HE IG VD

Topics for Thesis / Internships

2026-27

Hes·so

TOPICS FOR THESIS / INTERNSHIPS 2026-27

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 4 and 6 months.
Some professors may exceptionally accept shorter or longer ones.

GEOMATICS, CIVIL 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.

Prerequisites: 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.

Prerequisites: 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.

Prerequisites: 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.

Prerequisites: 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.

Prerequisites: 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.

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

CORRELATION BETWEEN ROCKFALL AND CLIMATE CHANGE

Prof. E. Prina Howald

Climate change has an important influence on the increasing frequency of events related to natural hazards. Study on pilot sites of the effect of climate change on rockfall.

The objectives of this study are to characterize the different effects of climate change and to determine the real impacts. In addition, it will be important to participate in the creation of a comprehensive methodology for the risk management and risk mitigation.

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

SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY

Prof. M. Viviani

The research project in which the candidate will work targets enhancing sustainability in construction projects, especially transformation projects, through the use of smart digital twins. These twins are tailored to incorporate crucial information on existing structures, monitoring data, and local suppliers of sustainable products and services.

Architects and engineers can leverage these digital twins to evaluate project impacts early in the design phase and optimize designs in line with corporate social responsibility principles. This approach ensures that construction projects efficiently meet societal and environmental obligations.

Prerequisites: Knowledge and interest in the following areas: sustainable construction materials, recycling, reuse, BIM, Sustainability in construction industry, Corporate social responsibility, Innovation economy, construction processes

Duration: 6 months

Keywords: Sustainability in costruction, digital twins, environmental impacts, costruction processes

BOND STRENGTH OF STRENGTHENING LAYERS

Prof. M. Viviani

The research project in which the candidate will work focuses to advance the development of predictive models to ensure the durability of bond strength in advanced strengthening materials like Ultra High Performance Fiber Reinforced Concretes (UHPFRC) and geopolymers. These models will specifically address concerns related to seismic loads and viscous phenomena, which currently lead engineers to rely heavily on mechanical connectors. By enhancing these predictive models, the study aims to mitigate concerns about bond strength evolution over time, ultimately ensuring the long-term effectiveness and stability of these materials, particularly in seismic conditions.

Prerequisites: Knowledge and interest in the following areas: Laboratory testing, material science, modeling, structural engineering
Duration: 6 months

Keywords: Bond strength, strengthening materials, geopolymers, structural engineering

SHEAR WALLS IN EARTHCRETE

Prof. M. Viviani

The research project in which the candidate will work focuses on advancing the development of structural calculations for load-bearing walls made with Shot-Earth, a novel excavation-earth-based material.

Currently, the different earth-based concretes available on the market are at various stages of development, and progress is being made in detailing their structural applications. Reinforced Shot-Earth has been extensively tested to assess whether conventional structural calculation models used for reinforced concrete (RC) are suitable. Furthermore, models for shrinkage and creep have also been verified.

The aim of this project is to design a residential building with structures made of Shot-Earth and identify the actual challenges that a structural engineer would face when using this material in everyday practice.

Prerequisites: Knowledge and interest in the following areas: Laboratory testing, material science, modeling, structural engineering, seismic analyses, structural modeling with FEM software

Duration: 6 months

Keywords: Structural engineering, seismic analyses of RC structures earth-based reinforced concretes

GEOREFERENCING OF TEXTS THROUGH MACHINE LEARNING

Prof. J. Ingensand

Automatic natural language processing reveals hidden information in unstructured texts. We propose analysing a collection of newspaper articles to extract place names and map the geographical focus of the newspapers. The objective is to study the spatial and temporal evolution of a given subject.
This project will involve the use of machine learning techniques, in particular the training of neural networks for the recognition of toponyms (geographical names) in texts, as well as their mapping to a database of places. The results should be presented using appropriate visualizations.
Various analysis options could be explored: comparing media coverage with real data, using and training topic modelling algorithms to extract and classify texts into sub-themes, or sentiment analysis to map opinions.
Some examples of possible topics: invasive species; urban-rural behaviour in voting

Prerequisites: Geographical Information Systems (GIS), Development skills (Python)

Duration: 2 to 6 months

Keywords: Toponym recognition, spatial databases, natural language processing, machine learning

LABELING OF 3D SCENES SHOWING HISTORICAL IMAGES

Prof. J. Ingensand

The smapshot.heig-vd.ch has about 300'000 historical images that have been georeferenced by the crowd. 3D referencing implies that the 3D coordinates of all pixels are known and thereby the development of an algorithm that automatically labels images becomes possible. The idea of the project is to:

1. Conduct a experiment involving citizen with historical images to find out which labels citizen would put on a photo. Deduce labeling rules from the experiment.
2. Implement an algorithm that automatically places labels (based on available datasets) on a historical photo
3. Test the algorithm with images from smapshot.

Prerequisites: Geographical Information Systems (GIS), Development skills (Python, Javascript)

Duration: 2 to 6 months

Website: https://smapshot.heig-vd.ch/

Keywords: Labeling of 3D scenes, historical images, spatial data processing algorithm, user experiment

VIRTUAL GLOBE OF THE PAST

Prof. J. Ingensand

The smapshot.heig-vd.ch has about 300'000 historical images that have been georeferenced by the crowd in a virtual globe. 3D referencing implies that the 3D coordinates of all pixels are known. The idea of the project is to use existing machine learning algorithms that do an automatic segmentation of a photo (e.g., detection of forests, buildings, etc). Since the dates of most photos are known it becomes possible to map the segmented, extracted information in a virtual globe and thereby to create a virtual globe of the past. The goal is to implement a prototype that allows for navigation in both time and space.

Prerequisites: Geographical Information Systems (GIS), Development skills (Python, Javascript)

Duration: 2 to 6 months

Website: https://smapshot.heig-vd.ch/

Keywords: Virtual globe, Image segmentation, 3D mapping, spatial data processing

ENERGY, ENVIRONMENTAL 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 non-fossil 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 Energies has been active for several years in this research field, mainly in process optimization through cow manure pretreatment as well as enhancement through CO_2 injection. The work proposed consists in contributing to further develop the cow manure pre-treatments through optimized grinding, thermal hydrolysis and weak acid attack.

