Visiting Students Research Program CEMSE

Teaching Cars to Drive and UAVs to Race

Internship Description

At the Image and Video Understanding Lab (IVUL) at KAUST, we have developed a photo-realistic simulator (denoted UE4Sim) based on the open-source computer game engine Unreal Engine. The UE4Sim simulator has been designed to facilitate the integration of computer vision and machine learning techniques into a realistic looking 3D environment with the following advantages.

(1) By facilitating the generation of 3D worlds, UE4Sim enables the quick and automatic acquisition of large amounts of labelled data to be used for training data-hungry machine learning models (specifically deep neural networks) targeting a multitude of computer vision and machine learning applications ranging from self-navigating cars/drones and aerial tracking to indoor 2D/3D scene understanding and 3D reconstruction.

(2) UE4Sim provides simple-to-use connections with third party software to allow for real-time evaluation of AI techniques. The photo-realism of UE4Sim facilitates the transfer of the learned models to the real-world.

In this internship project, we plan to develop UE4Sim further, motivated by the goal of teaching a car to drive in previously unseen scenarios and unmanned aerial vehicles (UAVs) to race through obstacle courses. All this functionality will be done within UE4Sim with an ultimate aim at transfer this learned knowledge to real world vehicles.

Deliverables/Expectations

Improvements on the UE4Sim simulator to make it more streamlined, efficient, and developer friendly for future development and integration with various types of learning (e.g. deep learning and reinforcement learning).

Development of deep learning methods to estimate future positions of the vehicles (called waypoints) directly from images (perception network).

Development of reinforcement learning methods to generate the appropriate vehicle controls, e.g. steering wheel angle or pitch/yaw/roll (control network).

System integration of the perception and control network within UE4Sim.

Faculty Name

Bernard Ghanem

Field of Study

Electrical Engineering or Computer Science

GNSS attitude determination and precise positioning

Internship Description

The goal of this project is to develop new techniques for accurate GPS/GNSS positioning and attitude determination for mobile platforms (vehicles, etc.). The main application area is vehicle control and vehicle autonomy. The project focuses on instantaneous methods that are capable of delivering real-time results in semi-occluded environments such as urban areas. This requires extending existing techniques of phase ambiguity resolution, or developing new methods. Methods that leverage multiple GNSS signals (from GPS, GLONASS, etc.) will be given more consideration. A GNSS testbed is available in lab that will be used to carry out the experimental part of this project.

This project consists of different activities:

1. Review relevant and most recent publications in the area.

2. Develop the precise positioning and/or attitude determination techniques from first principles or by extending existing methods.

3. Study the performance of the developed methods using simulations.

4. Carry out experimental tests using the existing GNSS testbed.

5. Analyze the results and derive conclusions. Write final report.

6. Write publications and attend relevant conferences/events to gain more knowledge in the area.

Deliverables/Expectations

1. A complete assembled system (hardware + software).
2. Final design, algorithms and system parameters.
3. Experimental results. 4. Final report summarizing and explaining the whole project with results and uture recommendations.

Faculty Name

Tareq Al-Naffouri

Field of Study

Electrical Engineering

Large-scale scholarly data mining

Internship Description

Delve is an on-going project in my group. It is a web-based dataset retrieval and document analysis system. Unlike traditional academic search engines (e.g., Google Scholar) and dataset repositories (UCI repository), Delve is dataset driven and provides a medium for dataset retrieval based on the suitability or usage in a given field. It also visualizes dataset and document citation relationship, and enables users to analyze a scientific document by uploading its full PDF.

Deliverables/Expectations

The internship position is for candidates who can contribute to the system by using machine learning and data mining techniques on the analysis of document text, citation and co-author graphs. Deep learning, graph embedding and graph mining techniques should be explored for improving the search accuracy in the system.

Faculty Name

Xiangliang Zhang

Field of Study

Machine learning, data mining

Machine Learning based Precoder design in massive MIMO systems

Internship Description

Massive MIMO is an exciting area of 5G wireless research. For next-generation wireless data networks, it promises significant gains that offer the ability to accommodate more users at higher data rates with better reliability while consuming less power. The efficient precoding design at the massive MIMO base station is the basic requirement to fulfil the promises expected by this state-of-the-art technology. The precoding matrices need not only to be estimated at the beginning of the communication, but also require to be updated in every communication block due to the change in block fading channel. The training overhead to update the precoder design is one of the factors affecting the data rates in massive MIMO systems. As a first step, the project will aim to identify state-of-the-art precoder designs. The main aim would be to devise an efficient (complexity-wise) precoding update mechanism. Machine learning (ML) can play a role to predict the new precoding matrices efficiently for the ongoing communication, thus improving the spectral efficiency (due to less training overhead) as well as the computational complexity. The aim is to identify the most appropriate features to address the problem. Basically, history or training data for ML, that would be mapping the estimated channels to the precoding matrices, could be helpful to develop a robust feature vector for ongoing ML-based precoding update design.

Deliverables/Expectations

1. Literature survey of precoder design methods in the field of massive MIMO systems.
2. Understanding channel estimation and precoder design in massive MIMO communication systems.
3. Algorithms (MATLAB code) for precoder design in massive MIMO systems.
4. Algorithms (MATLAB code) for ML based precoder design in massive MIMO systems.
5. Final report summarizing and explaining all project work and reporting results of evaluation tests performed.

Faculty Name

Tareq Al-Naffouri

Field of Study

Electrical Engineering

Machine Learning based Channel estimation in V2V communication

Internship Description

The data rates provided by the prevalent dedicated short-range communication (DSRC) standard in vehicle-vehicle (V2V) communication do not support sharing of the large amount of data generated by sensors in modern vehicles. The solution lies in the exploitation of the large bandwidths available in the millimeter wave (mmWave) spectrum (30 - 300 GHz). Fortunately, contemporary automotive radars already operate in mmWave band and therefore, their hardware can be reused for V2V communication. The sparsity in angle and delay domains of mmWave channels could be utilized for efficient channel estimation in V2V communication. As the sparsity structure in mmWave channels is dictated by the locations of scatterers, we expect the structure to change rapidly in highly mobile environment of V2V communications. However, the quick variation in channels is expected to be systematic as the location of scatterers will change in a systematic manner. This effect will be more prominent in the vehicle-to-infrastructure (V2I) scenario where the fixed location of the antenna and surrounding objects results in a fixed sparse component in addition to a varying sparse component. In this project, our goal would be to use radar estimates to quickly predict and track the expected pattern in sparsity structure using machine learning algorithms. Specifically, we aim to propose sparsity aware channel estimation methods that could predict and track the fast changing sparsity pattern to assist in channel estimation.

Deliverables/Expectations

1. Understanding channel estimation in mmWave communication.
2. Understanding the blend of automotive radar operations and communication in V2V scenarios.
3. Algorithms (MATLAB code) for channel estimation in mmWave based V2V communication.
4. Final report summarizing and explaining all project work and reporting results of evaluation tests performed.

Faculty Name

Tareq Al-Naffouri

Field of Study

High-Speed Wireless Communication for Data Centers and High Performance Computing

Internship Description

Design and implementation of optical wireless connections for data center networks.

Deliverables/Expectations

The student is expected to closely work on a novel framework for replacing traditional wired network of data center networks to free space optics. Under the novel framework, the student solves complex optimization problem that involve scheduling mice and elephant flows per servers.

