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

CIVIL, ENVIRONMENTAL, BIO- ENGINEERING AND GEOMATICS		
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**

Vulnerability assessment of buildings to landslides **Prof. E. Prina Howald**	Landslide is a natural hazard that occurs when the natural stability of a slope is disturbed. It is often accompanied by heavy rainfall or follows droughts, earthquakes or volcanic eruptions. Landslide hazard analysis furnishes valuable information that can be of assistance in reducing catastrophic losses. The objective of this study is to assess the vulnerability of different types of building structures to landslides. To accomplish the aim, it is first necessary to identify the multiple factors related to landslides, to evaluate the related contribution of the factors causing slope failures, to establish a relationship between the factors and the landslides. Secondly, based on the previously defined parameters and existing methodologies it is required to develop a general methodology for assessing the vulnerability of predefined types of building structures.	**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 cological material made of high percentages of excavated soil. This materials has been tested and mix design methodologies has been prepared. A recent series 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**
Effect of biomass ashes in cement pastes and concrete **Prof. M. Viviani**	The number of biomass power plants is increasing since decades. The ashes produced during the burning process have to be disposed unless a valorization is found. Regulations for disposal and utilization of this ashes are very strict due to the presence in many ashes of hazardous substances such as chrome IV and heavy metals. The use of these ashes in concrete is possible but their effect on the hydration process of the cement, on the rheology and on the durability of concrete must be known. The aim of this process is twofold: study the effect of the ashes as they are produced and after a chemical treatment. The project includes laboratory test on cement pastes and mortars with techniques such as isothermal calorimetry and rheolometer. Keywords: valorization of byproducts, cement hydration, rheology of concrete	**Students in Civil engineering and Material sciences with strong interest for lab tests and modelling**
Data mining in a building energy performance certificate (EPC) database **Dr. S. Lasvaux**	This internship will be conducted in the framework of "HISTO-RENO" a European research project funded by the Interreg France-Switzerland fund. This project aims to develop a web-based simplified energy pre-audit tool to guide the building owner in their energy-related renovation. The goal of this internship is to derive statistical distributions on the input parameters (U-values, surface area of the main elements: external walls, roof, slab, windows, etc.) of the building heating demand of the current Swiss building stock with the help of the information of individual buildings in the Building energy certificate database (EPC), called "CECB" in Switzerland. The methodology of the analysis will be based on the previous work from Streicher et al 2018. The statistical analysis on the heating demand parameters will then serve to define probability density function (PDF) as input for a stochastic simplified energy audit tool used in a preliminary step of a renovation process indicating the estimates in kWh, carbon footprint and costs of a set of renovation measures. The Laboratory of Solar thermal Energy and Building Physics (LESBAT) from HEIG-VD has been funded by the Interreg France-	**Keywords: Existing building stock, envelope, technical systems, statistical analysis**