Duration: Minimum duration 4 months, preferably 6 months

Keywords: Methanization, anaerobic digestion, substrate pre-treatments, CO_2 injection

PARAMETERIZED LIFE CYCLE ASSESSMENT OF HEAT PUMPS INTEGRATED IN SWISS BUILDINGS

Prof. S. Lavaux & A. Duret

The internship focuses on assessing the carbon footprint of heat pumps (HP) in Swiss buildings throughout their entire life cycle, from design and installation to operation, maintenance, and electricity consumption. The mission is part of the LCA-PAC project, which involves the Institute of Energy (IE), industry partners, and public authorities working together to replace fossil fuels with this technology. The goal is to improve the evaluation of decarbonization strategies for heating and hot water production using heat pumps.

The internship involves four main tasks:

1. Data Collection: Gather information on heat pumps, including refrigerant leaks and CO2 emissions of Swiss electricity, in collaboration with industry partners.
2. Development of a Parameterized Model: Create a life cycle model that accounts for design, installation, operation, and maintenance of heat pumps.
3. Application on Case Studies: Apply the model to several heat pumps and at least one full building case study.
4. Analysis and Reporting: Analyse results and produce a detailed report.

The internship offers practical experience in life cycle analysis (LCA) for energy systems, helping to decarbonize building heat production by 2050. Interns will gain valuable skills while working in a dynamic R&D team.

Keywords: Life cycle assessment, heat pumps, GHG emissions, buildings, data, parameterized model

OPTIMIZATION OF LARGE-SCALE SOLAR THERMAL FIELD INTEGRATION IN DISTRICT HEATING NETWORKS

Prof. Dr. A. Duret

This master internship takes place within the SolNET applied research project at HEIG-VD's Institute of Energy. In collaboration with

several district heating network operators, the project aims to develop methodologies to facilitate the integration of large solar thermal fields into thermal networks. SolNET focuses on optimizing hydraulic configurations for distributed fields, standardizing sizing methods, and defining performance monitoring strategies. The consortium brings together academic partners, engineering firms, solar thermal specialists, and network operators, ensuring effective deployment of results.
The student will contribute to Work Package 1 (Solar potential analysis & thermal network coupling optimization).

The work will involve:

1. Literature review: Compilation and critical analysis of international best practices for solar thermal field integration in district heating networks
2. Potential characterization: Spatio-temporal solar resource analysis, thermal demand profile modeling, and existing production infrastructure assessment
3. Technical optimization: Available surface evaluation, collector technology comparison, layout optimization, and thermal storage sizing
4. Hydraulic design: Development of centralized and decentralized integration strategies for multiple solar fields
5. Practical application: Methodology validation on three real case studies in collaboration with district heating operators

Prerequisites: Master's degree in Thermal Engineering, Renewable Energy, Energy-focused Civil Engineering, or related field

Duration: 4-8 months

Keywords: Solar thermal, District heating, Energy optimization, Hydraulic integration, Thermal modeling

NETWORK INERTIA – BATTERIES OR SYNCHRONOUS CONDENSERS?

Prof. D. Siemaszko

The rise of renewable energy integration is leading to a gradual decline in the number of mechanical synchronous generators within transmission grids. Historically, grid stability relied on these synchronous machines, which provided three essential functions:

1. Frequency stability through mechanical inertia;
2. Voltage stability, often expressed by the ability to supply fault current (characteristic impedance);
3. Contribution to fault current, essential for the protection and coordination of switching devices.

Faced with the reduction of these resources, two main approaches are being considered:

- Conversion of existing synchronous generators into synchronous capacitors, in order to preserve the historical dynamic characteristics of the grid.
- Replacement or supplementation with electronic power converters, in particular grid-forming E-STATCOMs, an emerging technology promising increased flexibility.

This research project aims to analyse and compare these two solutions through the following steps:

- Characterisation of conventional synchronous generators in terms of inertia (frequency), reactance (voltage) and contribution to fault current.
- Modelling of a 100 MVA Single Machine Infinite Bus (SMIB) system under PLECS, including a 100 MW solar power plant operating at different short-circuit ratios (SCR) for stability assessment.
- Integration of a mechanical synchronous converter (Syncon) to observe its stabilising effect on the system.
- Integration of a grid-forming E-STATCOM and comparison of its stabilisation performance with that of the Syncon.

Prerequisites: Basic competences in Power electronics and Control theory.

Keywords: Power converters for Grid Support, BESS for Grid Inertia

800V DC ARCHITECTURE FOR AI SERVERS - ADVANCED ENERGY BUFFERS

Prof. D. Siemaszko

Artificial intelligence inference and training servers currently consume several kilowatts per computing unit. To achieve the required power densities, manufacturers (NVIDIA, AMD, etc.) offer «800 V DC» architectures, where each rack receives a high direct current voltage directly. This approach has many advantages (reduced I^2R losses, fewer converters, better overall efficiency), but it also introduces a series of technical challenges that must be resolved to ensure reliable and safe operation.

The project focuses on the design of an advanced energy buffer to power AI racks operating at 800 V DC. The main challenge is to ensure bus stability and fault tolerance while improving the overall efficiency of the system. To achieve this, we are combining:

