



PROPOSED INTERNSHIP PROJECTS

2020

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PROJECT 4 – IMPROVED WIRELESS LOCALIZATION WITH SMART RECONFIGURABLE SURFACES

Laboratory: CEA-Leti DSYS/STSF/LCOI, 17 rue des Martyrs, 38054 Grenoble

Keywords: accurate localization, beyond 5G & 6G wireless communications, smart environments, intelligent reflecting surfaces

Description of the project:

In future wireless communication systems (i.e., beyond the 5th generation (5G) currently under development), ultra-accurate localization capabilities (typically, within an accuracy of a few cm) will be required to further increase achievable data rates and network loads through location-aware approaches. Besides, « localization as a service » is also expected to feed various application domains (e.g, autonomous vehicles, advanced control-command for smart factories, new Human-Machine interactions, immersive augmented/virtual reality...).

Very recently, so-called « intelligent » surfaces (e.g., electronically-reconfigurable materials or small devices integrated in walls) have been promoted in the research community as low-cost means to dynamically control the radio propagation channel, primarily for communication purposes (e.g., so as to serve users located in dead/obstructed zones, limit radio interferences, or even reinforce the data link security with respect to eavesdropping attacks...). On the other hand, advanced signal processing approaches have also been proposed to exploit multipath echoes (typically, resulting from « uncontrolled » reflections or diffractions of the transmitted radio signal in its physical environment), as a meaningful source of information for indoor tracking and radio-based environment cartography.

During this internship, we thus propose to investigate the potential of combining both smart reconfigurable surfaces and multipath-aided location estimation approaches for demanding beyond-5G localization applications. After studying related models that are available in the recent literature (e.g., signal and channel models, theoretical performance bounds...), the surface-aided multipath localization problem will be analysed and mathematically stated. Then, estimation algorithms will be designed accordingly, along with suitable supporting protocol mechanisms. Finally, the proposed solutions will be validated by means of extensive computer simulations using Matlab®.

Candidates (MSc. level) are expected to have a solid background in signal processing and preferably, in wireless technologies.

PROJECT 5 – NANOMECHANICS AT ULTRA-LOW TEMPERATURES

Laboratory: CNRS, Institut Néel, 25 avenue des Martyrs, 38000 Grenoble

Keywords: NEMS, microkelvin, microwave optomechanics, continuous nuclear demagnetization refrigeration

Description of the project:

The cross-over from atomic-size quantum objects to macroscopic classical systems is remains puzzling. We know that macroscopic quantum states exist (e.g. the quantum coherence of the current state in a superconducting loop), but our knowledge is essentially limited to electromagnetic degrees of freedom. Quantum states of moving objects have undergone relatively little experimental study. One of the goals of our research group, to which the intern would contribute, is cooling a glass nanomechanical resonator to the microkelvin range, so that its fundamental mode reaches the quantum ground state. This is essential for probing low energy excitations present in the amorphous lattice of the resonator. New cryogenic technology is required to efficiently carry out this research. In particular, we are developing a continuous nuclear demagnetization refrigerator (CNDR) that will, for the first time, allow measurements below 1 mK on unlimited timescales. Specific activities of the intern will include one or more of the following: development of a superconducting heat switch with ultra-low thermal resistance, which is crucial for the operation of the CNDR; characterization of nanomechanical resonators at low temperatures; characterization of superconducting microwave resonators at low temperatures.

Relevant papers:

- David Schmoranzer *et al.*, arXiv:1912.01290
- X. Zhou et al., Physical Review Applied 12, 044066 (2019) arxiv:1903.04992.

PROJECT 6 – DEVELOPMENT OF NIR OLED TECHNOLOGY: DEVICE INVESTIGATION AND MARKET OPPORTUNITIES

Laboratory: CEA-Leti, DOPT/SNAP/LCEM, 17 avenue des Martyrs, 38000 Grenoble

Keywords: OLED, ALD, NIR

Description of the project:

In the framework of its optics and photonics activities, the CEA-LETI starts to investigate the industrial applicability of NIR-emitting (< 1000 nm) OLED architectures. The 700–1000 nm electromagnetic window coincides with the biological tissue semitransparency window. Together with the advantages of flexible electronics, low cost and potential biocompatibility, this makes NIR OLED interesting candidates for new applications in bioelectronics for optical probing of analytes with absorption in this range, as well as for photothermal and photodynamic therapeutics based on NIR photoactivation of dedicated drugs. Another opportunities for NIR OLED is their monolithic integration as transmitters onto photonic circuits, for Lifi applications, where the transmission becomes invisible to the human eyes.