Faculty Name

Mohamed-Slim Alouini, Basem Shihada

Field of Study

Electrical engineering

High-efficiency AI and ML distributed systems at Big-Learning scales

Internship Description

The position will be in the context of a project whose goal is to make distributed AI and ML more efficient. Enabled by the rise of big data, today's AI and ML solutions are obtaining remarkable success in many fields thanks to their ability to learn complex models with millions to billions of parameters. However, these solutions are expensive because running AI and ML algorithms at large scales requires clusters with tens or hundreds of machines to satisfy the high computation and communication costs of these algorithms.

Many systems exist for performing AI and ML tasks in a distributed environment. Yet, the performance requirements and input data sizes are steadily growing. The next level of efficiency is required to address key challenges like network communication bottlenecks and uneven cluster performance.

Moreover, the fidelity of ML models is very sensitive to many hyperparameters. To produce accurate models, it is of great importance to tune these hyperparameters well. However, this requires exploring a large space of possible configurations, which must be done efficiently.

The internship work will generally integrate in the current challenges faced during the project whether that is to investigate the trade-offs between reduced communication and model precision or to identify the bottlenecks and develop new algorithms to overcome them.

Ongoing directions are

(1) exploring the use of new networking hardware and architectures to make network-based communication more efficient and (2) designing new search algorithms that can make a better use of resources and determine optimized hyperparameters more efficiently.

Candidates should be motivated to work on research-oriented problems in a fast-paced and tight-knit team. They should have a strong computing or engineering background with a good background in algorithms, machine learning, distributed systems, and networking. Ideally, they would have experience in building and working with large software systems and tools, and proven knowledge of C++/Java.

Deliverables/Expectations

The students are expected to study the existing solutions and devise theoretically-sound approaches (with the assistance of the supervisor) to improve their performance. The students will be able to also collaborate with other team members and to evaluate the mechanisms on real-world datasets on a state-of-the-art testbed. The above results, if completed, are considered novel and can result into a publication (with the agreement of the supervisor).

Faculty Name

Marco Canini

Field of Study

Computer Science

Non-stationary Gaussian fields with physical barriers

Internship Description

Creating spatial Gaussian models where the dependency structure obeys physical barriers like cost-line, rivers and islands, have proven difficult. Recent developments have shown that it can be done rather easily, conceptually, using SPDE's, but can be rather involved in practice unless there is good documentation. This project aims to producing a tutorial that demonstrate the use of these models within the R-INLA framework, including well documented examples with code in R and Shiny apps.
Start date could be later. The student will during this project learn about recent development in the field and how to make these developments accessible for researchers outside core-statistics.

Deliverables/Expectations

The first aim is a tutorial with examples in R and additional Shiny apps.
The second aim, is to wrap this up in a R package and with an article submitted to Journal of Statistical Software.

Faculty Name

Haavard Rue

Field of Study

Statistics

3D/Inkjet Printed Cube Satellite Transparent Antenna Design

Internship Description

A **CubeSat** (*Short form of Cube Satellite*) is a miniaturized satellite (of the order of 10 cm^3) intended for a number of space research applications in the Low Earth Orbit (LEO). CubeSat are typically launched by deployers from the International Space Center. The concept of CubeSat was introduced to lower the cost associated with launches as it can be launched as a secondary payload on the launch vehicle.

This project will focus on an innovative antenna design for CubeSat which is expected to cover the entire frequency band for the application and also provides near isotropic radiation pattern with decent gain performance. In order to lower the cost as well as weight, additive manufacturing techniques such as 3D and Inkjet printing will be employed. An important aspect is to make this antenna transparent as it should not block the light coming to the on board solar cells. So a transparent material will be explored which can be compatible with the printing processes. It will also be considered that the antenna design occupies minimum space on the CubeSat surface. This project will enable student to first design an innovative antenna in industry standard electromagnetic simulators, realize it through printing techniques with the state of the art printers in KAUST and then test it in latest anechoic chambers available in IMPACT Lab KAUST.

Deliverables/Expectations

Optimized Design of Cube Sat Antenna through EM simulations

3D Inkjet Printed Prototype

Test results of fabricated prototype

Short report of the project

Faculty Name

Atif Shamim

Field of Study

Electrical Engineering

Advanced Terahertz Source Generation using Plasmonic Photomixers

Internship Description

Photomixers are one of the most promising sources of continuous-wave terahertz (THz) radiation with excellent frequency tunability and high spectral purity while operating at room temperature. The objective of this project is to develop a new generation of high-performance photomixers that enable new functionalities for practical THz imaging, sensing, and communication systems that are not possible through existing technologies. Specifically, we plan to utilize plasmonic nanostructures inside photomixer active area to enhance its optical-to-THz conversion efficiency and THz radiation power by several orders of magnitude. This project will enable student to understand and design nano-plasmonic structures in industry standard electromagnetic simulators. The student will also be able to participate in the nano-fabrication process of these structures (under the supervision of an expert postdoc) in KAUST nano-fabrication facilities.

Deliverables/Expectations

Optimized Design of photomixers

Prototype fabrication in clean room facilities

Short report of the project

Faculty Name

Atif Shamim

Field of Study

Electrical Engineering

Predictable Performance in the Cloud

Internship Description

The position will be in the context of a project whose goal is to enable cloud-based applications to achieve more predictable performance. Our main focus is on modern, highly distributed applications that are realized as service-oriented architectures. In particular, we focus on how to enable consistent low latency, which is critical for many cloud applications yet difficult to achieve due to many complex sources that skew the tail of latency distribution even in well-provisioned systems. Execution in multi-tenant environments further exacerbates things as it is known that performance degrades due to contention for shared resources in face of imperfect resource isolation.

The internship work will upon our recent EuroSys '17 results and improve our Rein approach in regard to some of the open questions such as accurate bottleneck estimation and using server-based feedback. Candidates should be motivated to work on research-oriented problems in a fast-paced and tightly-night team. They should have a strong computing or engineering background with a good background in computer systems, networking, and distributed systems. Ideally, they would have experience in building and working with large software systems and tools, and proven knowledge of Java.

Deliverables/Expectations

The students are expected to study the existing Rein solution and devise theoretically-sound approaches (with the assistance of the supervisor) to improve its performance. The students will be able to also collaborate with the lead PhD student of Rein and to evaluate the mechanisms on real-world datasets on a state-of-the-art testbed. The above results, if completed, are considered novel and can result into a publication (with the agreement of the supervisor).

Faculty Name

Marco Canini

Field of Study

Computer Science

Brain Inspired Computing

Internship Description

Conventional computing based on Von Neumann architecture has been shown to be approaching its limits in scalability and power consumption. If solved with contemporary machines, today's applications in science and industry related to data analysis, pattern recognition and prediction would demand a huge computing power. In the era of ubiquitous sensing and data acquisition, a way to cheaply and power efficiently make sense of the collected 'big data' is of utmost importance. Here, human brain's efficiency becomes the ultimate standard and inspiration for any future technology. Such trend of understanding the brain behavior is currently gaining a huge attention worldwide. At the sensors lab, students under the supervision of Prof. K.N. Salama are exploring new computing technologies miming the way our brains process and store data.

Deliverables/Expectations

Report of state of art brain inspired computers;
Implementation of state of art;
Exploration of neuromorphic architectures;
Simulation and comparison of various alternatives.