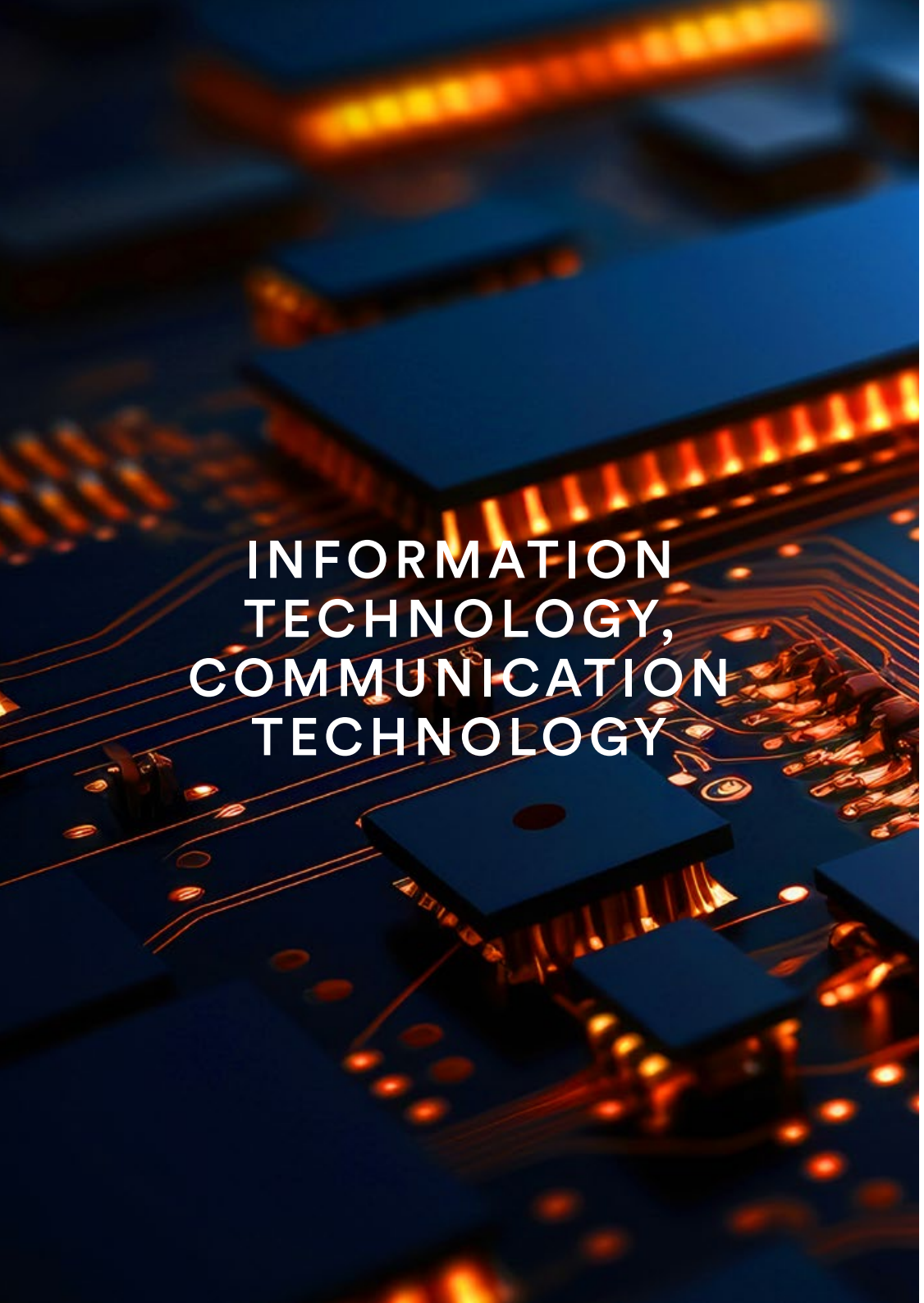
- Physical modelling of the battery + supercapacitor network and DC-DC converters to understand the fast dynamics of the high-voltage bus.
- Robust predictive control (MPC) integrating the neural model and a safety layer (tube-based or barrier function) to ensure that voltage constraints are always met, even in the presence of modelling errors or hardware faults.
- Purpose of the master's thesis

This research project aims to:

- Study the proposed system, starting with NVIDIA's white paper, 800V DC networks, and supercapacitor energy buffers.
- State of the art in predictive control Model predictive controllers (MPC) enable the control of unpredictable and highly disturbed loads. How can this be applied?
- Simulate a PLECS model energy buffer controller, implementation on TI board, HIL-RTS testing.

Prerequisites: Basic competences in Power electronics and Control theory.

Keywords: LVDC for AI Farms/Datacenters, Energy Buffer, Model Predicitive Control



INFORMATION TECHNOLOGY, COMMUNICATION TECHNOLOGY

MACHINE TRANSLATION AND LARGE LANGUAGE MODELS

Prof. A. Popescu-Belis

The goal of this internship is to study the capacity of recent language models (LLMs) to improve machine translation (MT), either in cases of low-resource language pairs, or where large contexts are needed to translate correctly.

The internship can be devoted to evaluation issues, i.e. measuring precisely the types of errors that are most often observed, or to issues related to transfer learning and the capacity to address low-resource languages by using information from better-resourced related languages.

Prerequisites: Advanced courses in machine learning (deep learning) and at least one introductory course in natural language processing

Duration: 4-6 months

Keywords: Machine translation, large language models

KNOWLEDGE INTEGRATION IN CHATBOTS

Prof. A. Popescu-Belis

Chatbots using deep neural networks (such as large language models) 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 external knowledge bases, so that they perform useful tasks, such as question answering or database transactions.

The internship will focus on hybrid chatbots, which can access knowledge bases and also have conversational capacities for the social aspects of an interaction. The goal is to compare question answering capabilities, either using the large language model alone, or combining it with a knowledge base.

Prerequisites: Advanced courses in machine learning (deep learning) and at least one introductory course in natural language processing

Duration: 3-6 months

Keywords: Chatbots, large language models, retrieval augmented generation

OPTIMIZING MULTISPECTRAL IMAGE PROCESSING FOR VINEYARD HEALTH ANALYSIS

Prof. Dr. L. Raileanu

Drones equipped with multispectral sensors flying over the fields of vine are capturing images that reveal information invisible to the naked eye. This project aims to address two issues:

1. Optimizing the generation of orthomosaic images, which involves studying optimization technologies and strategies for generating a large number of orthomosaic images (RGB and multispectral)

2. Exploring image analysis and machine (deep) learning techniques for characterizing the health status of the vine plants through generation of health prediction maps.

The development of this project will be realized on several series of multispectral and RGB images acquired on vineyards of between 0.5 and 6 ha.

Prerequisites: Knowledge and experience with image processing, machine /deep learning, and Python

Duration: 4-6 months

Keywords: Image processing, data analysis, machine/deep learning, vineyards, multispectral images

ELIMINATION OF ARTIFACTS FROM EYE IMAGES USING RAW MRI DATA

Prof. Dr. L. Raileanu

Magnetic Resonance Imaging (MRI) is a non-invasive technique providing detailed internal body structure images, which are crucial for diagnosing, treating, and performing surgeries for oculomotor disorders. However, eye motion artifacts in MRI scans remain unresolved, hindering such eye examinations.

A recent study uses an Eye Tracker (ET) to address this issue, but it is a resource-demanding task. This project aims to design and implement a pipeline employing data analysis techniques on raw eye-MRI data to automatically detect eye movement-affected acquisitions and classify the data following the gaze direction. This will eliminate the need for an ET to obtain artifact-free images of the eye.

Prerequisites: Knowledge and experience with data preprocessing and analysis, machine learning, and Python

Duration: 4-6 months

Keywords: Data analysis, machine learning, eye imaging

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 challenging. 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.

Prerequisites: Knowledge and experience with image processing, machine learning, and Python.