	Switzerland program along with the cantons of Geneva, Vaud, Jura, Neuchâtel, Valais and Bern to conduct a research project on the development of a GIS-based platform linked to a web-based building energy pre-audit tool to foster energy-related renovation and decarbonisation of existing historic buildings. The student selected for this internship will be involved in the statistical analysis of a large database of residential buildings EPC and its exploitation through the web-based tool for energy-related building renovation scenarios under development. For this topic, the minimum duration of this internship is 5 months (preferably 6 months). Proven knowledge in numerical and scientific programming tools like Python or R is required to successfully reach the goals of this internship project.	
Dynamic Life Cycle Assessment (LCA) of the energy uses in Swiss buildings **Dr. S. Lasvaux**	The internship is part of an applied research project whose objective is to study the load shifting in a view of minimizing the carbon footprint of the energy use in Swiss buildings. With technologies to achieve the Energy Strategy 2050, the energy demand profile of buildings is changing. However, we are still dependent on electrical energy from the grid. The carbon footprint of this grid not only fluctuates seasonally, but also strongly within a day. In Switzerland, in winter, most of the peak demand is covered by imported electricity from Germany with a higher CO2 content. Promoting the use of electricity when the carbon footprint of the Swiss grid mix is low and/or store this electricity and shift the uses when possible are appropriate means to fulfil this goal. In this internship, this carbon footprint will be applied to different building case studies with different load profiles and predictive controller (at the DSO and energy contractor level). The Laboratory of Solar thermal Energy and Building Physics (LESBAT) from HEIG-VD has been appointed by Swiss Federal Office of Energy (SFOE) together with EMPA to conduct a research project of the Sustainable Demand Site Management of the Energy use in buildings. The student selected for this internship will be involved in the analysis of the data collected, the development and monthly updates of the hourly carbon footprint of the Swiss electricity mix and the analysis of this carbon footprint of electricity on selected building case studies together with HEIG-VD partners. For this topic, the minimum duration of this internship is 4 months (preferably 6 months). Proven knowledge in numerical and scientific programming tools like Python or R is required in order to successfully achieve the goals of this internship.	**Keywords: Life Cycle Assessment (LCA), building energy simulation, dynamic carbon footprint, electricity, hourly assessment**
Life Cycle Assessment (LCA) of biogas and biomethan used in building energy systems **Dr. S. Lasvaux**	The internship is part of an applied internal research project's portfolio at HEIG-VD on the Life Cycle Assessment (LCA) of Energy uses in buildings. One of this project aims at analysing the ecological consequences of an increasing use of biogas & biomethan in the energy systems using a life cycle approach and particularly in the Swiss building sector by 2050. This renewable source is of strong interest since it would contribute to improve the environmental performance of the natural gas as energy vector, while valorising local resources. However, in the literature, current LCAs of the renewable gas and its usage show a large variability in terms of carbon footprint due to different data and allocation rules which hinders to get a clear picture. It is thus necessary to conduct a detailed analysis and reliable quantification of the environmental impacts. Two key aspects regarding the renewable gas successful integration in the future Swiss Energy will be taken into account in this internship project: the LCA of the heat and electricity produced with variable shares of renewable gas (i.e. biogas or biomethan), and the identification of the promising integration scenarios for the technologies relying on renewable gas. The Laboratory of Solar thermal Energy and Building Physics (LESBAT) from HEIG-VD is the main LCA research centre in LCA of energies and buildings. The student selected for this internship will be involved 1) in the definition of the technologies to	**Keywords: Life Cycle Assessment (LCA), building energy simulation, biogas, allocation rules, electricity, heat production**

	analyse, 2) in the literature review of existing LCA of biogas and biomethan in order to get a range of carbon footprint for a unit of biogas/biomethan, 3) in the LCA of the heat and/or electricity produced with the technologies selected and 4) in the comparative LCA of heat production with other technologies (e.g. electric-based air-to-water heat pump) or electricity production in micro-CHP comparing biogas/biomethan solutions with electricity ones (using electricity from the grid). The data used for the carbon footprint of the Swiss electricity mix will be based on the ones available at HEIG-VD. For this topic, the minimum duration of this internship is 4 months (preferably 6 months). Proven knowledge in numerical and scientific programming tools like Python or R is required.	
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**
High evaporating temperature hydrocarbon heat pump **Prof E. Da Riva**	The Institute of Thermal Engineering (*Institut de Génie Thermique*, IGT) is active in the experimental development and testing of low-charge high-evaporating-temperature (≥ 35°C) heat pumps employing hydrocarbons as the refrigerant. The availability of heat pumps capable of evaporating at high temperature is fundamental in order to properly exploit non-conventional heat sources such as waste heat or to develop new-generation low-temperature (~40°C) district heating networks. The project proposed may cover the following topics: -) Experimental test and analysis of heat pumps and compressors -) Thermodynamic modelling of vapor crompession refrigeration cycles -) Energy assessment of low-temperature district heating networks employing heat pumps for local temperature rise	**Students with previous knowledge from courses in refrigeration engineering, thermodynamics, heat transfer**

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 CO_2 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**
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**

