimal design and operation of a virtual power plant in the vicinity of small-scale hydro power plants

Prof. M. Bozorg

This project deals with the optimal design and operation of a Virtual Power Plant composed by a set of distributed resources connected to a distribution grid in the vicinity of small-scale hydro power plants in order to optimize energy and flexibility (ancillary service) exchanges. The optimization process will be formulated in two stages. The first stage deals with design of the components of the VPP (i.e., selection of possible resources including PVs, battery energy storage systems, wind turbines, pump-turbines, etc as well as optimal size and location of each resources connected to the grid). The second stage deals with optimizing the operation of the VPP components within various time horizons (weekly, daily, intra-day) with respect to market conditions, and uncertainties related to renewable generations and natural water discharge.
In particular, the following activities are envisaged:

1. Optimal design of the VPP
   - Definition of VPP components (distributed resources); two case studies
   - Definition of yearly scenario of operation (available water, PV production, etc) for the two case studies
   - Optimization of the size and location of resources regarding yearly scenarios with respect to overall potentials for energy and flexibility (ancillary service) provision for the two case studies
2. Optimal operation of the VPP
   - Definition of market scenario with different time horizons (monthly, weekly, daily, and intra-day) in a benchmark year regarding both energy, balancing, and ancillary service markets. At least one of the two case studies.
   - Quantification of uncertain parameters within the above time-horizons including intermittent renewable generations (PV and wind)
   - Optimization of the operation of the VPP at hourly, and 15 minutes time resolution with respect to the above market scenario and constraints (uncertainties and distribution grid power flow)

Basic knowledge in power power systems and renewable energy sources, optimization techniques, and mathematical modeling

Distribution Grid Asset Planning under Uncertainties of Load Configuration and Flexibility Provision

Prof. M. Bozorg

Due to the pressing need to address climate change and decarbonisation, the

deployment of electric vehicles (EVs), photovoltaics (PVs), and heat pumps (HPs) is growing quickly worldwide. However, this is causing issues for electrical distribution grids, as increased supply or demand in low- and medium-voltage grids can lead to voltage violations, branch overloads, and transformer aging. To achieve the goals set by the governments on decarbonisation, it is essential to consider the impacts of EVs and HPs on the grid, as well as the role of prosumers to provide flexibility.
In this context, the objective of this project is to study and develop an asset-planning method for Distribution system Operators (DSOs) that considers the technological risks of the energy transition (e.g., the impacts of EVs, PVs, and HPs on the grid, like voltage violations, branch overloads, and transformer aging) and the spatial/ temporal uncertainties of flexibility provided by prosumers. To this end, an optimization model will be developed in which the decision variables include reinforcement, replacement, and expansion capacity of transformers and branches. The overall purpose is to ensure that the distribution grid is operated securely and economically under uncertainty.

Basic knowledge in power power systems and renewable energy sources, optimization techniques, and mathematical modeling

Community Microgrids: toward electrical grid reliability and resiliency increase

Prof. M. Carpita

A community microgrid is designed to serve the energy needs of a residential neighborhood, a build-ing complex, etc.; it includes several GFMI and is connected to a distribution grid. Furthermore, community microgrids can be owned and operated by local communities rather than a centralized utility. The interaction of multiple GFMIs in a community microgrid in «standalone» operation modes, as well as the interaction of GFMIs and the power grid in «grid-connected» operation modes, will be studied and tested by building a second proprietary GFMI inverter (with a power capacity in the same order of magnitude than the first GFMI). Other technical risks, including load imbalances and short-circuits of GFMIs in a community microgrid, will be studied. Using GFMIs within a community microgrid will enhance Switzerland's energy supply's resilience to external drivers and will participate in laying the groundwork for the implementation of the «Energy Strategy 2050» in an affordable and secure manner.

Overall, the project aims to explore the role of community microgrids in enhancing the reliability and resilience of the grid.
A community microgrid co-ordinates several grid-forming inverters (GFMIs) equipped with im-proved damping and virtual inertia, within a local distribution grid in both grid-connected and standalone operational modes. Through simulations and experimental validation, this study will propose a decentralized control strategy for GFMIs within a community microgrid. The project will investigate the advantages and effectiveness of the proposed community microgrid scheme, including improved grid relia-bility and resilience as well as supporting grid restoration. The project

will also examine the technical risks of voltage instability, load imbalance, and short-circuits in both operational modes to deter-mine adequate control measures and protection strategies.