The present internship project proposes to make a full survey of NIR OLED literature, together with a full understanding of market opportunities. An output of the project will be to spot organic molecules providers around the world and to propose some NIR OLED architectures that can be implemented with moderate to high external quantum efficiency in the CEA-LETI OLED line facilities.

The recommended background of the candidates is semiconductors and organic semiconductors physics, thin solid films, clean room, nanotechnology, photonics, semiconductor components, PVD, ALD, PECVD, etching, photolithography, etc...

PROJECT 9 – ARTIFICIAL INTELLIGENCE FOR NEUTRON SCATTERING INSTRUMENTS (AINSI)

Laboratory: Institut Laue-Langevin, Division of Science, Scientific Computing Group, 71 avenue des Martyrs, 38000 Grenoble

Keywords: Deep learning, neural networks, artificial intelligence, neutron scattering

Description of the project:

Deep neural networks are a powerful tool for experimental data processing. They have proven to have superhuman performance in solving classification, regression, prediction, clustering or other tasks in various domains. Neutron scattering, a popular technique to study the structure and dynamics of matter, is not an exception. Recently there has been a fast progress in applications of the AI and DL techniques to neutron data demonstrating promising results.

The aim of this internship would hence be to explore the domain and propose applications of DL to solve problems spanning from more intelligent data acquisition to data reduction and analysis.

The ultimate goal would be to architect and train an artificial neural network to solve a concrete problem as a proof-of-concept. Simulated data and the CPU/GPU cluster to be used for training the network. Examples of applications include denoising, super resolution image reconstruction, peak prediction, peak classification or regression analysis of complex multi-dimensional data.

The ideal candidate should be involved in a PhD program in Artificial Intelligence, Data Science, Statistics, Image Processing, Computer Vision, Pattern Recognition or other relevant field of Applied Mathematics. Profound background in mathematics, proficiency in programming (Python) and fluency in deep learning libraries (Keras, PyTorch, TensorFlow) are indispensable.

PROJECT 10 – MAKE A CTF ON THE VULNERABILITIES OF THE SMART CONTRACTS

Laboratory: CEA-Leti, Security of the Physical Objects and Systems, 17 avenue des Martyrs, 38000 Grenoble

Keywords: smart contracts, solidity, ethereum, linux

Description of the project:

The aim of this internship is to make “Capture The Flag” challenges on the vulnerabilities of smart contracts. The challenges will be experimented during the CTF session of the Grehack 2020 conference (<https://grehack.fr/2019/ctf>).

The work will consist on developing a standalone docker container including the environment to develop, test and execute smart contracts on Ganache (<https://www.trufflesuite.com/ganache>), the Ethereum simulator. The development languages used are Javascript and Solidity, and the development suite used is Truffle (<https://www.trufflesuite.com/>), the Ethereum development suite.

In the following, several well-known vulnerabilities of smart contracts will be considered. For each one, the challenge will be to find the fault present in the given smart contract and to propose a correction. A library will be built based on SmartDec (<https://github.com/smartdec/classification>), the smart contract vulnerabilities classification, in order to maintain an up-to-date version consistent with the latter solidity compiler and pyethereum virtual machine execution. These challenges will encourage to draw attention on the best practices to consider when developing smart contracts and decentralized applications (dApps). Each challenge will have to be scripted in a fun way.