Faculty Name

Khaled Nabil Salama

Field of Study

Electrical Engineering, Computer science, physics, neurosciences

Internship on Statistical Methods for Brain Signals

Internship Description

The student will learn the state-of-the-art methods for pre-processing and modeling brain signals (in particular, electroencephalograms (EEG)). The student will explore various measures of brain functional and effective connectivity through numerical simulations and actual EEG recordings during various learning tasks. At the end of the internship, the student is expected to submit a written report, a poster and give an informal seminar in the Statistics Program.

Deliverables/Expectations

At the end of the internship, the student is expected to submit a written report, a poster and give an informal seminar in the Statistics Program.

Faculty Name

Hernando Ombao

Field of Study

Computer Science, Engineering, Statistics, Applied Mathematics, Economics, Physics.

Solar-hydrogen generation using semiconductor nanostructures

Internship Description

Smart living with minimal environmental impact has been the motivation of our research in the Photonics Lab (KAUST). Our research topics include highly efficient light generation in all colors, high-speed communication using light, and clean energy generation of hydrogen. At Photonics Lab, we are able to preciously control the semiconductor material types and nanoscale structures utilizing our in-house growth and fabrication facilities to realize the novel device designs for various purposes. Recently, three-dimensional nanostructures were employed in generating hydrogen gases from splitting water under the sunlight. The device architectures are being explored to promote the process of photon to current and eventually to gas generation and thus solar energy storage.

Deliverables/Expectations

Students involved will be trained on solar-hydrogen cell fabrication. Device characterization such as current-voltage characteristics, incident photon-to-current conversion efficiency, applied bias photon-to-current conversion efficiency, solar-to-hydrogen efficiency, etc will be performed to evaluate the performance of the device.

Faculty Name

Boon Ooi

Field of Study

Electrical engineering, physics or chemistry

Underwater wireless optical communications

Internship Description

Recently, underwater wireless optical communication (UWOC) has been proposed as an alternative or complementary solution to acoustic and radio frequency (RF) underwater communication links over short and moderate distances (<100m) to alleviate the current problem of low data rate and large transmission delays. UWOC uses visible blue-green (400-550 nm) laser diodes to establish secure, efficient and high data rate communication systems. However, the underwater environment is optically very challenging. The propagation of laser beams in seawater is significantly affected by absorption scattering, and turbulence. In KAUST, we are experimentally addressing these challenges. We developed an experimental test-bed in the laboratory with an embedded water tank to simulate the ocean environment.

Deliverables/Expectations

Students involved will focus on developing experimental and theoretical models to better understand the underwater optical channel and the effects of turbulence, absorption, and scattering in different waters and at different depths. In particular, the focus is on investigating bit error rate (BER) performance under air bubble, temperature and salinity induced oceanic turbulences, and developing a comprehensive and unified statistical turbulence model for the ocean.

Faculty Name

Boon Ooi, Mohamed-Slim Alouini

Field of Study

Electrical engineering or physics

Persistent Automated Tracking from Unmanned Aerial Vehicles (UAVs)

Internship Description

Empowering unmanned aerial vehicles (UAVs) with automated computer vision capabilities (e.g. tracking, object/activity recognition, etc.) is becoming a very important research direction in the field and is rapidly accelerating with the increasing availability of low-cost, commercially available UAVs. In fact, aerial tracking has enabled many new applications in computer vision (beyond those related to surveillance) including search and rescue, wild-life monitoring, crowd monitoring/management, navigation/localization, obstacle/object avoidance, and videography of extreme sports. Aerial tracking can be applied to a diverse set of objects (e.g. humans, animals, cars, boats, etc.), many of which cannot be physically or persistently tracked from the ground. In particular, real-world aerial tracking scenarios pose new challenges to the tracking problem, exposing areas for further research. Visual tracking on UAVs is a very promising application, since the camera can follow the target based on visual feedback and actively change its orientation and position to optimize for tracking performance. This marks the defining difference compared to static tracking systems, which passively analyze a dynamic scene.
In this project, we will develop novel tracking strategies that are designed for real-time operation on a UAV. These tracking methods should be fast, reliable, and accurate. For evaluation purposes, we will use the newly developed aerial tracking benchmark that the IVUL group has developed. Moreover, we will test out these trackers within the aerial simulator that the IVUL group developed based on a photo-realistic game engine and a VR setup, which allows the user to move the object to be tracked in the simulated environment. Finally, these tracking methods will be embedded in a fully functioning UAV, which will be able to automatically and persistently track an object of interest on the ground.

Deliverables/Expectations

Statistics on the nuisances commonly faced in aerial tracking scenarios.

Novel techniques to track a single object from a single aerial viewpoint.

Novel techniques to search for an object when it moves outside the field of view of the camera.

A fully functioning prototype UAV that runs the tracking method locally and that interfaces tracking results into the UAV's navigation system.

Faculty Name

Bernard Ghanem

Field of Study

Computer, Electrical , Mathematical Sciences , Engineering

Large-Scale Human Activity Recognition in the Wild

Internship Description

With the growth of online media, surveillance and mobile cameras, the amount and size of video databases are increasing at an incredible pace. For example, YouTube reported that over 300 hours of video are uploaded every minute to their servers. Moreover, the commercial availability of inexpensive cameras has led to an overwhelming amount of data, of which video streams from surveillance systems have been quoted to be the largest source of *big data*. However, the significant improvement in camera hardware has not been paralleled with accompanying automated algorithms and software that are crucial to intelligently sift through this ever-growing data heap. This situation has become so dire that much of large-scale video content (either online or in local networks) is rarely processed for meaningful semantic information. With such a development, this data merely serves as dense video sampling of the real-world, which is void of connectivity, correlation, and a deeper understanding of the spatiotemporal phenomena governing this data. Arguably, people are the most important and interesting subjects of these videos. The computer vision community has embraced this observation to validate the crucial role that human activity/action recognition plays in building smarter surveillance systems (e.g. to monitor public safety and public infrastructure usage), as well as, to enable business intelligence, semantically aware video indices (e.g. intelligent video search in large databases), and more natural human-computer interfaces (e.g. teaching robots to perform activities by example or controlling computers with natural body language). However, despite the explosion of video data available, the ability to automatically detect, recognize, and represent human activities is still rather limited. This is primarily due to impeding challenges inherent to the task, namely the large variability in execution styles, complexity of the visual stimuli in terms of camera motion, background clutter, and viewpoint changes, as well as, the level of detail and number of activities that can be recognized.

In this project, we will address the important problems of human activity detection/classification, summarization, and representation with a suite of algorithms that are capable of *efficiently* and *accurately* learning from a newly compiled large-scale video dataset equipped with descriptive, hierarchical, and multi-modal annotations, called ActivityNet. We will investigate different facets of these problems with the ultimate goal of improving state-of-the-art performance in detecting and classifying human activities in real-world videos at large-scales.

Deliverables/Expectations

Novel techniques to classify snippets of video according to the activities they entail

Novel techniques to quickly localize “activity proposals”, i.e. temporal segments in video where the probability of finding interesting activities is high.

Combining the knowledge of objects and scenes in classifying an activity, since an activity is a spatiotemporal phenomenon where humans interacts with objects in a particular place

Crowd-sourcing framework (e.g. using Amazon Mechanical Turk) to cheaply extend the annotations of ActivityNet to object and place classes, as well as, free-form text description. These annotations will enrich the dataset, forge links with other large-scale datasets, and enable new functionality (e.g. textual translation of a video that enables text queries).

