MS Project/Thesis Topics for Summer/Fall 2023
4.6.23

Image classification and reconstruction with directional image sensors

Faculty: Professor Roberto Paiella (rpaiella@bu.edu), Professor Lei Tian (leitian@bu.edu), and Professor Janusz Konrad (jkonrad@bu.edu)

Project Description: The goal of the project is to demonstrate basic image classification and reconstruction tasks using convolutional neural networks (CNNs) combined with pixel arrays of specially designed directional image sensors. These devices have been developed in our lab based on a new type of photonic nanostructures, and their experimental characteristics will be made available for use in the project. The project activities will consist of numerical simulations involving various data sets for object recognition and image reconstruction.

Number of students: 1
Semester: Summer / Fall
Expected period of the project: 1-2 semesters
Possibility of extending to a thesis: Yes.
Required background: Prior experience in developing deep learning algorithms in TensorFlow / PyTorch, as well as very basic knowledge of optics and imaging systems

Application requirements: CV and interview

Mapping Rocket and BOOM RISC-V processors to FPGA

Faculty: Professor Ajay Joshi (joshi@bu.edu)

Number of students: 2
Semester: Summer / Fall

Expected period of the project: 1 semester
Possibility of extending to a thesis: Yes.
Required background:
- EC513: Computer Architecture
- EC551: Advanced Digital Design with Verilog and FPGA
- EC535: Introduction to Embedded Systems
- Or prior experience in FPGA projects, RISC-V processors and Linux boot-up process.

Application requirements: CV or other information required from the prospective students: CV that includes GPA information, list of relevant courses the student has taken, and description of relevant projects (FPGA projects, projects involving compiling and booting Linux for an embedded system, etc).

High-Accuracy Indoor Positioning with Directional Media and ML

Faculty: Professor Thomas Little (tdcl@bu.edu)

Number of students: up to 3
Semester: Summer / Fall

Expected period of the project: 1 semester for a project or more for a thesis
Possibility of extending to a thesis: Yes.
Required background: EE, signal processing, ML.

Project Description: We want a mobile device to be able to (a) localize itself, (b) localize other devices, (c) localize objects within a space. Assume 3D volume. Assume indoors in rooms, buildings, warehouses at scale 1s of m, 10s of m, 100s of m. Can use anchors or intelligent surfaces, repeaters, or imaging solutions. Assume human or robot mobility. Operates in real
time (not an offline solution). Compare THz with visible, IR, mmWave (models, analysis, simulation). Potentially demonstrate solution in testbed.

Application requirements: A CV should be provided along with a statement of interest.

Background on the topic:

Logistics:
- Candidates will be required to submit a proposal from the topic area that is realizable during the project duration (typically 1 or 2 semesters).
- Additional project details will be provided on request.

Implementation of rate-compatible Invertible Bloom Lookup Tables within the GenSync framework

Faculty: Professor Ari Trachtenberg (trachten@bu.edu)
Number of students: 1-2 students
Semester: Summer, possibly Fall
Expected period of the project: 1 semester
Possibility of extending to a thesis: Yes, upon promising results.
Required background: Solid C++ programming skills (ideally a 500-level course in same), a solid course in algorithms and data structures (preferably at least EC504)
Application requirements: CV and relevant coursework.

Data Science for Sports-Related Contests

Faculty: Professor Vivek Goyal (goyal@bu.edu)
Semester: Summer / Fall
Expected period of the project: 1 semester
Project Description: Many contests involve predicting the winners of games. Examples include ESPN College Pick'em for college football and ubiquitous NCAA March Madness bracket pools. Methods for predicting individual game outcomes abound. In fact, it is reasonable to consider this problem to be completely solved by prices in betting markets. This project is focused on other aspects of optimizing contest performance. For example, these games often make population-level data on competitors' strategies available in advance (e.g., the fraction of competitors predicting that Georgia will defeat Tennessee), in addition to making past strategies available publicly. The central goal of the project is to use publicly available data to develop models for player strategies and then optimize against those players.
Required Background: Strong skills with software and machine learning (ENG EC 503 and similar courses). It is anticipated that the work will require creative methods for scraping data from the web in addition to the development of complicated models.
Application requirements: Resume and some narrative text (at most one page) on why the project interests you and why your skills are appropriate for it.

Deep learning for microscopy image analysis

Faculty: Professor Lei Tian (leitian@bu.edu)
Number of students: 1-2 students
Semester: Summer / Fall
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Expected period of the project: 1 – 2 semesters
Project Description: The student will work a group of PhD students to develop deep learning algorithms for quantitative microscopy image analysis
Scope of work: Deep learning algorithm development; Image / data analysis
Required Background: Coding: Python, Tensorflow or PyTorch
Application requirements: A CV must be submitted and applicants will be interviewed

Experimental measurements of photon correlation functions in nanostructured devices
Faculty: Professor Luca Dal Negro
Semester: Summer / Fall
Expected period of the project: up to 1 year
Project Description: This MS thesis project in Prof. Dal Negro NaNO group (ECE) https://www.bu.edu/nano/ focuses on the installation and testing of a new TCSPC (time-correlated single photon counting with picosecond timing) system for the characterization of quantum correlation functions of nanostructured materials and metasurfaces in the near-infrared spectral range.
Required Background: Candidate students must have an experimental background in optics and photonics, nonlinear optics, and a basic knowledge of quantum mechanics.
Application requirements: Contact faculty member

Experimental measurement of the spatio-temporal Green’s functions of random scattering optical nanostructures
Faculty: Professor Luca Dal Negro
Semester: Summer / Fall
Expected period of the project: up to 1 year
Project Description: this MS thesis project in Prof. Dal Negro NaNO group (ECE) https://www.bu.edu/nano/ focuses on the experimental installation and characterization of an interferometric dark-field scattering setup for the measurement of the electromagnetic Green’s function of complex photonic media with femtosecond time resolution. This state-of-the-art equipment will be installed and tested by the MS student using a number of complex photonic structures fabricated by the Dal Negro group.
Required Background: Candidate students must have an experimental background in optics and microscopy.
Application requirements: Contact faculty member

Hi-Res audio headphones
Faculty: Professor Robert Kotiuga
Number of students: 1-4
Semester: Summer / Fall
Project Description: This project consists of coming up with a headphone design, either in-ear or electrostatic, with flat frequency response beyond 100kHz, for the purpose of demonstrating the difference in transient detail in Hi-Res Audio (i.e. better than CD quality audio formats.) This project can leverage recent convergence between advances in hearing aid design and in-ear audiophile designs.
Application requirements: Contact faculty member
Efficient hybrid solar panels for hot water

Faculty: Professor Robert Kotiuga
Number of students: 1-4
Semester: Summer / Fall

Project Description: Solar hot water panels can be 80% efficient, but this efficiency can only be realized with a considerable amount of storage. Photovoltaic panels are little more than 20% efficient but the electricity they produce can be stored, and later heated with a heat pump to produce on-demand hot water with a minimum of hydraulic storage. One drawback to photovoltaics is the efficiency drops with rising temperature. The idea behind a hybrid solar panel is to have a heat pump extract heat from a small solar hot water panel and use a photovoltaic panel to preheat the fluid going into solar hot water panel, increasing the efficiency of the photovoltaic panel in the process. This project will quantify the trade-offs in such a scheme, optimize the design parameters for various scenarios, and build a prototype as proof of concept.

Application requirements: Contact faculty member