However, a reduced student term of reference will be agreed with the candidate, according to his/her time availability and technical beckground

Competencies in power electronics and Power Systems

Power converter topologies to improve the efficiency and lifetime of PEM (and other) hydrolyser technologies

HEIG-VD referring person: Mauro Carpita

Polymer Electrolyte Membrane (PEM) technology is really interesting for electrolyser applications mainly thanks to its ability to operate at high current densities and variable (low) power levels within seconds and with a higher rate of hydrogen production. However, it is emerging that its performances can deeply degrade in a few years. This seems to be mainly due to the current harmonics produced by the power supply on the DC side. Other really important issues are that the power supply must respect AC grid code requirement, together with obtaining reduced costs (reduced CAPEX) and high efficiency (rediced OPEX).

Aim of this project is to choose and design an optimal structure of the power converter, concerning both topology and control, for improving both AC and DC side behavior. Therefore, this will lead to have a high power quality of the whole system and a more gentle impact on the electrolyser of the power electronics. Moreover, the possibility of operating PEM electrolysers as close as possible to their optimal functioning conditions, independently of fluctuations on the power grid side.

Hence, at a more global level, our project has the following purposes: improving the way the power electronics affect the hydrolyser, enhancing the overall efficiency and reliability of future power-to-gas schemes by using modern power electronics applied to electrolysers, in a similar fashion to variable speed generators in hydro pump-turbines.
For testing the developed principles, a reduced scale demonstrator together with an emulator of the electrolyser will be developed.

The project will be developed in order to solve the following issues raised in the literature:

- Optimal choice of the power converter topology
- Application flexibility
- High level control - AC side impact and ancillary services to the grid:
- Inverter current control - DC side impact:
- Dynamic model of the electrolyser

A reduced student term of reference will be agreed with the candidate, according to his/her time availability and technical background.

Basic competences in Power electronics and Control theory.

Self-adaptive sampling rate data acquisition system

Prof G. Courret

The goal of this internship is to contribute to the development of a self-adaptive sampling rate data acquisition system designed for larg band signals. The work will be performed in collaboration a researcher working in our laboratory on the development of a software and firmware dedicated to signal processing and real time analysis. This internship will also participate in the design of the algorithm for compression, analysis and storage of measurement data.

Knowledge of signal processing for spatial engineering as well as medical engineering is potentially useful. Minimum duration for master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Students with previous knowledge from courses in data compression, analysis, storage, signal processing engineering, digital electronics (FPGA-SoC) and Matlab or Octave programming

Hypersonic plasma in a light bulb

Prof G. Courret

This internship aims to contribute to a research project dedicated to the study of an acoustic resonance phenomenon in a high pressure plasma lamp which could be used to measure hypersonic aerodynamic parameters relevant to the design of space shuttle thermal protection systems. Minimum duration for master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Knowledge of non-equilibrium thermodynamics and molecular dynamics of gases is desired.

Students with previous knowledge from courses of power electronics engineering

Sterilization with cold atmospheric plasma

Prof G. Courret

The objective of the internship is to take part of the development of a method to sterilize products using a cold atmospheric plasma (CAP). The cold sterilization has several advantages as compared to the traditional thermal treatment such as lower energy consumption and, potentially, a much faster processing time. Minimum duration for master students 3 months, preferentially 4-6 months.

Knowledge of plasma technologies is desired. In addition, knowledge of microbiology for decontamination would be potentially useful.

Students with previous knowledge from courses on plasma engineering as well as on the physics of weakly ionized gases

Laser surface patterning in liquids

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences, www.comatec-lans.ch) is active in research on

surface coatings.

Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.

In this project we will investigate pulsed laser surface structuring techniques in liquids as an eco-friendly surface structuring technique. Surface structures will be analysed using atomic force microscopy and optical interferometry. Tribological properties of the surfaces and generated structures will be evaluated in various configurations. For this aim, a test bench will be developed and tested. The project is best suitable for master or PhD students in mechanical engineering, materials or surface science, as well as for students in industrial process technologies. Minimum duration master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Keywords: laser surface structuring, tribology, test bench development, applied nanosciences for robotics and machines

Flexible electrodes for biosignal monitoring and nerve stimulation

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences, www.comatec-lans.ch) is active in the field of nano- and microfiber composite materials. Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.

The laboratory has recently developed materials for flexible electrodes for biosignal monitoring and nerve stimulation. The project aims at conducting further improvements and experiments on soft flexible electrodes.

The project involves process and materials development, electrical material characterization, as well as prototyping and testing of the material and electrode designs for wearable and medical applications.

Actuator, or energy storage applications can be furthermore envisaged. The project is suitable for master or PhD students with interest in electrical characterizations, and background in materials engineering (physics or chemical engineering). Minimum duration master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Keywords: conductive polymer nanocomposites, electrical probing, electrical impedance spectroscopy, prototyping, lab and field tests.