Faculty Name

Bernard Ghanem

Field of Study

Computer, Electrical , Mathematical Sciences , Engineering

Water splitting to produce clean hydrogen energy by semiconductor band engineering

Internship Description

To suppress or recover from the global warming, development of clean energy technology is important to research area from now on. Hydrogen is useful energy for fuel-cell cars, aircraft, etc. Since hydrogen becomes water after its combustion, it is clean energy. If hydrogen gas could be produced from natural energy such as solar light, the final clean energy cycle would be possible.

Let's develop clean energy technology together. The following topics are available for internship students.

1.Photocatalysis for hydrogen generation

2.Co-catalyst study for higher efficiency

3.Other state-of-art topics

The students will learn and challenge electrochemical measurement, photocatalytic measurement, and various physical & chemical characterization such as SEM, Spectroscopy, XRD, XPS, gas/liquid/ion chromatography. This project needs 2-6 months to be completed.

Deliverables/Expectations

The internship students will learn photo-electrochemical knowledge on energy conversion by semiconductors from light to hydrogen clean energy.

The students are expected to work full-time.

The results are utilized for publications.

The students attend weekly meetings with the Faculty Advisor

Faculty Name

Kazuhiro Ohkawa

Field of Study

Chemistry, Physics, and Electrical Engineering

Underwater Optical Communication

Internship Description

More than two-thirds of the Earth's surface is covered by water. The oceans and seas play a critical role in many of the Earth's systems including climate, weather and food production cycles. Even though underwater communications have been under research since long time ago, most of the underwater world still remains unexplored so far. To further explore the underwater environments, developing efficient communication technology is of crucial important. Underwater wireless transmission can be achieved through radio, optical, or acoustic waves. Transmission of signal through radio water is limited to a few tens of meters. Although long distance transmission of acoustic waves has been demonstrated, transmission of signal through this technique offer a low data rate of 20 kbps.

In this project, our goal is to develop a high data rate line-of-sight and non-line-of-sight underwater wireless optical communication system using highly coherent, either broad or narrow beam divergence semiconductor lasers. When developed, this giga-bit bandwidth, kilometer range underwater communication system will enable many novel applications includes seafloor survey, underwater oil field exploration, etc.

Deliverables/Expectations

Demonstrate the transmission of high bit-rate signals in water channel using laser diodes.

Faculty Name

Boon Ooi

Field of Study

Electrical Engineering, Applied Physics

Solar Hydrogen Fuel Generation

Internship Description

The expected depletion of fossil fuel reserves and its severe environmental impact have emphasized the need for sustainable and clean energy resources. Solar hydrogen fuel generation by water splitting using sunlight, water, and semiconductors is a promising alternative to conventional fossil fuels, which has great potential to relieve energy and environmental issues and bring an energy revolution in a clean and sustainable manner. To be practical, solar hydrogen production via water splitting needs to tackle the challenges of high solar-to-hydrogen (STH) energy conversion efficiency and high stability of the materials and devices. In photoelectrochemical (PEC) water splitting, as an example, the bandgap of semiconductors, band-edge potentials, optoelectronic efficiency, and stability must be satisfied simultaneously to improve the STH efficiency. In this regard, extensive research efforts have been devoted to address these challenges.

In this project, our goal is to fabricate a stable semiconductor photoelectrode that can absorb the visible light as well as produce a high rate of hydrogen fuel. The student engaged to this research activity will be able to receive a high-quality training and gain a valuable experience in the field of semiconductor nanostructures fabrication and the solar hydrogen generation, which can help his future career significantly in the academic and the industrial fields.

Deliverables/Expectations

Demonstrate the process of photoelectrochemical water splitting for solar hydrogen fuel generation.

Faculty Name

Boon Ooi

Field of Study

Electrical Engineering, Applied Physics

Group-III Nitride Nanowire UVLEDs on Metal

Internship Description

Ultraviolet (UV) light emitting diodes (LEDs) and lasers have wide applications in sterilization, environmental cleaning, medicine, and lighting, among other fields. The unresolved material-related challenges and problems are a lack of efficient p-type doping in high-Al-content AlGaN, high threading dislocations and defect densities in planar UV LEDs grown on foreign substrates, and low light extraction efficiency. Considerable progress has been made in nanowire-based UV LEDs and lasers because of the superior crystalline quality (dislocation free) of the AlGaN NW and the surface-enhanced p-type dopant (Mg) incorporation. The blue, green, and red LEDs grown using molecular beam epitaxy (MBE) already demonstrated the potential of nanowires emitters for practical applications, beyond lighting.

In this project, student involved will study the growth of III-N nanowires UVLEDs on metal using a molecular beam epitaxy system. Nanowire materials and nanowire LEDs characterizations using the various spectroscopy and microscopy, and LED device characterization techniques will be performed.

Deliverables/Expectations

Demonstration and characterization of nanowires-based UV-LEDs.

Faculty Name

Boon Ooi

Field of Study

Electrical Engineering, Applied Physics

Autonomous multi-agent robotics

Internship Description

This project involves the design of algorithms for autonomous robotics. Depending on the background of the applicant, the specific application of interest may be aerial, ocean, or manipulator platforms. The objective is to design algorithms to enable teams of autonomous agents to collaborate effectively for missions such as dynamic area coverage or collaborative manipulation. Methodologies include a combination of control and computer vision algorithms, with onboard execution being a requirement.

Deliverables/Expectations

Learn about onboard mobile robot dynamics and control.

Learn about computer vision algorithms for object detection.

Learn about control algorithms such as model predictive control.

Learn about onboard implementation systems (pixhawk & odroid & ROS).

Implement and test algorithms of experimental platforms.

Faculty Name

Jeff Shamma

Field of Study

Electrical Engineering

Augmented Reality with Google Tablets and Glasses

Internship Description

Wearable devices have attracted a lot of attention from the research community. These devices enable access to a user's day-to-day life. Many of these devices support multi-modal sensors that can record and/or transfer sensory data including video and audio. Coupling this source of data with network connectivity can enable a wide range of augmented reality (AR) applications, which serve to enrich the user's life and provide more insight in making decisions. For example, a wearable device supported by intelligent computer vision and machine learning methods can automatically infer and relay information about the place and situation to the user directly. This provides the user with more information to make a particular decision, e.g. whether or not to buy a product in a store based on reviews and competitor pricing found online. Moreover, these augmented capabilities could be very beneficial for people with sensory impairments, e.g. a visually impaired person wearing an AR device can be warned (through audio) of immediate obstacles in his/her way or a hearing impaired person can be notified (through words on a display) of someone calling out to him/her.

In this project, we aim to build an AR system based on the Google Glass and a Google Tablet, which will automatically acquire visual and audio data and transfer it to a central processing station for analysis. Information inferred from this data will be transferred back to the Glass, so that it is conveyed to the user in visual or audio form. This is possible because the Glass supports both visual and audio sensors. One possible output of this project is the ability to project on the Glass display automatically-generated results of recognizing (i.e. labeling) and detecting (i.e. localizing) objects in front of the user.

Deliverables/Expectations

A software module based on the Google Glass SDK to acquire and transfer still images and videos from the Glass to a central processing station and transfer meta-data in the opposite direction.

An API for the central processing station to invoke automatic computer vision and machine learning algorithms on the received images and videos.

A software module based on the Google Glass SDK that conveys to the user the meta-data acquired from the central processing station on the Glass display.

A large-scale dataset of videos and still images captured by a Google Glass during day-to-day activities. The important objects and activities in these videos will be manually labeled and used for training as well as testing the overall system. This dataset will be made publicly available to the research community for future algorithm evaluation and comparison.