Duration: 4-6 months

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

ANALYSES OF BACK MOVEMENT DATA

Prof. Dr. L. Raileanu

Low back pain is a prevalent symptom and the leading cause of disability worldwide. Using smartphone applications to promote self-management (giving regular advice and prescribing exercises) is essential for improving back pain management. Moreover, using artificial intelligence, personalization could also be achieved.

This project aims to develop a framework for automatically detecting patterns of interest in back movement sequences. Additionally, an adapted resampling frequency to these sequences should be selected and evaluated regarding the quality of motion measurements.

Prerequisites: Knowledge and experience with analysis of time series, machine learning, and Python

Duration: 4-6 months

Keywords: Time series, longitudinal relationship, low-back pain

SMARTWATCH APPLICATION TO MEASURE BACK MOVEMENT AND COLLECT PHYSICAL ACTIVITY DATA

Prof. Dr. L. Raileanu

Low back pain is a prevalent symptom and the leading cause of disability worldwide. Using smartphone applications to promote self-management (giving regular advice and prescribing exercises) is essential for improving back pain management. Moreover, using artificial intelligence, personalization could also be achieved. This project aims to develop a smartwatch application to measure trunk kinematics.

The collected data will be evaluated regarding the quality of motion measurements and transmitted to the mobile application.

Prerequisites: Knowledge and experience with mobile programming, data analysis, machine learning, and Python

Duration: 4-6 months

Keywords: Smartwatch app, data analysis, low-back pain

A STANDARDIZED APPROACH TO MRI RADIOMICS IN MULTI-PATIENT FOLLOW-UP STUDIES

Prof. Dr. L. Raileanu

Accurate monitoring of vestibular schwannomas after Gamma Knife surgery is essential for evaluating treatment response and avoiding unnecessary repeat interventions. However, the lack of uniform definitions for tumor control and failure complicates follow-up. MRI-derived biomarkers may provide reproducible indicators of treatment success, such as the radiomics (e.g., shape, texture, intensity statistics). Additionally, machine learning enables automated detection of complex patterns that are not discernible to the human eye. Therefore, this project's aim is to establish a standardized pipeline producing robust radiomics features for machine learning analysis across patients and time.

Prerequisites: Knowledge and experience with image processing, machine learning, and Python

Duration: 4-6 months

Keywords: AI, data analyses, image processing, MRI

SECURE GEOLOCATION SOLUTION ON MOBILE

Prof. F. 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.

Prerequisites: Android or iOS app development, geolocation

Duration: 2-6 months - The scope of this project can be adjusted to accommodate different internship/thesis duration

Keywords: Mobile development, geolocation, BLE-beacon, security

VIDEO ANALYSIS OF POSTURE DURING FREE WEIGHT EXERCISES

Prof. R. Mosqueron

In fitness, some exercises performed by athletes are more dangerous than others for the physical, especially for the back. Free weights are largely responsible for these injuries either because of the load or a poorly performed movement.

The new health centre in Champagne (VD) https://centre-sante.ch/ aspires to become a reference place in the field of health, sport and well-being in the North Vaud region by using technological innovations to improve the monitoring of fitness enthusiasts.
The objective of the project will be to recognize the user of the free weights during these exercises with the help of cameras. These cameras will also be used to calculate the weight put on the bar(s). The user will be able to do these exercises while being analysed in these movements.

The system will therefore be able to analyse his posture during these movements and will be able to tell him if he is doing the right thing or not. This assessment will be transmitted to him on his smartphone by showing him the dangers of his movements on his body and the user can then ask for advice by an explanatory video of the movement to be worked on or by calling a coach from the gym.

In addition, this system will be able to monitor the subscriber's performance as these workouts go on.

Specifications:
- Research of face recognition technologies to recognize the subscriber
- Research of motion tracking technologies
- Weight Analysis
- Movement learning and recognition to recognize «wrong movements»
- Implementing the algorithm
- Development of the application for the Proof of Concept

Keywords: Machine Learning, embedded systems, video

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

Keywords: Telecom, embedded systems, 5G

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

Keywords: Cloud computing, Network

SILVER RADAR: HELPING ELDERLY PEOPLE WITH RADAR

Prof. R. Mosqueron

Background Adapted housing with support (LADA) is a subject that is increasingly being studied by the cantons and associations. To adapt these homes, several ideas are emerging such as chat and reminder robots, sensors, bracelets, and any other possibilities that can be used so that people can stay at home as long as possible rather than going to a nursing home. Indeed, in the face of demographic change in Switzerland – with an increasingly older population – it is becoming important to offer innovative systems that can allow seniors to stay in their homes for as long as possible. Today, existing systems are mainly based on Secutel-type alert watches, smartphone applications (fall alert, for example) or surveillance cameras, which are often poorly accepted, because they are considered intrusive in the daily lives of seniors.

This project aims to offer a privacy-friendly alternative, which can be installed in an already occupied home, and capable of triggering an alert automatically. The objective is to use a radar-type sensor to automatically detect abnormal actions (such as falls) in the elderly, without cameras, wearables and human action by integrating other data (temperature, CO2, etc.) to prevent these risks. While there are already solutions for detecting falls, radar makes it possible to go further by addressing several risks that are still poorly or not covered, such as prolonged inactivity, night-time disorientation, mobility anomalies, risky behaviour, lack of activity in critical areas or unusual presence in the home.

Project objectives:
The objective of the project is to set up the capture of radar data, to interpret it and to use it for the detection of anomalies mentioned below and to set up the detection system but also a learning pipeline to be adapted for new detections.

Keywords: Health, embedded systems

SMART NETWORK FOR EXTENDED MANAGEMENT OF AUTONOMOUS VEHICLES

Prof. R. Mosqueron

Autonomous vehicles are developing more and more to the point where they are becoming ubiquitous in certain use cases, e.g. autonomous pallet trucks in a warehouse. Similarly, the environments in which these autonomous vehicles operate are becoming more complex. Vehicles, while autonomous, would benefit greatly from additional information from the infrastructure in order to make earlier and more accurate decisions. In the context of an autonomous pallet truck moving through a warehouse, it embeds the necessary movement logic and safety sensors. That is, the pallet truck is able to move on its own and detect an obstacle at a short distance. However, the pallet truck is not warned in advance of an obstacle in its path. If the warehouse infrastructure could tell him about this obstacle before the pallet truck arrives there, the pallet truck could change its route efficiently and seamlessly. The objective of this project is to set up an intelligent infrastructure supporting V2I – Vehicle to Infrastructure – and allowing improved traffic management by pooling detection resources in a private 5G network.