MATHEMATICS, INFORMATION TECHNOLOGY AND COMMUNICATION (TIC)		
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	**Keywords: data analysis, machine learning, neonates survival**

	the chances of a kid's 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**

Innovative system to detect and locate interference sources using a signle measurement point **Prof. M. Rubinstein**	The student will work on a new technique that reduces the number of measurement points for the location of interference sources from 4 to 1 using a technique known as time reversal. This is a very interesting project with high potential and the student will be working with engineers that have done initial work showing that the technique is indeed viable.	**Prio experience at course level on electromagnetic simulation software is desirable**
Measurement of enevironmental data using a radio-controled small airplane **Prof. M. Rubinstein**	The measurement of environmental data at heights other than ground level is generally achieved by using balloons. However, ballons and drones have been observed not to be usble in practice. Preliminary wok done by partners in Spain has shown that the use of small remot-controlled airplanes with embedded sensors connected to a platforms such as a Raspberryy Pi is a solution worth exploring. The student will work on a prototype based on commercially available small airplanes for that purpose.	**Some prior experience in embedded systems.**
Simulator of a gravitational multi-body system using classical newtonian mechanics **Prof. M. Rubinstein**	In this project, a student will write a simulation for the calculation of the positions and speeds of a large number of physical bodies that are aware of the gravitational pull from all other bodies in the system with delayed action due to the finite speed of propagation of the information. The forces will be based on classical Newtonian gravitation and mechanics but the underlying equations will be definable for each object so that the simulations are also applicable to electric and other forces.	**Knowledge of object oriented programming and basic physics.**
Design and construction of commmunicaiton system using digital modulation techniques with acoustic signals **Prof. M. Rubinstein**	The student will design a system to communicate using digital modulation and multiplexing techniques based on acoustic waves.	**Knowledge of digital modulation techniques. Experience with Matlab or octave is desirable but not an absolute pre-requisite fo this project.**
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**	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**	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	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	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	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	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. For more information: http://iict-space.heig-vd.ch/ape	**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**
Placement of emergency vectors in strategic locations as needed	The mission of the emergency services (ambulances, helicopters) is to ensure 24 hours a day, at the decision of an alarm center, in all places and on a defined territory, the medicalization of interventions with patients whose condition requires emergency medical attention. They must demonstrate rigorous medical and logistical organization, benefit from the implementation of the most modern technologies and evaluate their practices. In this project, we will be studying the ideal location of the means of	**Mathematics, physics or computer science students with data science skills**

Prof. S. Robert	intervention in order to be able to provide the necessary assistance as quickly as possible to the people who need it. The study will first be theoretical and scenarios will be evaluated with different evaluation methods and then applied to real cases. The tools used will be mainly mathematics (graph theory and algorithmics) and deep neural networks. Page: http://www.stephan-robert.ch/research/	**Optimisation, Deep Learning, mathematics, Graph Theory, Programming skills: Python**
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. 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 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.	**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**

	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.	
Heterogeneous System Infrastructure **Prof. A. Dassatti**	The end of the Moore's law imposes new specialized hardware solutions to serve the increasing computing demand. System composed by several domain specific accelerators are available, but from the system integration and programming point of view they rely on custom solutions. The idea of this project is exploring the state of the art in compiler infrastructure for heterogeneous hardware and implement a prototype to measure real benefit and compromises of these solutions. Several research project have already been carried out in our laboratory on this subject.	**Compiler, heterogeneous systems, accelerator, runtime.** **Requirements: computer architecture, C/C++ programming, basic FPGA knowledge a plus.**
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 f the technology and this project will focus on extending its functionalities and benchmark it extensively. **Keywords**: Linux, nvme, file system	**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++ programming, 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 explore the state of the art in the domain with the aim at developing a prototype capable to off-load tasks to an FPGA.	**Keywords: Linux, nvme, file system** **Requirements: computer architecture, C/C++ programming, basic FPGA knowledge a plus, Operating**