Faculty Name

Bernard Ghanem

Field of Study

Computer, Electrical , Mathematical Sciences , Engineering

Experimental validation of new neuro-vascular fractional model

Internship Description

The neurovascular coupling is a key mechanism linking the neural activity to the hemodynamic behavior. Modeling of this coupling is very important to understand the brain function but it is at the same time very complex due to the complexity of the involved phenomena. Many studies have reported a time delay between the neural activity and the cerebral blood flow, which has been described by adding a delay parameter in some of the existing models. An alternative approach has been recently proposed where a fractional system is used to model the neurovascular coupling. Thanks to its nonlocal property, a fractional derivative is suitable for modeling phenomena with delay. The model has been validated with extensive simulation study.

In this project, the student will validate the neuro-vascular fractional model using real cerebral blood flow and Blood Oxygen Level Dependent (BOLD) measurements. This work will be conducted with our collaborators from Ghent University.

Deliverables/Expectations

Expect to submit a paper on this experimental validation

Faculty Name

Taous Meriem Laleg

Field of Study

Electrical engineering/ Applied Mathematics

Shape recognition using squared eigen-functions of the Schrödinger operator

Internship Description

A new adaptive signal/image reconstruction, analysis and denoising method has been recently developed in our group where the signal is decomposed into signal dependent functions. These functions are the **L2**-normalized squared eigenfunctions associated to the discrete spectrum of a Schrödinger operator, the potential of which considered to be the signal/image. These signal dependent functions provide a good approximation of the signal and exhibit interesting localization properties, and they supply new parameters that can be used to extract relevant features of signal variations. They also constitute an efficient analysis tool as the information about the signal is continuously reflected on these localized functions.
In this project, the student will study the potential use of this algorithm to shape recognition where the new spectral data provided by the method will be combined with data mining approaches with a potential application to red sea marine creature recognition

Deliverables/Expectations

A shape recognition algorithm will be provided with Matlab or C++ implementation.
A paper will be submitted

Faculty Name

Taous Meriem Laleg

Field of Study

Electrical engineering/ Applied Mathematics/Signal processing/Data mining

Optimization, control and monitoring of solar driven desalination systems

Internship Description

Membrane distillation (MD) is a thermally driven distillation process. In this process, hot feed stream is passed along one side of a hydrophobic membrane, which is only permeable for water vapor and retains liquid water, whereas the other side is kept at a lower (cooler) temperature. Due to temperature difference across the membrane, water evaporates at the feed-membrane interface and the induced partial vapor pressure difference drives only water vapor through the membrane where it condenses on the other side of the membrane, called the permeate side.

MD requires low-grade heat, which can be harvested from solar thermal energy, and other renewable or waste heat sources. Also, unlike the well-known reverse osmosis, MD operates at a lower water pressure, which in turns reduces the capital and operational costs. All these advantages make MD ideal for remote area desalination plants installations with minimal infrastructure and less demanding membrane characteristics. However, MD is faced with challenges that are yet to be addressed in order for this technology to be competitive with conventional desalination techniques. In recent years, MD has been coupled with renewable energy sources, such as solar thermal collectors and photovoltaic (PV) panels, to capitalize on the attractive features of MD. However, the unsteady nature of renewable energy sources imposes a challenge on solar powered membrane distillation (SPMD) that requires special attention on process modeling and system control. Moreover, over time, membrane permeability changes due to scaling and fouling. All these factors have to be taken into consideration when modeling MD.

In this project, the student will design an optimal control strategy to control the productivity of the combined solar-MD system under different constraints. He will also design monitoring strategies for fouling detection using estimation methods. Experimental validation will be performed in collaboration with Water desalination and Reuse center at KAUST.

Deliverables/Expectations

Controller will be deigned and tested by simulations and if time will allow experiments will be performed.

A paper will be submitted

Faculty Name

Taous Meriem Laleg

Field of Study

Electrical engineering/ Applied Mathematics/Control Theory

Indoor Ultrasonic Communication

Internship Description

In this project, we will investigate and develop transmission and detection techniques for short-range ultrasonic based digital communication in air. The focus will be on the multi-user case. We want to identify the best signal designs and detection strategies given the challenging communication channel. The project will consist of both theoretical and practical parts. In the theoretical part, we will try to find the answer to different questions and design signals, detection and estimation techniques to optimize performance. In the practical part of this work, we will test the developed techniques in real-world environments. At the end of the project, we will have a complete implementation of an ultrasonic communication systems that comprises both software and hardware (the hardware part is already done). The procedure will generally involve the following steps:

1.Consider the available techniques. Study these techniques (analytically or using simulation). Identify the most suitable ones to ultrasonic communication and the available resources/hardware.

2. Improve these techniques and/or design new techniques to overcome the shortcomings of the existing ones.

3. Implement selected techniques using the available test bed and evaluate performance in terms of the data rate, bit-error rate, etc.

4. Improve the design and test again

Deliverables/Expectations

1.A report on the most relevant systems.
2.Improved designs of the above systems
3.Software implementation of systems.
4.Performance results obtained from the implementation of different designs.
5.Final report summarizing and explaining all the project work together with future recommendations.

Faculty Name

Tareq Al-Naffouri

Field of Study

Electrical Engineering

Activity Detection for Ambient Assisted Living (AAL)

Internship Description

Ambient assisted living (AAL) paradigm offers a viable solution for monitoring the health and daily activities of the elderly in a self-dependent living environment. AAL systems are expected to meet a number of requirements such as accuracy, ease of use, minimal supervision, privacy, and cost effectiveness. Non-wearable systems are preferred over their wearable counterparts since the latter can cause discomfort and inconvenience to the user. The system should also be able to keep track of the user and his activities and detect significant events in real-time to trigger intervention from care-takers.

In terms of functionality, tracking of the subject activities and significant event detection is an essential task which allows monitoring the user's life style. Activities that are of interest include walking, sitting, standing, sleeping, speaking, crying, moaning, falling along with other body gestures and positions.

Different kinds of modalities can be used for AAL monitoring using non-wearables. Our focus is on the acoustic and radio-frequency (RF) modalities. Challenges include, but are not limited to, cost effective solutions for enhancing the monitoring range and coverage, dealing with noise and interferences in uncontrolled environments, training of complex model parameters for activity classification and recognition, and computational complexities related to system scale, hardware, and data processing.

Deliverables/Expectations

1. Algorithms for Enhanced Signal Acquisition such as noise filtering algorithms, techniques dealing with static and time-varying background clutter, novel schemes for reducing sampling rates requirements along with other techniques dealing with issues like multipath, pulse shaping, drift correction, smoothing etc.