Surface modification by atmospheric pressure plasma

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences, www.comatec-lans.ch) is active in the field of atmospheric pressure plasma treatment of surfaces.
Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.

The aim of the project is to modify surface properties on various biocompatible or bio-sourced nano- or microfiber-based materials. Nano- and microfiber-based materials will be generated using electrospinning. The influence of process parameters during atmospheric pressure plasma treatment will be studied at the nano- and microscale using various surface analysis techniques, such as atomic force microscopy and surface wettability analysis. The project is best suitable for master or PhD students in chemical engineering, material or surface science, applied physics, as well as for students in industrial process technologies. Minimum duration for master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Keywords: Atmospheric pressure plasma, surface treatment of materials, applied nanosciences

Artificial muscles

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences, www.comatec-lans.ch) is active in the field of transparent electrodes.
Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.
The goal of the project is the design and characterization of soft flexible articifical muscles and sensor materials based on conductive polymer nanocomposites. Prototyping, test-bench developments, lab- and field tests for actuation and sensing. The project is best suitable for master or PhD students in chemical or materials engineering, applied physic, robotics, as well as for students in industrial process technologies. Minimum duration for master students 3 months, preferentially 4-6 months; PhD interns 6-12 months.

Keywords: conducting soft materials, electro-mechanical actuation and sensing, test-bench developments, prototyping, lab- and field tests

Integrated simulation-experimental optimization of bike suspensions

Prof. A. Schorderet

The Machine and Design Applied Research Group is active in high dynamics systems, additive manufacturing and composite structures research fields. Suspension bicyles used in sports and recreative/ leisure activities are pushing for always better suspension components and set up. The original idea of the main project is to develop a numerical and experimental framework to define optimal suspension setup for MTB cycles. To achieve this goal, an optimization algorithm driving a suspension non-linear simulation model is combined with experimental suspension characterization (test bench) and real conditions data (in situ testing). The algorithm will provide the suspension stiffness and damping characteristics (set-up) minimizing a function based on tyre adherence and rider accelerations, or a “comfort criterion”.

2022 projects have developed the numerical simulation, in situ testing environment and

a suspension test bench. The simulation results were compared to experimental data for a step down case. Overall behaviour is good but significant discrepancies are observed. The model assumption that the rider doesn't move with respect to the bike is probably not valid in this case.

The goals of the project are :

1. Develop rider-bike force measurement capability to include rider-bike interaction in the model and obtain a reliable and precise simulation model fitting the experimental in situ data for the step-down and periodic bumps cases
2. Implement the optimization algorithm in order to provide the best setup for both cases.

Keywords: force sensors, testing, bike dynamics, optimization, simulation

Micro-milling quality criterion

Prof. A. Schorderet

The Machine and Design Applied Research Group is active in high dynamics systems, additive manufacturing and composite structures research fields. Using a strong dual numerical-experimental approach, the Group has developed mechanical design solutions for the high performance machine-tool field. A holistic system approach has been created within the mecatronYx interdisciplinary platform, in tight association with the automatic control and embedded systems groups. They produced patented dynamic optimization algorithms that allow very significant quality and/or productivity improvements when implemented on high-end milling machines (5 times quicker milling speeds).

To improve the process quality, the machined parts quality is correlated to the process dynamics. The machined surfaces are characterized using a confocal microscope analysis and the surface spatial patterns are correlated to the dynamic and vibrational behaviour of the machine.

The goal of the proposed project is to develop a method providing real-time information instead of the microscope surface analysis provided after machining. Therefore, advanced data analysis of specific sensors data (force, vibration, acoustic emission) and available machine signals (position, current, errors, ...) will be realized to develop a real-time sensitive micro-milling process quality criterion. Once available, this criterion could be used to implement a very novel process control loop able to guarantee manufactured parts accuracy, and surface quality.

Keywords: micro-milling, process quality, sensors, intelligent data analysis

Large high speed CoreXY 3DP machine

Prof. A. Schorderet

The Machine and Design Applied Research Group is active in high dynamics systems, additive manufacturing and composite structures research fields. Using a strong dual numerical-experimental approach, the Group has developed mechanical design solutions for the high performance

machines field. A holistic system approach has been created within the mecatronYx interdisciplinary platform, in tight association with the automatic control and embedded systems groups. They develop OpenCN, an open CN dedicated to high dynamic machines control and trajectory optimization. The improvement and optimization of dynamic performances of large machines (intrinsequently showing low structural frequencies) is studied using OpenCN to control a large CoreXY type machine (700x700x600 mm strokes). It allows highly dynamic movements, for which the head's trajectory precision is usually improved by using FIR filters or other strategies avoiding excitation of the low frequency structural modes. Another way to improve the machine's dynamics is to use stiff lightweight structures, like composite structures. Considered test cases are laser engraving/cutting applications and 3D printing, like #speedboatrace with a precision criterion.