		systems
FPGA compression for stereo RGBd Stream **Prof. R. Mosqueron**	Goals : Due to the large amount of data providing by the images sensors, the goal of this project must be to send a compressed stream for storage and for processing. Images come from a RGBd sensor which is a stereo camera plus a depth sensor. This kind of sensor is very useful to manage a 3D environment illustrating the virtual rehabilitation environment. The bandwidth is very high (10Gbps per sensor) and medium capacity is limited. In this case, USB3 is used and the bandwidth is close to 5Gbps (10 for USB3.1). Then, capacity of the medium for uncompressed is not sufficient. The solution is to use compression. Compression for stereoscopic field could be specific. Either the stereo compression is done in a smart system before sending the stream or two separate compressions are done. Some compression can be used with strict constraint of latency. The latency (Glass to glass) must be less than 40 ms. It means that most of the standard cannot be used.	**Video analysis** **Student with a good knowledge in compression**
Sustainable agriculture Multispectral approach for efficient watering **Prof. R. Mosqueron**	We aim to develop a watering robot for seedlings in order to support ecological and sustainable agriculture. During the first days, seedsare very sensitive to a lack of water by the low volume and depth of their roots. This stress can cause fairly substantial production losses. The objective of this project is to produce an image analysis system into the robot allowing the detection of seed pieces and weeds. This project will study the different detection solutions by image analysis. Multispectral cameras can be used to define the spectrum of the plant and determine the type of plants. Machine learning is a possible solution for this kind of system. The project will include the implementation of a prototype in order to carry out real tests in a field. Specifications: - Study of the vision system - Study of algorithms, definition of constraints - Simulation - Implementation on the on-board system (RPi, PinQ, ...) - Integration on the prototype robot	**Video analysis and processing, robotics, ROS is a plus**
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.	**Telecom, embedded systems, 5G**

	• Progress of the project: • Study of the different types of SIM card • Selecting a SIM card type • SIM deployment	
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**
IoT counting people **Prof. R. Mosqueron**	The project aims at designing an entire IoT system which will be based on the following scenario: We have a closed room with a certain number of windows. We have an embedded system whichmeasures at regular intervals the temperature, humidity and CO2. The data is uploaded by usingcellular connectivity to a public cloud (Azure, AWS or Swisscom Cloud). The date (time series) will besubsequently analyzed and based on the parameters, a basic data processing will be made in order todetect the number of persons which are in the room (CO2 should vary linearly with the number ofpersons in the room). This way an indirect person counter will be implemented. The CO2 variationwill tell also the user when the window should be opened, before the values will become dangerous.Sensors will be installed also on the windows to detect when it is opened.From a hardware point of view, the system will consist in an embedded system (RPi or Arduino typeor both) together with a cellular modem and the sensors.The cloud architecture consists in a virtual machine with a nonSQL database which ingests the data.A dashboard will be also put in place so that the user can check the actual status.All the hardware and cloud client will be provided by Swisscom. Also several resources andknowledge about the cellular connectivity will be shared along the project	**Signal processing and network** **Student with good knowledge in network and signal analysis**
Elastic edge-to-cloud resource management techniques	The popularization of artificial intellengence is bringing deep learning to a myriad of novel applications. Image analytics, video surveillance, self-driving card or real-time population monitoring are among the novel killer applications that require efficient	**Computer Science and Computer Architcture** **Student with good**