2. Algorithms for Localization and Tracking based on techniques such as Time-of-Flight (TOF), Angle-of-Arrival (AOA), Received Signal Strength (RSS), Doppler radar, and Radio Tomographic Imaging (RTI).Algorithms (MATLAB code)

3. Algorithms for Classification and Detection of activities

4. Final report summarizing and explaining all project work and reporting results of evaluation tests performed.

Faculty Name

Tareq Al-Naffouri

Field of Study

Electrical Engineering

Wireless Sensor Node Analysis Employing Energy Harvesting

Internship Description

The project consist of a theoretical and a system research thrusts in energy-harvesting wireless sensor networks. Looking at the energy harvesting module in sensor node from the system's prospective, we observe that adopting an interruption/harvesting policy enhances the energy consumption, but it also increases average packet end-to-end delay and packet dropping! There are various tradeoffs exist in wireless sensor network (WSN) design. Of particular interest to the project are 1) End-to-end delay vs. energy harvesting & network size, and 2) Increasing network size allows for a smaller number of data sink nodes and reduces dropping but it also increases average end-to-end delay. In order to quantify the tradeoffs, we raise a question. How delay, network size, and harvesting policy (service vacation) interact with each other? In other words, how large the network dimensions can go to considering certain packet latency threshold and dropping? Energy harvesting module can arbitrary be triggered, upon empty buffers, and thus, imposes random interruption periods on the sensor node, these random cycles (vacations) increases latency due to residual vacation time that is consumed for harvesting. In order to solve the above challenge, the student will study this system and think of a theoretical and a system approaches (with the assistance of the instructor) to improve the end-to-end delay. For instance, a possible solution would be, instead of arbitrary harvesting time, we aim at optimizing this value to minimize the delay and dropping. We also aim at adding a constraint that forces the sensor node to trigger the harvesting phase once its battery is low! Currently, the networking lab has a set of 20 sensor motes that are programmable using TinyOS and also has all the necessary mathematical packages to evaluate the student proposed models.

Deliverables/Expectations

The student is expected to achieve:

1. (theatrical component): An optimization of the energy harvesting value that minimizes the system end-to-end delay validated using matlab.
2. (systems component): Translate the results from (1) into a working code, which can be tested over our TelosB sensor motes using TinyOS (C/C++).

The above results, if completed, are considered novel and can result into a publication with the agreement with the instructor.

Faculty Name

Basem Shihada

Field of Study

Computer science and electrical engineering

Frebonics- Nature inspired engineering

Internship Description

Nature has amazing mysteries. The vast ecosystem is balanced in impeccable efficient manner. Take an example, butterfly. How do they choose flowers to fly around? How their wings are so colorful? How to they morph from a larva to a full blown butterfly? How do they fly? All these are essentially vast set of engineering: motor mechanics, materials and bits of devices here and there synchronized *via* physics and mathematics. In this project, we explore such engineering in nature and inspired by that learning we simply complex engineering to address global challenges and augment the quality of our life. We believe by integration of freeform electronics (physically flexible, stretchable and reconfigurable in shape and size) with robotics we can imagine and create various frebonics which can essentially be used for advanced healthcare like prosthetics, artificial organs, advanced environmental monitoring, security and self-driven vehicular technology. We are presently working on understanding how flowers bloom: from a tiny entity when it blossoms completely – imagine a display system like your 5.5” iPhone when stretched becomes a 55” television. Fusion of electrical engineering, mechanical engineering, bioengineering, chemistry, civil (structural) engineering, computer science, material science and engineering, we envision to make such a singular gadget which can be reconfigured adaptively in shape and size. This is just one example and there are many – we look forward to working with you!

Deliverables/Expectations

Literature survey, programing, fabrication, material and device analysis, device characterization, system integration, oral and written reports.

Faculty Name

Muhammad Mustafa Hussain

Field of Study

Electrical Engineering, Mechanical Engineering, Bio Engineering, Computer Science (Robotics, Automation), Civil Engineering (Structural Engineering), Physics, Material Science and Engineering

DIY Electronics

Internship Description

We all use electronics. But why electronics design is not pervasive? If we look around, you will see that there are so many innovations taking place with software technology: social media, ecommerce, Apps, etc. The fundamental tenant of software and computer engineering is to empower all. One learns a language (acquires a skill) and has an idea – just makes that happen. We all have tangible problems in our daily life as an individual and as a community. Electronics can empower us, help us to solve those challenges. Therefore, we have to make electronics simple: easy to understand and to learn and more importantly easy to implement. Because such electronics can then be used (same as programing language) by commoners to democratize electronics. In that regard, recently we demonstrated recyclable materials based paper skin which can function like a natural skin. We see tremendous potential with such materials and we are calling them DO IT YOURSELF (DIY) Electronics. Using various recyclable materials and simplifying complex electronics, we envision to make plug and play DIY Electronics which can be used by all and in that way, we will have citizen science. This is the project for true innovators – those who imagine and make.

Deliverables/Expectations

Literature survey, programing, fabrication, material and device analysis, device characterization, system integration, oral and written reports.

Faculty Name

Muhammad Mustafa Hussain

Field of Study

Electrical Engineering, Mechanical Engineering, Bio Engineering, Computer Science (Robotics, Automation), Civil Engineering (Structural Engineering), Physics, Material Science and Engineering

CESE solver on GPUs for real gas flow simulations

Internship Description

The project focuses on the extension to more complex thermodynamic models and equation of states of a two and three dimensional compressible fluid dynamic solver for the Euler and Navier–Stokes equations. Specific interest are developed to the implementation and use of the polytropic van der Waals (PvdW), and the polytropic Peng-Robinson (PR) models in one of the compressible solver available in our research group. The goal is to investigate and asses the accuracy of the PvdW and PR models coupled with the the so-called conservation element and solution element (CESE) algorithm for simulating nonideal compressible fluid flows. The latter is a branch of fluid mechanics which studies the characteristic of dense va- pors, supercrtical flows, and compressible two-phase flows where the thermodynamics of the fluid differ substantially from that of the perfect gas. In fact, in particular thermo- dynamic conditions, the fluid flows may exhibit nonclassical gas-dynamic phenomena, e.g., expansion shock waves. The application of nonideal compressible fluid flows in industry is already widespread. They can be found in CO2 power cycles, pharmaceu- tical processing, transport of fuels at high-speed, organic Rankine cycles for power conversion. Therefore, an accurate understanding of the complex physics behind fluid flows that differ substantially from that of the perfect gas would undoubtedly pave the way for introducing technological improvements in real-world applications. A number of research projects are actively ongoing for better understanding and modeling non- ideal compressible fluid flows and defining implications in terms of engineering design. However, as already shown several researchers, the accuracy of the thermodynamic model has a strong influence on the simulation of nonclassical phenomena, to the point that their presence can depend on the accuracy with which fluid model parameters are determined. Thus, a high-fidelity and highly accurate simulation of nonideal compress- ible fluid flows is of paramount importance and can provide considerable insights both for the study of nonideal thermodynamics and engineering design and optimization.

In this projects, the CESE algorithm coupled with a the PvdV and PR thermodynamic model will be used. The subsonic inviscid flow over a NACA-0012 airfoil, the tran- sonic inviscid flow over a NACA-0012 airfoil and the Prandtl-Meyer expansion will be used for the assessment of the numerical accuracy and efficiency of the new solver for nonideal compressible fluid flows.

Deliverables/Expectations

Implement new thermodynamic models in an existing, high preformat CESE code, port fundamental part of the solver to single and multiple GPU and solve some canonical but extremely important test problems to validate the solver

Faculty Name

Matteo Parsani

Field of Study

Applied Mathematics and Computational Science; GPU programming; Compressible Flows

Multipurpose Nanowires Transducers

Internship Description

Magnetism has a long history in science and engineering and has enabled much economic and technical advancement from the compass, more than 2000 years ago, to contemporary spintronic devices. Magnetic nanotransducers are already central to data storage and sensor devices, and more recently they are penetrating various new areas including life sciences and biomedical applications.

Magnetic nanowires offer unique properties, due to a high aspect ratio and shape anisotropy. They are characterized by a single magnetic domain, rendering them nano permanent magnets. This feature allows energy-efficient and remote operation of the nanowire transducers, i.e. induce motion, produce heat or sense their location.