The project aims at increasing the machine's dynamics (modal properties : frequency, compliance, damping) by designing improved structural composite components (e.g. transverse beam) and/or developing and implementing new control algorithms (FIR, optimized Jerk, etc.). The structural work includes design, FE simulations, prototype realization, experimental modal characterization and testing the machine's performances with the new component. The algorithms development focuses on trajectory optimization schemes, NC implementation and testing the machine's performances with the new algorithm.

Keywords: 3DP, machine dynamics, composite structures, optimization, motion control

Nanotech 1 – Electrodeposition of nanowire structures : growth front control

Prof. Dr. L. Gravier

The COMATEC institute develop for years a very accessible technology called "template synthesis", i. e. an electrochemical deposition of nanowires structures in nanoporous polymer thin film. These thin film nanocomposites are mainly used for microscale sensors applications, but also haptic actuators or smart filters. The major challenge of this nanotechnology is the control of the nanowire growth rate, naturally quite inhomogeneous.

The goal of this project is to adapt the existing electrochemical cell to monitor to control the nanowires growth front. The forseen strategy is to achieve homogeneous nanowires electrodeposition via a sequence of deposition-dissolution. Scanning electron microscope images will be used to characterize the growth front control. A secondary goal is to gather practical data to published the results in a scientific and/or technique journal.

Keywords: microtechnology, nanotechnology, electrochemical deposition of nanostructures

Nanotech 2 - Ultra-fast reactive nanostructured temperature sensor

Prof. Dr. L. Gravier

In the frame of the Industry 4.0 research program, a new generation of sensors is needed, to be integrated in micromachines or devices.

The project aim at the design and fabrication of a ultra-fast reactive temperature sensor using thermoelectric properties of a nanostructured thin film, using the nanotechnology techniques mastered in the lab. The very short time response of such tiny strucutres will be characterized by detection of the thermoelectric power using a lock-in amplifier technique. A test bench will be developed, which will be integrated in a technology demonstrator.

Keywords: microtechnology, nanotechnology, thermoelectric power, lock-in detection, micro-thermal engineering.

Nanotech 3 -Nanostructured Infrared light sensor

Prof. Dr. L. Gravier

In the frame of the Industry 4.0 research program, a new generation of sensors is needed, to be integrated in micromachines or devices.

The project aim at the design and fabrication of a small scale infrared light sensor using thermoelectric properties of a nanostructured thin film, using the nanotechnology techniques mastered in the lab. A test bench will be developed to characterize the sensitivity and response time of this sensor, which will be integrated in a technology demonstrator.

Keywords: microtechnology, nanotechnology, IR light sensors.

Pediatric respiratory flow meter by nanotechnology

Prof. Dr. L. Gravier

In intensive care units, many biomedical devices monitor patients' vital functions. An important parameter is the measurement of respiratory flow. However, this is tricky to measure for premature babies, since their low lung capacity is of the same order of magnitude as the «dead volumes» of conventional monitoring devices. One solution is to install a very small flow meter at the end of the intubation pipe, right at the entrance to the lungs.

The goal of this project is to prove the feasibility of such small-scale flowmeter, which will integrate ultra-thin flexible sensors developed by nanotechnology in our lab.

Keywords: medtech, microtechnology, nanotechnology, micro-thermal engineering

Energy efficiency pneumatic actuator

Prof. Dr. L. Gravier

In the frame of energy transition, new mechanical actuators has to be developed to drastically lower any energy losses due to friction. The goal of this project is design

and build up a new kind of high efficiency piston, whose feasibility has already been demonstrated. A secondary goal is to adapt an existing pneumatic test bench to quantitatively characterize the energy efficiency of this piston used as a pneumatic actuator.

Keywords: Mechanical engineering, pneumatics, microtechnology.

Haptics 1 - Low consumption power supply for electroactive haptic surface

Prof. Dr. L. Gravier

In the frame of the Industry 4.0 research program, a new generation of sensors is needed, to make machine control more and more easy and intuitive for human users. To this purpose, haptic surfaces are request, which allow to a user swift interactions with a machine via the sense of the touch.
Ths project aims at the design and fabrication of an integrated power supply for electrostatic haptic surfaces, to be plugged to the mains (230 V / 50 Hz) and that deliver an output voltage of about 500 V peak-to-peak at frequencies in the audio range of 20-1000 Hz. This device will power haptic power surfaces, commercial or made in the lab.