PROJECT 11 – DEVELOPMENT OF ARTIFICIAL INTELLIGENCE ASSISTANTS FOR SYNCHROTRON BEAMLINE DATA ANALYSIS

Laboratories:

- CEA, DRF/IRIG/DEPHY/MEM/NRS, 17 avenue des Martyrs, 38000 Grenoble
- European Synchrotron Research Facility (ESRF), 71 avenue des Martyrs, 38000 Grenoble

Keywords: Machine Learning, Artificial Intelligence, X-ray Image pattern, Data Analysis

Description of the project:

The aim of the internship is to dive into the exciting world of studies and characterization of materials at the European Synchrotron (ESRF) and the related advanced instrumentation for X-ray scattering.

Due to the growing amount of data in synchrotron beamlines using rapid 2D detector new approaches to handle collected data from X-ray characterization measurements are needed. Over the last few years Artificial Intelligence has entered into the synchrotron world with significant and promising results. Several demonstrations of Machine and deep learning algorithms and architectures were made for a higher general beamline throughput and better data interpretation by users.

During the internship we plan to test and implement various learning techniques on the analysis of x-ray 2D pattern recorded by Laue microdiffraction to enable on fly diagnosis & analysis. For instance, several assistants could be trained: to detect and sort data for further analysis, to perform regression for the determination of crystal orientation, to speed up the handling of complex or multicomponents scattering peaks, or deal with 2D (3D) microstructure reconstruction from sample raster scan. Sample or optics alignment procedures could also be implemented.

Background in scientific computing is highly recommended. Knowledge in physics, materials science and crystallography would be an asset.

PROJECT 12 – CONVOLUTIONAL NEURAL NETWORKS FOR SUPER-RESOLUTION HOLOTOMOGRAPHY

Laboratory: European Synchrotron Research Facility (ESRF), 71 avenue des Martyrs, 38000 Grenoble

Keywords: X-ray nano-imaging, deep learning, super-resolution microscopy, holography, tomography, artificial intelligence

Description of the project:

X-ray holography combined with tomography is a 3D microscopy technique that is exceptionally suited to image biological samples at the micrometer and nanometer scales. This technique can offer unprecedented insight into the complex structures formed by neurons in brain. However, several challenges need to be addressed in order to mitigate the necessary radiation dose and data collection time to obtain the sought-after data quality. Too much radiation dose may damage the sample and compromise image quality, while long acquisition time prevents imaging of enough samples to enable addressing scientific questions.

The solution to this problem resides also in the development of super-resolution approaches, which retrieve high-resolution images from low resolution data. A new kind of convolutional neural network scheme, called Mixed-Scale Dense neural network (MS-D Net), was recently demonstrated to super-resolve tomographic data obtained with laboratory X-ray sources.

The goal of this project is to translate this method to synchrotron X-ray holo-tomographic imaging, with focus on application to brain tissue.

The student should have good programming and image processing skills, and basic understanding of convolutional neural networks. Familiarity with python and tomographic imaging will be appreciated.

Autumn intake

PROJECT 14 – STRUCTURAL BIOLOGY OF RNA MODIFICATIONS

Laboratory: [EMBL Grenoble](#), 71 avenue des Martyrs, 38000 Grenoble

Keywords: Biochemistry, Structural biology, protein-RNA interactions, RNA modification

Description of the project:

The central dogma of molecular biology described a linear flow of information from genes towards the protein level. However, many regulatory steps between tightly control actual gene expression, also on the level of RNAs. RNA modifications are ubiquitously present on all kinds of RNA molecules (mRNA, tRNA, lncRNA etc.) and in all kingdoms of life. They add a reversible layer of information on top of the coding sequence of the RNA. Modifications can effect RNA structure, stability and localization and the interaction with other cellular players. In humans, RNA editing events are also linked to diseases like amyotrophic lateral sclerosis (ALS), schizophrenia, epilepsy, neuronal disorders and cancers. In the Kowalinski lab at EMBL Grenoble, we study the biochemistry and structural biology of RNA modification mechanisms to understand how these modifications are specifically written, read or erased. Practically in the lab, we purify proteins and RNA and assess the sample quality by different biophysical methods before we proceed to structural analysis by x-ray crystallography or cryo-electron microscopy. Once a structure is solved and the model built, we interpret the models and test our hypotheses, on how a particular interaction could function with biochemical or cellular assays. The internship project will comprise a particular section of this workflow, best matching the applicant's interests and the status of a project.