In our research group (Sensing Magnetism and Microsystems, http://smm.kaust.edu.sa) we are exploiting those properties for cancer treatment, drug delivery, artificial skin, cell probes, cell substrates and energy harvesting.

Deliverables/Expectations

In this internship, the student will be engaged in the design, fabrication and testing of nanowire transducers. The student will first be introduced to the background of nanotransducers and will conduct a literature study on this topic. In parallel, the student will complete the safety trainings required for lab access and tool training. Then, the student will be trained on nanofabrication methods (i.e. patterning and deposition for realizing specific nanotransducer designs. The student will be fully integrated in the ongoing research projects and will interact and collaborate with several students and postdocs in the group. This will engage the student in complex multidisciplinary project questions ranging from magnetic field aspects over peculiar properties of nanoparticles to cell biology. Senior PhD students of the group will be assigned as mentors to closely work with the internship student during the different phases of the project, ensuring a continuous progress and maximum support.

Faculty Name

Jurgen Kosel

Field of Study

Electrical Engineering, Material Science, (applied) Physics, (applied) Chemistry

Inkjet Printed Wireless Temperature and Humidity Sensors for Smart Bandage Application

Internship Description

In this project, the student will first learn inkjet printing in the lab. Then the student will design temperature and humidity sensors. These will be electrical sensors, specifically resistive and capacitive sensors. These sensors will be printed on a wearable bandage to determine the temperature and humidity levels in the wound. The bandage will also have a wireless part which will send this data to the cell phone in a wireless fashion. The project involves design, fabrication and characterization so the student will go through the entire cycle of a research project.

Faculty Name

Atif Shamim

Field of Study

Electrical Engineering

Inkjet Printed Flexible RF Energy Harvesting Module

Internship Description

In this project, the student will design a flexible antenna in an EM simulator to collect RF energy. Then the student will learn inkjet printing in the lab. The designed antenna will be printed on a PET or a PEN substrate. The antenna will be integrated with a custom rectifier chip (previously done). The student will need to do the layout for mounting of the chip on the antenna substrate and will also integrate the chip with the antenna. Finally, characterization of the complete energy harvesting module will be done through an RF source and suitable load.

Faculty Name

Atif Shamim

Field of Study

Electrical Engineering

Novel semiconductor materials and devices

Internship Description

We have a few challenging projects for the outstanding and serious students who are interested in becoming future world-leading researchers.

The projects are related to growth and fabrication of III-nitride semiconductor devices. The devices include LED, laser, sensors, power electronics, and solar cells. These devices are expected to become the enabling technologies to revolutionize energy, communication, biochemical, biomedical, and data storage industries. Yet major challenges exist for you to solve.

The projects need 5-6 months to be completed. It is going to be an exciting period with intense training and research work in my group. Successful students can likely publish their results in prestigious scientific venues.

Faculty Name

Xiaohang Li

Field of Study

Physics, Electronic Engineering

High accuracy ultrasonic indoor location system

Internship Description

Location information is of high importance in most of now a days applications. GPS provides satisfactory location information for many outdoor application. A reliable, robust, accurate, and low cost system that provide location information indoors and outdoors in GPS challenged areas is still an open research problem. This project will focus on building and testing an indoor location system using of the shelf hardware. The student will be working with an ultrasonic kit currently exist in the lab. The student will investigate different aspects of the location system including number and configuration of base station, optimal ultrasonic signal design, user privacy, and various algorithms for ToF, TDoA, AoA, and location estimation. Practical consideration such as easy system setup, calibration, real time implementation, and integration with other systems might be investigated. The student is expected to participate in writing journal publications and presenting research at conferences.

Deliverables/Expectations

1. Parameters of ultrasonic signal design optimal for the targeted application

2. Algorithms (MATLAB code) for processing the received signal and obtaining location information.

3. Notes about practical considerations such as number of base station (transceiver) required, preferable locations and distribution of base stations, and real time implementation.

4. Final report summarizing and explaining all project work and reporting results of evaluation tests performed.

Faculty Name

Tareq Al-Naffouri

Field of Study

Electrical Engineering

A domain- specific language and code generation for Riemann solvers

Internship Description

Riemann solvers are the core algorithms in numerical methods for wave propagation. They are also the most complex part of developing code for new applications. The design and implementation of an effective approximate Riemann solver typically requires substantial expertise and time. However, there exist generic approaches that utilize relatively straightforward properties of the hyperbolic system and are reasonably efficient. The goal of this project is to develop a domain- specific language for hyperbolic conservation laws and Riemann solvers, and implement automatic generation of efficient solvers based on a purely symbolic representation of the problem.

Faculty Name

David Ketcheson

Field of Study

Mathematics, computer science or engineering

Study of Optical Wireless Communication Systems

Internship Description

Network topology. This project can start anytime and is 3 to 12 months in duration. This project is open to Juniors, Seniors, and MS students in Electrical Engineering, Applied Math, and Statistics

Deliverables/Expectations

It is expected that the student will submit one publication to a good venue by the end of his/her internship

Faculty Name

Mohamed-Slim Alouini, Boon Ooi

Field of Study

Communication, probability, Matlab programing.

Theoretical and numerical study on complex materials

Internship Description

The students are required to perform theoretical and numerical studies on wave propagation in artificial structures with complex structures. The contents include but are not limited to Fano resonance, absorption, trapping of electromagnetic or acoustic waves.

Faculty Name

Ying Wu

Field of Study

Physics, Mathematics, Material Sciences, and related

Power Shell Integrated energy network with flexible and stretchable solar cells, hydrogen generators and storage.

Internship Description

We are exploring and developing a large-are curvilinear surface deployable energy network on flexible and stretchable platform which can be used for smart world application specially for civil infrastructure and/or transportation including aero plane to automobile to sea vessels.

The nature of this project is extremely multi-disciplinary:

- Material science and chemistry will let us choose the correct materials.
- Electrical engineering will let us design, fabricate, characterize the energy harvesting and storage devices and their reliability.
- Chemical engineering will allow us to develop chemical processes for fabrication and process integration.

Deliverables/Expectations

1.. Weekly meetings with the Faculty Advisor.
2. Weekly written report to the Faculty Advisor.
3. Monthly presentation.

Faculty Name

Muhammad Mustafa Hussain

Field of Study

Any relevant field of science or engineering.

Nonlinear Partial Differential Models

Internship Description

In this project we will study some nonlinear partial differential equations models that arise in applications ranging from population dynamics, mean-field games, quantum chemistry and mechanics, medicine, quasi-geostrophic flows, and water waves.

Deliverables/Expectations

The objective of the project is to study in detail modeling, analytical and numerical aspects of partial differential equations from concrete applications. A final report and presentation will be required. The work will be developed and the guidance of Prof. Diogo Gomes and the Research Scientist Dr. Saber Trabelsi.

Faculty Name

Diogo Gomes

Field of Study

Mathematics or related field

Classification of long non-coding RNAs

Internship Description

Long non-coding RNAs (lncRNAs) have been found to perform various functions in a wide variety of important biological processes. To make easier interpretation of lncRNA functions and conduct deep mining on these transcribed sequences, it is important to classify lncRNAs into different groups. lncRNA classification attracts much attention recently. The main technical difficulties are 1) the limited number of known lncRNAs (small training sample size), and 2) the very different lengths of lncRNAs. This project is to apply and further improve the string kernel algorithms developed in Prof. Gao's group to the lncRNA classification problem.