Keywords: Electric engineering, power electronics and control systems, Human-machine interface

Haptics 2 - Test bench for unbiased characterization of electroactive haptic surfaces

Prof. Dr. L. Gravier

In the frame of the Industry 4.0 research program, a new generation of sensors is needed, to make machine control more and more easy and intuitive for human users. To this purpose, haptic surfaces are request, which allow to a user swift interactions with a machine via the sense of the touch. However, current characterization techniques mostly used human fingers, inducing large biases in the results. To overcome this, a device is currently developed in the lab, using an artificial finger for an objective measurement of haptic properties of electrostatic haptic surfaces. This device needs one more step to be finalized.

This project aims at the final improvement of an existing prototype of haptic characterization test bench, and a full characterization of its performances. A secondary goal is to gather practical data to published the results in a scientific and/or technique journal.

Keywords: microtechniques, haptic sensors, Human-machine interface

Haptics 3 - Audio signals for electroactive haptic surfaces to mimic textures sensations

Prof. Dr. L. Gravier

In the frame of the Industry 4.0 research program, a new generation of sensors is needed, to make machine control more and more easy and intuitive for human users. To this purpose, haptic surfaces are request,

which allow to a user swift interactions with a machine via the sense of the touch. One interesting outcome is to induce artificial sensation of surface texture – fabrics, wood, rubber... - to the finger tip, via electrovibrations in the audio range. However, audio signals have to be adapted to this purpose.

This project aims at to set a library of audio signal able to induce artificial texture sensations to the finger tip on a commercial electroactive haptic surface. The main effort is to record audio signals of a finger sliding on various surfaces, and to convert them into effective haptic signals via a sound card. The haptic test bench developed in the lab will be used for objective measurements of haptic responses.

Keywords: microtechniques, sound board control, haptic surfaces, Human-machine interface

Nanotech 1 – Electrodeposition of nanowire structures : growth front control

Prof. Dr. L. Gravier

The COMATEC institute develop for years a very accessible technology called “template synthesis”, i. e. an electrochemical deposition of nanowires structures in nanoporous polymer thin film. These thin film nanocomposites are mainly used for microscale sensors applications, but also haptic actuators or smart filters. The major challenge of this nanotechnology is the control of the nanowire growth rate, naturally quite inhomogeneous.
The goal of this project is to adapt the existing electrochemical cell to monitor to control the nanowires growth front. The forseen strategy is to achieve homogeneous nanowires electrodeposition via a sequence of deposition-dissolution. Scanning electron microscope images will be used to characterize the growth front control. A secondary goal is to gather practical data to published the results in a scientific and/or technique journal.

Keywords: microtechnology, nanotechnology, electrochemical deposition of nanostructures

Development of industrial and collaborative robotic applications

Prof. M. Kunze

The robotic laboratory is active in the field of industrial and collaborative robotics. In this field the following topics are studied:
Bin picking: in the case of small production batches it is interesting to be able to perform bin picking instead of using vibratory bowl feeders. However, the time to setup up the bin picking task is often too long. Different technics to reduce this time are studied and implemented.
Collaborative robot: nowadays collaborative robots are more and more used in the industry. Thus, humans need to interact with this kind of robot. Interaction can be in terms of task teaching by demonstration, robot path adaptation function of the environment, robot – human interdaction.
3D printing with a robotic arm: 3D printing is often done with a cartesian robot. In this project, the idea is to perform this task using a robotic arm which offers several

advantages (non-planar trajectories, different orientation of the head, increased stiffness…).
For all these projects ROS (Robot Operating System) middleware is used.

Keywords: industrial robot, collaborative robot, bin picking, robot – human interaction, 3D printing, ROS

Control of a parallel robot

Prof. M. Kunze

The robotic laboratory owns a Delta parallel robot. For different applications it is necessary to interact with its environment and especially cameras, conveyor, … Its actual controller has some limitations and does not allow to have interactions with external devices easily and fast enough. Moreover, it is not possible to modify it. Thus, the idea of this project is to develop a new controller. To achieve this goal the following tasks have to be done:

- Computation of the forward and inverse kinematic models
- Computation of the Jacobian matrix
- Computation of the dynamic model
- Study of different control strategies in simulation
- Implementation of the best control strategy in an embedded PC
- Interaction with external devices such as cameras and conveyor
- Test and evaluation of the dynamic performances

Keywords: parallel robot, dynamic model, control, simulation

INTERESTED ?
CONTACT US !

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