Specifications:
- WP1 Specifications
- WP2 5G connectivity
- WP3 smart network
- WP4 Autonomous vehicles

Duration: 3-6 months

Keywords: Signal processing, machine learning, deep learning, embedded systems

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 real-time 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

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

Duration: 4 months

Keywords: GUI, remote control, automation

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 real-time 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.

Prerequisites: Strong C programming knowledge. Motion control would be a plus

Duration: 4 -6 months

Keywords: Linux, PLC, automation

OPENCN - VIRTUAL MACHINE

Prof. D. Rossier

OpenCN is an open, flexible, and powerful solution for system control with embedded path planning algorithms and hard real-time 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

Prerequisites: C programming, simulation, motion control

Duration: 4 -6 months

Keywords: Digital twin, automation, simulation

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.

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

Duration: 4 -6 months

Keywords: ARM microcontrollers, security, operating system

ORCHESTRATION OF EMBEDDED SERVICES IN A HIGHLY SECURE CONTAINERIZED ENVIRONMENT

Prof. D. Rossier

Over the last years, the edge computing paradigm turned out to gain an important momentum in the field of embedded systems.

Edge computing is a way to perform possibly complex processing in a local embedded system closed to sensors or actuators and to exchange data with a server located in the cloud.

This project will consist in using the lightweight SO3 operating system developed in our Institute to manage some containerized entities which will be deployed in a Linux based environment. SO3 will also be used as hypervisor to manage the interactions between the containerization engine and the SO3 containers based on Docker technology.

We will then propose to use micro-python in SO3 containers to deploy custom algorithms in order to monitor and to collect data as well as to partially control the peripheral environment.

The framework could be used by Enterprises who develop critical systems and would like to provide end customers with the possibility to deploy their own algorithms and execution environment.

Duration: Minimum duration 4 months, preferentially 6 months

Keywords: Orchestration of services, edge computing, Linux, embedded systems

OPENCN - ROBOT DELTA

Prof. D. Rossier

OpenCN is an open, flexible, and powerful solution for system control with embedded path planning algorithms and hard real-time 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 adapt the framework to enable control of a delta robot.

The main objectives are:
- Implementation of stepper motor control
- Integration of delta robot kinematics
- Development of a functional demonstrator.

Prerequisites: C programming, motion control

Duration: 4 -6 months

Keywords: Linux, stepper motor, kinematics, automation

OPENCN - ROS

Prof. D. Rossier

OpenCN is an open, flexible, and powerful solution for system control with embedded path planning algorithms and hard real-time 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.

ROS 2 is a modular software architecture designed for the development, communication, and management of complex robotic systems. Communication between ROS 2 and OpenCN would enable interaction between systems developed and controlled via ROS 2 (such as a robotic arm) and a system designed and controlled by OpenCN—for example, within an automated assembly line.
This project is divided into two main phases: First, the development of a ROS 2 package dedicated to reading and writing OpenCN PINs from within the ROS 2 environment. The second objective is to integrate ROS directly into the OpenCN environment, enabling both ROS and OpenCN to run simultaneously on the same board.

Prerequisites: C programming, motion control. ROS control would be a plus.

Duration: 4 -6 months

Keywords: Linux, ROS, automation

OPENCN - EVL

Prof. D. Rossier

OpenCN is an open, flexible, and powerful solution for system control with embedded path planning algorithms and hard real-time control. It is used to control different kind of machine like 3 or 5 axes milling machines, laser engraver, Pick & Place robot.

OpenCN is based on a quad-core processor architecture using asymmetric multiprocessing (AMP). This architecture includes a modified kernel integrating Xenomai / Cobalt to provide hard real-time (RT) management on a dedicated core. Xenomai recently released a new version of its real-time core—Xenomai 4 / EVL. Initial evaluations conducted at the institute indicate that it is suitable for integration into OpenCN.

The goal of this project is to update OpenCN's real-time core, migrating from Xenomai/Cobalt to the new Xenomai/EVL version. OpenCN's core, particularly the HAL, as well as its existing components, will need to be modified to interface with the new real-time core.

Link: https://v4.xenomai.org/overview/index.html

Prerequisites: C & linux programming

Duration: 4 -6 months

Keywords: Linux, real-time, kernel

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.

https://github.com/rick-heig/nvme_csd
https://github.com/rick-heig/eNVMe

Prerequisites: Computer architecture, C/C++, basic FPGA a plus, Operating systems

Duration: 2-6 months

Keywords: Storage, NVMe

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.

Prerequisites: C/C++, FPGA design experience

Duration: Minimum 4 months

Keywords: LDPC, SDR

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 with a strong focus on RDMA.

Prerequisites: computer architecture, C/C++ programming, basic FPGA knowledge a plus, Operating systems

Duration: 2-6 months

Keywords: Networking, Hardware

DEEP-INSIGHTS: EXTRACTING INTERNAL REPRESENTATIONS FROM DEEP NEURAL NETWORKS

Prof. C. Peña/X. 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 can identify input patterns which are significant for the predictions of a given Deep Neural Network and that may explain how these networks 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.

Prerequisites: Machine Learning, Deep learning
Duration: 6 months

Keywords: Machine learning, Deep learning, Explainable Artificial Intelligence

RULE-DEEP-EXTRACT: EXTRACTION OF RULES FROM DEEP NEURAL NETWORKS

Prof. C. Peña/X. 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 to extract knowledge in the form of hierarchical rule representations to explain how Deep Neural Networks make their predictions while 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 one of the specific deep network architectures that we are using in our research projects. For instance: 1D convolutional or LSTM networks.

Prerequisites: Machine Learning, Deep learning

Duration: 6 months

Keywords: Machine learning, Deep learning, Explainable Artificial Intelligence

TL-MICROBIAL-GENOMICS: EXPLORING THE USE OF FOUNDATION MODELS AND TRANSFER LEARNING ON MICROBIAL GENOMICS MODELLING.

Prof. C. Peña/X. Brochet

The goal of this project is to explore modelling approaches combining the power of foundation models with transfer learning to deal with microbial genomic data in the context of biological classification. These methods 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

Prerequisites: Machine Learning, Deep learning, notions of biology

Duration: 6 months

Keywords: Machine learning, Deep learning, Bioinformatics, Genomics.