Prof. M. Zapater	management between edge and cloud. To maximize performance and minimize the energy consumption of both edge devices and cloud platforms, there is a need to develop efficient resource management techniques able to take workload allocation decisions, on when and where to execute the workload, in the edge to cloud continuum in an elastic way. To exploit elasticity, these techniques need to be aware of the underlying hardware and software stack, which often consist on a lightweight virtualization (like containers) deployed on ARM or RISC-V based edge devices. This project proposes the design of heuristic and meta-heuristic based workload managemet techniques and tools to adequately allocate deep learning workloads in edge and cloud devices. To test the proposed techniques in a large-scale scenario of hundreds of nodes, we will use an efficient in-house open source simulator tool that will be extended with novel features to ensure scalability.	**knowledge of C/C++. Basic ML knowledge would be a plus.**
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) algorithm. The goal of this project is to deploy neural network algorithms (such as DroNet) is a nanodrone (Crazyflie 2.1) in order to enable the drone to fly autonomously. For this purpose, the student will have to modify and accelerate the provided algorithm in order to make it fit and run efficiently on a small embedded processor deployed on the drone. The intern will be expected to explore and implement ways of deploying this DNN on the drone by properly programming and accelerating the code in the embedded system.	**Background on embedded Systems. Knowledge of C/C++. Python and ML would be a plus.**
Acceleration of a Deep Neural Network for Epilepsy detection using FPGAs Prof. M. Zapater	Epilepsy is a neurological disease characterized by seizures, arising from the abnormal activation of neuronal networks. This abnormal activation translates into changes in the pattern of electrical activity generated by the brain, which can be captured through electroencephalography (EEG). The disease affects 50 million people worldwide, among which 30% will continue to have recurring seizures despite treatment. Deep Learning, and specifically Convolutional Neural Networks, can be used to predict epileptic seizures with a 90% accuracy. However, running the training and inference of these networks efficiently still remains a challenge. The goal of this project is to accelerate the training/inference of CNNs for epilepsy detection by using FPGAs, by analysing current performance bottlenecks and proposing specific accelerators to be implemented on FPGAs.	**Background on VHDL/Verilog. C++, Python and ML would be a plus.**
Implementing RISC-V vector extension for artificial intelligence over the PULP platform 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 Parallel Ultra Low Power (PULP) platform, created by ETHZ and University of Bologna, is an open platforms that allows to improve both the hardware architecture and the software around RISC-V processors for low-power embedded systems. The goal of this project is to propose new vector extensions on RISC-V that will be tested on the PULP platform. For this purpose the intern will need to get familiarised with the PULP toolchain and development workflow, and propose novel extension that will be tested on FPGA.	**Background on VHDL/Verilog. SystemVerilog and C would be a plus.**
Small Datasets Reinforcement Learning for Emergencies	The intern will be incorporated in a project, which aims to find optimal solutions to guide and involve the most appropriate vector (helicopter, ambulance) in the face of an emergency, accident or disaster. For moderately severe cases, it is often preferable to use a vector that is not the closest, but the one which minimizes the redistribution of the vectors on the territory.	**Master student in Mathematics or Data Science**

Prof. S. Robert	We believe that machine learning and more precisely reinforcement learning could provide an interesting framework to solve this problem. Unfortunately, reinforcement learning needs millions of samples to achieve good performance and we only have access to a few hundreds of thousands. The intern will explore methods, which aims to use reinforcement learning with a (reasonably) small dataset. The precise project will be determined with the intern according to his background and ideas.	
Convergence of Markov Chains to self-similar Processes **Prof. S. Robert**	Self-similar processes are stochastic processes that are invariant in distribution under suitable scaling of time and space. These processes can be used to model many space-time scaling random phenomena that can be observed in physics, biology and other fields. One could mention stellar fragments, growth and genealogy of populations, option pricing in finance, various areas of image processing, climatology, environmental science, . . . Self-similar processes appear in various parts of probability theory, such as in Lévy processes, branching processes, statistical physics, fragmentation theory, random fields, ... Some well known examples are: stable Lévy process, fractional Brownian motion,. . . but it has also been shown that relatively simple Markov models can produce self-similarity. Even though the cardinality of the state space increases to infinity, it has also been shown that its rate is quite low. The aim of the study is to prove how theses Markov models converge to self-similar limit processes, under which conditions.	**Master student in mathematics (probability)**

INDUSTRIAL ENGINEERING (TIN)		
Integration of smart meter data in distribution system state estimation with respect to privacy constraints **Prof. M. Bozorg**	Domain: Energy and Smart Networks 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.	**Basic competences in power systems, programming, and data analysis**

	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	
Identification of inverter malfunctioning and Power Quality distorting components using grid side measurements **Prof. M. Bozorg**	Active power distribution networks are going to be dominated by distributed converters on both generation (e.g., photovoltaic inverters), and consumption (e.g., electric vehicle charging stations) sides. Malfunctioning of such converters not only reduce the quality of service but also disturbing the functionality of local control and communication systems. In this activity we aim at identifying location of malfunction components (feeder or point of connection) using data from limited number of grid-side measurements devices (e.g., GridEye from Depsys SA [1]) based on a novel data-driven approach. We primarily focus on malfunctioning related to grid-connected distributed resources, namely, excessive harmonics injections, unbalanced current injections, leakage current fault, and restart failure after grid faults, as malfunctioning of PV and EV converters. Two main objectives are as follows: 1) Assessment of the impact of malfunctioning converter-interfaced devices at local and distribution grid level on the quality of service as well as impact on the functionality of auxiliary local control and communication systems 2) Identifying location of malfunction components (feeder or point of connection) using available data from limited number of grid-side measurements devices	**Basic knowledge in power electronics and power systems. Competencies in Machine Learning and programming**