Deliverables/Expectations

The visiting student for this project is expected to finish the following deliverables:
Give a throughout literature review on lncRNA classification methods and potential machine learning methods that can be applied to this problem.
Get familiar with the string kernel algorithms developed in Prof. Gao's group.
Gather an lncRNA dataset to be used as the benchmark set for this research.
Conduct a comprehensive comparative study of the state-of-the-art methods on the benchmark set.
Apply the string kernel algorithms on lncRNA classification and evaluate the performance.
If necessary, improve the string kernel algorithms to achieve better performance.

Write a report to summarize the results.

Faculty Name

Xin Gao

Field of Study

Computer science, bioinformatics, electrical engineering, applied mathematics

Study of Physical Layer Security Systems

Internship Description

Study of Physical Layer Security System. This project can start anytime and is 3 to 12 months in duration. This project is open to Juniors, Seniors, and MS students in Electrical Engineering, Applied Math, and Statistics

Deliverables/Expectations

It is expected that the student will submit one publication to a good venue by the end of his/her internship

Faculty Name

Mohamed-Slim Alouini

Field of Study

Computer, Electrical, & Mathematical Science

More Than Natural Skin

Internship Description

Natural skin is an engineering wonder due to its multisensory capability in a singular platform with simultaneous sensing capability. At the same time, many people have been suffering from skin burns and damages due to acid, burn, wound, etc. Therefore it is an important scientific and engineering challenge to develop an affordable and biocompatible artificial multi-sensory mesoporous singular platform like natural skin and then to integrate that with our neurological system. Paper by virtue of its critical role in our daily life, its physical flexibility, ultra-light weight and affordability make it an amazingly simple but effective material for such skin platform. In the recent past, we have demonstrated a paper based multisensory singular platform which can perform simultaneous sensing. The developed paper skin shows unprecedented functionality and performance over cost. We have tested its effectiveness as environmental sensor as well as for body vital monitor. Therefore, in this project, we will develop and engineer skin like multi-sensory platform for artificial organs and various wearable applications.

Deliverables/Expectations

Literature survey, programing, fabrication, material and device analysis, device characterization, system integration, oral and written reports.

Faculty Name

Muhammad Mustafa Hussain

Field of Study

Electrical Engineering, Mechanical Engineering, Bio Engineering, Computer Science (Robotics, Automation), Civil Engineering (Structural Engineering), Physics, Material Science and Engineering.

Study of Massive MIMO Systems for 5 G Networks

Internship Description

Optimization, Signal processing, Linear Algebra, and Probability. This project can start anytime and is 3 to 12 months in duration.
This project is open to Juniors, Seniors, and MS students in Electrical Engineering, Applied Math, and Statistics.

Deliverables/Expectations

It is expected that the student will submit one publication to a good venue by the end of his/her internship

Faculty Name

Mohamed-Slim Alouini

Field of Study

Computer, Electrical, & Mathematical Science

Energy Harvesting-Based Wireless Sensor Networks

Internship Description

Development of energy efficient large scale wireless sensor networks. This project can start anytime and is 3 to 12 months in duration.
This project is open to Juniors, Seniors, and MS students in Electrical Engineering, Applied Math, and Statistics

Deliverables/Expectations

It is expected that the student will submit one publication to a good venue by the end of his/her internship

Faculty Name

Mohamed-Slim Alouini

Field of Study

Electrical and Computer Engineering (with emphasis on Communications Engineering)

Study of Cognitive Radio (Spectrum Sharing) Systems

Internship Description

Study of Cognitive Radio (Spectrum Sharing) Systems

Faculty Name

Mohamed-Slim Alouini

Field of Study

Computer, Electrical & Mathematical Science

Computer Graphics, Computer Vision, and Visualization

Internship Description

The internship is in the area of graphics, vision, or visualization. The exact topic is determined in discussion with the student to obtain a good fit with the student's interest and background. Example projects are 3d reconstruction from images and laser scans, geo-spatial visualization, remeshing, sampling, procedural modeling, and design computation using machine learning.

Deliverables/Expectations

The student should either contribute to an existing research project or leading his/her own project. That includes reading literature, solving technical problems, and implementation.

Faculty Name

Peter Wonka

Field of Study

Computer Science

Combining deep learning and ontologies

Internship Description

The project aims to identify applications of deep learning to classification problems involving ontologies, and apply these methods to biological and biomedical datasets. The main challenges of the project are (1) to develop methods that can effectively be applied both to unstructured and structured data and classify instances into classes from ontologies, and (2) to utilize data already structured with ontologies effectively in classification and regression problems. The students will be provided with real-world several datasets and are expected to implement and evaluate deep learning approaches on these datasets. To evaluate the methods on a large scale, students will have access to one of the compute clusters at KAUST.

Faculty Name

Robert Hoehndorf

Field of Study

Computer science, artificial intelligence, machine learning, data mining, bioinformatics, or related

Development and optimization of algorithms for cloud-enabled heterogeneous radio-access networks

Internship Description

Development and optimization of algorithms for cloud-enabled heterogeneous radio-access networks. This project can start anytime and is 3 to 12 months in duration. This project is open to Juniors, Seniors, and MS students in Electrical Engineering, Applied Math, and Statistics

Deliverables/Expectations

It is expected that the student will submit one publication to a good venue by the end of his/her internship

Faculty Name

Mohamed-Slim Alouini

Field of Study

Computer, Electrical, & Mathematical Science

3D Human Pose Estimation and Tracking across a Network of RGB and RGB-D Cameras

Internship Description

Tracking people and estimating their 3D pose in video, captured from multiple static cameras, is an essential problem in computer vision. It is a fundamental building block of activity recognition, surveillance, and augmented reality (AR) systems. The knowledge of a person's location and 3D pose in a dynamic scene is important in determining what he/she is doing and how he/she is interacting with other entities in the scene (e.g. other humans, inanimate objects, or even augmented/virtual objects). A major hurdle for human tracking and pose estimation across a camera network is the so-called camera-handoff problem. Since cameras have a limited field-of-view that collectively may not span the whole scene (i.e. dead/invisible zones exist), persistently tracking and identifying a person moving from the view of one camera to another is a difficult problem. This is due to the fact that the moving person may appear very different (e.g. because of lighting differences or perspective) between camera views. In fact, this problem exists even when there is only one camera, where the person crosses the field-of-view of the camera into the dead zone to re-enter from a different point. This handoff problem plagues commercial surveillance systems, as well as, state-of-the-art gaming systems (e.g. MS Xbox using the Kinect sensor).

In this proposed project, we aim to construct a camera network of RGB and RGB-D sensors (Kinect) that can be efficiently streamed across the IP network. We will develop and implement robust algorithms (based on sparse and low-rank pose/appearance representations) that enable persistent tracking across our camera network. Moreover, by accumulating and transferring the RGB-D model of each moving individual from one camera view to another, 3D pose can be persistently estimated too. Our proposed method will be applied to multi-human markerless augmented reality in the NexCave in the Visual Computing Center at KAUST.

Deliverables/Expectations

A hybrid network of RGB and RGB-D cameras setup in the NexCave to be used for AR and visualization purposes

A large-scale dataset of multi-view RGB-D video feeds, where each individual is tracked over time and his/her pose is manually labeled. This dataset will be made publicly available to the research community for future algorithm evaluation and comparison

Novel techniques to robustly track and re-identify each moving person across cameras

Faculty Name

Bernard Ghanem

Field of Study

Computer Vision, Machine Learning, Image Processing