EVO-PERPHECT: ARTIFICIAL EVOLUTION ON NATURAL VIRAL GENOMES

Prof. C. Peña/X. 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 therapeutical performance.

Prerequisites: Machine Learning, Evolutionary algorithms, notions of biology

Duration: 6 months

Keywords: Machine learning, Deep learning, Bioinformatics, Genomics

PERPHECT-RL: MODIFYING VIRAL GENOMES THROUGH DEEP REINFORCEMENT LEARNING

Prof. C. Peña/X. 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 therapeutical performance.

Prerequisites: Machine Learning, Reinforcement learning, notions of molecular biology

Duration: 6 months

Keywords: Machine learning, Deep learning, Bioinformatics, Genomics

GENERATING PERCENTILES FOR PHARMACOKINETIC DRUG MODELS IN THE CONTECT OF DOSAGE ADAPTATION : HOW TO IMPROVE THE PERFORMANCES WHILE KEEPING A GOOD ACCURACY

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. It does so by computing concentrations predictions and dosage adjustments. The core system is written in C++, but the drugs specific kinetics are described in external files, offer flexibility to people developing the models. One of its features is the display of population percentiles to assess the likelihood of observed drug concentrations in blood. Currently the software "simply" generates 10'000 random patients based on the variability expressed in the model of each specific drug and compute predictions for each of them. This number is quite arbitrary and the goal of this project is to evaluate the number of random patients that should be generated for each drug. Depending on the underlying model we could expect to reduce this number in order to save computation time. Also, instead of generating purely random patients, there could be better ways to select interesting values depending on the type of variability.

The work would be carried out in python for evaluation of the number of patients required, and in C++ if the core system for changing the way random patients are generated. The result of this project will then be integrated into the source code already available as open source.

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

Duration: 4-6 months

Keywords: Pharmacokinetics, Python scripting, C++

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 technic that offers the possibility to formally check a design against properties, and to end up with more reliable systems. Proprietary solutions exist, but are very expensive for our partners. SymbiYosys is an open-source initiative that allows to perform some formal verification (https://github.com/YosysHQ/sby).

The goal of the project is to select some already existing interesting VHDL designs, to implement properties and assertions to formally verify their behaviour, and to end up with a good comprehension of the possibilities and limitations of the open-source option versus the commercial ones.

Prerequisites: Computer engineering students or electrical engineering students with background in HDL design (VHDL or SystemVerilog)

Duration: 3-6 months

Keywords: Digital systems, Verification, formal

SMAPSHOT - SCIENTIFIC MEDIATION EXPERIENCE

Prof. S. Lecorney

Smapshot is an online platform for 3D georeferencing of historical images. Over 250,000 images have been georeferenced by volunteers and are visible in 3D in a virtual globe. In this context, several image archive libraries would like to showcase the project as part of an exhibition for the general public. The aim of the internship is to design and implement interactive experiences around Smapshot, for example:

- Tutorial on the georeferencing process: Can you georeference this image?
- Gamification: Find the date of this image? Where is this image located (geoguesser)?

Prerequisites: Web design, web development (vueJS, REST API)

Duration: 2 to 6 months

Website: https://smapshot.heig-vd.ch/

Keywords: Interactive experience, web, front-end

FEDERATED AND COLLABORATIVE LEARNING FOR NANODRONE SWARM

Prof. M. Zapater

The Crazyflie 2.1 is a 27-gram nanodrone. In our research institute we have worked on the creation of Artificial Intelligence (AI) algorithms that enable the drone to fly autonomously. The goal 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. The student will put in place the system and create the algorithms for federated and collaborative intelligence.

Prerequisites: Background on computer science and programming (C, C++, Python) Knowledge on training and deployment of AI algorithms (neural networks)

Duration: Minimum 3 months

Keywords: Nanodrone, autonomous navigation, artificial intelligence, deep neural networks

CREATION AND SIMULATION OF NOVEL GPU MODELS

Prof. M. Zapater

GPUs are the most prominent choice when it comes to accelerating artificial intelligence (AI) models. Simulation of GPUs have long been hindered due to the closed-source ISA specifications. In this project, multiple simulation tools will be explored to enable cycle-accurate simulation of GPUs with the goal of simulating the most novel GPUs of the market and understand their benefits and bottlenecks. The preferred choice of the simulator would be gem5 (for the CPU models) and GPGPU-Sim [1] for timing models of the GPU complex, given the current expertise that we have with these tools within the research institute, which will allow us to guide the student closely in all steps of the project.

Prerequisites: C/C++ programming. Knowledge of computer architecture (including GPUs) or eagerness to learn. Basic knowledge of the Linux command line.

Duration: Minimum 3 months

Keywords: AI accelerators, gem5, simulation, GPUs

VALIDATION OF RISC-V CPU MODELS IN THE GEM5 SIMULATOR

Prof. M. Zapater

Simulation of Compute Systems is essential for improving their performance. Cycle accurate performance simulation of Compute Systems can identify performance bottlenecks. However, the simulated models have to be validated against actual hardware. In this project, an Out-of-Order RISC-V CPU model will be validated against in-house OoO CPU emulated on an FPGA. Both the simulated and the emulated system will run Ubuntu distribution (with recent linux version).

The simulator of choice is gem5, given the current expertise that we have with these tools within the research institute, which will allow us to guide the student closely in all steps of the project.

Prerequisites: C/C++ programming. Knowledge of computer architecture or eagerness to learn.
Basic knowledge of the Linux command line.

Duration: Minimum 3 months

Keywords: Gem5, RISC-V, simulation, CPU models

ENHANCING THE ENERGY EFFICIENCY OF AI MODELS VIA WORKLOAD PARTITIONING ON DISTRIBUTED EMBEDDED SYSTEMS

Prof. M. Zapater

The goal of this project is to enhance the energy efficiency of LLM workloads, by launching them on a set of low-power edge nodes equipped with embedded GPUs, instead of on a high-performance server equipped with a high-end GPU. To do so, we will develop the necessary software to build a demonstrator where multiple Jetson Orin Nano boards (~4 units) collaboratively execute LLM inference using the NVIDIA Dynamo framework. The focus will be on evaluating performance metrics such as Time to First Token (TTFT) and Tokens per Second (TPS), analyzing power consumption, and designing policies for workload splitting based on input token sizes.

Prerequisites: C/C++/Python programming. Knowledge on AI algorithms (LLMs desirable, but at least CNNs/DNNs).