	[1] https://www.depsys.com/solutions/grideye/	
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**

Theoretical and experimental comparison of the main inertia control techniques of the RES inverters. **Prof. M. Carpita**	Due to the large-scale penetration of renewable energy sources (RES) such as wind and photovoltaics, the power grid is evolving from a system based on synchronous machines to a system dominated by inverters. The traditional approach to inverters as grid following units can lead to frequency instability. The use of inverters with virtual inertia control algorithms, so that they appear as synchronous generators to the grid, allows to guarantee and improve grid stability. Numerous different inverter control topologies aimed at emulating virtual inertia have been presented in the literature in the recent years. Typically, all those methods are based on a suitable control topology, whose aim is to allow the inverter to reproduce the behaviour of a synchronous generator connected to the grid. The "quality" of a control topology depends on the control architecture of the system and the desired level of detail in the replication of the dynamics of the synchronous generators. Several different approaches have been studied in the recent past. Current research needs go towards the optimisation of those methods and the system-level integration of inverters with virtual inertia control. Aim of this project is the evaluation, comparison and optimisation of the main inverter inertia control techniques on the basis of the scenarios and the requirements that will be settled by projects of the two related activities.	**Competencies in power electronics and control systems**
Direct integration of photovoltaic systems in the 1500 Vdc traction network **HEIG-VD referring person: Marc Pellerin, Mauro Carpita**	Transport accounts for one third of Switzerland's energy consumption. While most of the public transport companies (PTC) buildings are suitable for the installation of photovoltaic systems, so far only a small number of PTCs have been able to cover a substantial part of their electricity consumption with their own power plants. Today, with photovoltaics (PV), all the other PTCs have for the first time the opportunity to cover a large part of their energy needs with their own production. However, the profitability of a photovoltaic system is only possible if the share of the solar electricity own consumption within the grid itself is maximized. In this project, the basic idea is to study and create a direct conversion system between a photovoltaic system and a traction system. The main specifications are as follows: Traction system voltage: 1.5 kVdc Rated voltage of the photovoltaic system VPVnom = 800Vdc Nominal power: 250 kW The study will consist in (at least) the following points to be studied: 1. Determining the optimal DC / DC conversion structure between the photovoltaic system and the traction system, 2. Simulating the normal and the fault behaviour of the whole system 3. Evaluating the protection requirements 4. Evaluating the optimal injection characteristics according to the traction characteristics, 5. Evaluating the development and construction costs of the converter prototype.	**Basic competences in Power electronics and Power Systems. Knowledge of Traction Systems is welcome but not mandatory**

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 running projects will develop the numerical simulation, in situ testing environment and a suspension test bench until end of	**Keywords: testing, dynamics, bike suspension, optimization, simulation, mechanical design**

	August 2022. The goal is to obtain a reliable and precise simulation model fitting the experimental in situ data. The proposed project will contribute to one of the following tasks : a) development of the optimization algorithm and numerical model; b) design and realize a test bench to simulate experimentally the fork response to a track measured input signal.	
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). The goal of the proposed project is to use intelligent data analysis/AI for specific sensors data (force, vibration, acoustic emission) and available machine signals (position, current, …) to define and implement a real-time sensitive micro-milling process quality criterion. Once available, this criterion will 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, AI**
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: machine dynamics, composite structures, optimization, trajectory optimization, motion control**
Nanostructured pressure 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 pressure sensor using nanostructured thin film, using nanotechnology techniques mastered in the lab. A test bench will be developed to characterize this sensor, which will be integrated in a technology demonstrator by 3D print techniques.	**Keywords: microtechniques, nanotechnology, sensors, 3D print**

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. The light will be detected by thermoelectric effect combined to lock-in amplifier technique. 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: microtechniques, nanotechnology, lock-in detection, 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: microtechniques, nanotechnology, micro-thermal engineering**
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**