Duration: Minimum 3 months

Keywords: Embedded Systems, GPUs, AI, LLMs

EDGE AI AND LLM-DRIVEN SEMANTIC OBJECT TRACKING FOR DRONE SWARMS

Prof. M. Zapater

The project explores combining edge AI with LLMs to enhance autonomous drone and nanodrone swarms for multi object detection and tracking. Instead of streaming raw video each drone performs onboard deep learning to detect and track objects. The high volume pixel data is converted into compact semantic tokens (IDs, positions, trajectories) and sent to a more powerful edge device such as a Jetson Orin Nano. This device aggregates data from all drones and uses an LLM to generate natural language summaries, anomaly alerts, and mission insights. The goal is to show how scaling with tokens rather than pixels improves swarm coordination and situational awareness.

The work focuses on AI algorithms deployable on Crazyflie 2.1 nanodrones and a Jetson Orin Nano.
Prerequisites: Background on computer science and programming (C, C++, Python) Knowledge on training and deployment of AI algorithms (neural networks). LLMs are a plus.

Duration: Minimum 3 months

Keywords: Nanodrone, autonomous navigation, artificial intelligence, deep neural networks

IGNITE: REAL-TIME PROCESSING OF HIGH-DENSITY EEG SIGNALS AT THE EDGE USING ARTIFICIAL INTELLIGENCE ALGORITHMS

Prof. M. Zapater

High density EEG requires heavy preprocessing, filtering, and feature extraction, making real time analysis difficult on standard embedded systems. Clinicians often rely on offline analysis with fewer channels, limiting hdEEG's capabilities. The project aims to develop both classical signal processing algorithms and deep learning models that can run in real time on edge hardware (CPU+GPU or CPU+FPGA). Using open source hdEEG databases, the student will design, train, and test models for applications such as dream analysis, epilepsy detection, and brain–machine interfaces.

Prerequisites: C/C++/Python programming. Knowledge on AI algorithms (DNNs, transformers, others). At least basic knowledge is required on DNNs. Knowledge on embedded FPGA systems and/or embedded GPU systems.

Duration: Minimum 3 months

Keywords: Embedded Systems, Edge-AI, DNNs, EEG signal processing, biomedical

INFORMATION TECHNOLOGY, COMMUNICATION TECHNOLOGY

MECHANICAL AND MATERIALS ENGINEERING

SELF-ADAPTIVE SAMPLING RATE DATA ACQUISITION SYSTEM

Prof G. Courret

The aim of this internship is to contribute to the development of a self-adaptive sampling rate data acquisition system designed for wideband signals, which are prevalent in surveillance monitoring. Working alongside other members of the research team, the intern will develop software and firmware for signal processing and real-time analysis. They will also design an algorithm to compress, analyse and store measurement data.

Prerequisites: Courses in data compression, analysis, storage, signal processing engineering, digital electronics (FPGA-SoC) and Matlab or Octave programming

Duration: Minimum 3 months for Master students, preferably 4-6 months; PhD interns 6-12 months

HYPERSONIC PLASMA IN A LIGHT BULB

Prof G. Courret

This internship involves contributing to a research project that studies an acoustic resonance phenomenon in a high-pressure plasma microwave setup. This phenomenon could provide a new way of measuring hypersonic aerodynamic parameters, which are crucial for designing space shuttle thermal protection systems. Current metrology is unable to measure some of these parameters directly.

Prerequisites: Courses of plasma physics and thermodynamics

Duration: Minimum 3 months for Master students, preferably 4-6 months; PhD interns 6-12 months

PLASTICS WASTE RECYCLING WITH PLASMA TECHNOLOGY

Prof G. Courret

The aim of the internship is to participate in a research and development project focused on recycling plastic waste. The research team is currently developing a reactor that uses microwave plasma to break down plastic waste — particularly packaging waste — into valuable molecules. This work is being carried out by a collaborative research team. The internship will involve upgrading the new laboratory setup, analysing measurement data and optimising parameters.

Prerequisites: Courses in plasma technology and materials science.

Duration: Minimum 3 months for Master students, preferably 4-6 months, PhD students 6-12 months

Keywords: recycling, sustainability, environment, climate change, plasma processes, polymers, plastics

FLEXIBLE ELECTRODES FOR BIOSIGNAL MONITORING AND NERVE STIMULATION

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences) 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 from humans and plants, as well as for 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.

You will use various printing and coating equipments. Flexible electrodes are also of interest for flexible actuators, or energy storage applications which can be furthermore envisaged. The project is suitable for master or bachelor students with interest in advanced electrical characterizations of novel materials, a good general understanding of general physics or in chemical engineering is expected.

Duration: Minimum 3 months for bachelor or master students, preferably 4-6 months; PhD interns 6-12 months

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

FLEXIBLE SUPERCAPACITORS

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences) is active in the field of flexible materials.
Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.

You will design and test flexible thin materials for the development of nano-composite based capacitors and supercapacitors. You will use various printing and coating techniques and be involved in developing and choosing the materials, as well as in advanced electrical and electrochemical characterizations, such as electrical impedance spectroscopy, electrical 4 point probing, current-voltage curves, etc. The effect of the capacitors' electrode materials and their surface structures will be analysed and their performance will be optimized along the project by comparing various fabrication techniques of nanocomposite electrodes.

The project is best suitable for bachelor or master students in mechanical, chemical or materials engineering, applied physic, or robotics, as well as for students in industrial process technologies.

Duration: Minimum 3 months for bachelor or master students, preferably 4-6 months; PhD interns 6-12 months

Keywords: Supercapacitors, flexible composite materials, material development and testing, prototyping, sensors, energy storage

LASER TECHNIQUES FOR NANO AND MICROPATTERN SURFACE ANALYSIS

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences, www.comatec-lans.ch) is active in research on surface coatings and analysis.
Within the study project, the candidate will participate in running research activities of the COMATEC-LANS.

In this project we compare our laser system for investigating surface nano- and microstructures with topographic information from optical profilometer measurements, as well as from atomic force microscopy. Our laser system uses angular detection of the scattered light as well as speckle detection from normal incidence. The system is motorised for angular positioning and data acquisition using diode arrays, and LabView control, further data recordings are made by a camera.

The data analysis is performed using Python. During the internship you will learn how to work with a laser system and how optical data can be used for quality control of nano- and microstructured surfaces, and for the detection of invisible anti-counterfeit structures. You will test and implement various calibration methods, and create and tests anti-counterfeit structuring. You will compare results for two different laser wavelengths. Our system has a housing for operation, protecting from ambient light, this implies also that measurements are performed in safe laser class 1 conditions.

The laser alignment on the samples is currently performed using appropriate goggles, alternatively a camera could be installed for laser alignment in closed system conditions.
Interested engineering students would also have the possibility to focus on improved data acquisition and control (as an alternative to the currently used LabView interface, Python could be implemented).

The project is best suitable for bachelor or master students in mechanical or microtechnical engineering, physics, materials or surface science, as well as for students in industrial process technologies.
Duration: Minimum 3 months for Bachelor or Master students, preferably 4-6 months; PhD interns 6-12 months.

Keywords: Laser surface analysis, angular light scattering, test bench development, applied nanosciences for robotics and industrial machines

SURFACE MODIFICATION OF BIO-SOURCED NANOFIBER MATS USING 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. You will generate nano- and microfiber-based materials using electrospinning. You will use our semi-automated atmospheric pressure plasma system (pilot system for industrial in-line nozzles) and investigate the influence of process parameters and treatment paths. You will apply various surface analysis techniques, such as atomic force microscopy and surface wettability analysis. The project is best suitable for bachelor or master students in machine engineering, chemical engineering, material or surface science, applied physics, as well as for students in industrial process technologies.

Duration: Minimum 3 months for Bachelor or Master students, preferably 4-6 months; PhD interns 6-12 months.

Keywords: Electrospinning, atmospheric pressure plasma, surface treatment of advanced materials, automation, applied nanosciences

ARTIFICIAL MUSCLES FOR ADVANCED ROBOTICS APPLICATIONS

Prof. Dr. S. Schintke

The research unit COMATEC-LANS (Laboratory of Applied NanoSciences) is active in the field of artificial muscles for advanced robotics applications.

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

You will perform design and characterization of soft flexible artificial muscles based on conductive polymer nanocomposites for the use in robotics applications. You will be involved in the prototyping of the muscles, and in adaptions of our test-benches. You will perform lab tests of the muscles in actuation and sensing geometries.

The project is best suitable for bachelor or master students in mechanical, chemical or materials engineering, applied physic, or robotics, as well as for students in industrial process technologies.

Duration: Minimum 3 months for bachelor or master students, preferably 4-6 months; PhD interns 6-12 months

Keywords: Conducting soft materials, electro-mechanical actuation and sensing, test-bench developments, prototyping, lab tests, advanced robotics applications

SIGNAL PROCESSING OF ROTATING MACHINERY FOR PREDICTIVE MAINTENANCE

Prof. A. Schorderet

The internship is part of an ongoing research effort on intelligent monitoring of industrial machinery. Industrial rotating machinery such as machine-tool spindles and motor–pump systems used in water treatment applications must be monitored to prevent unexpected failures and reduce maintenance costs. Advanced signal-processing techniques and machine learning are increasingly used to improve the reliability of predictive maintenance systems.

The objective of this project is to develop improved monitoring algorithms capable of detecting early signs of machine degradation and estimating the remaining useful life of critical components.

Large datasets of test-bench and in-situ measurements are already available from a previous research project. The work will focus on extracting relevant features from vibration and machine signals and combining physics-based signal-processing methods with machine and deep learning approaches.

Possible research directions include:
advanced time–frequency signal analysis
failure signature detection
hybrid physics-based and data-driven models
predictive maintenance indicators

The results of the project may contribute to ongoing research activities in machine condition monitoring.

Prerequisites: Machine design, machine dynamics, dynamic signal analysis

Duration: 4-6 months

Tools: Python / MATLAB, signal processing, machine learning, (depending on the project)

Keywords: Predictive maintenance, rotating machinery monitoring, signal processing, machine learning

REAL-TIME QUALITY MONITORING IN MICRO-MILLING

Prof. A. Schorderet

The internship is part of an ongoing research effort on intelligent monitoring of industrial machinery.

Achieving high surface quality in micro-milling is a major challenge in precision manufacturing. Recent research has shown that machine signals recorded during machining contain valuable information about the quality of the machined surface.
Previous work has demonstrated that a surface quality indicator can be estimated from machine signals using advanced signal-processing techniques. However, this indicator is currently computed offline.

The goal of this project is to develop algorithms capable of estimating a process quality indicator in real time. This would enable real-time monitoring of the machining process and open the possibility of implementing adaptive process control.

The work will include:

- advanced signal processing of machining signals
- feature extraction related to surface quality
- development of real-time algorithms
- potential implementation on FPGA hardware

Such a monitoring system could ultimately be integrated into a closed-loop control strategy to guarantee the quality of manufactured parts.

Prerequisites: Dynamic signal analysis

Duration: 4-6 months

Tools: Python / MATLAB, signal processing, machine learning, FPGA implementation (depending on the project)

Keywords: Micro-milling, surface quality monitoring, signal processing, real-time monitoring

ACOUSTIC EMISSION–BASED MACHINE MONITORING SUPERVISOR

Prof. A. Schorderet

The internship is part of an ongoing research effort on intelligent monitoring of industrial machinery.

Early detection of mechanical degradation is essential for improving the reliability of industrial machinery. Acoustic emission (AE) is a powerful sensing technique capable of detecting microscopic material events occurring during the early stages of damage. This project aims to investigate acoustic-emission-based monitoring methods for rotating machinery such as machine-tool spindles and motor–pump systems. By analyzing high-frequency AE signals, it may be possible to detect early-stage faults in mechanical components such as bearings and guideways.

The work will focus on developing signal-processing algorithms capable of identifying characteristic patterns associated with the onset of mechanical degradation.

Possible research topics include:

- time–frequency analysis of acoustic emission signals
- pattern detection and correlation-based methods
- identification of fault signatures
- development of robust monitoring indicators

The project contributes to ongoing research in advanced condition monitoring of industrial machinery.

Prerequisites: Machine design, machine dynamics, dynamic signal analysis

Duration: 4-6 months

Tools: Python / MATLAB, signal processing, machine learning, (depending on the project)

Keywords: Acoustic emission, machine monitoring, rotating machinery, signal processing

INTERESTED?
CONTACT US!

Haute École d'Ingénierie et de Gestion
du Canton de Vaud
Route de Cheseaux 1
1401 Yverdon-les-Bains

Christopher Martellet
Head of International Office
christopher.martellet@heig-vd.ch
+41 24 557 64 69