Project 1. Internship on the Career Paths of Immigrant CEOs

Supervisor:  Dr. Michael Adachi  
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Title: Nanomaterial and Nanodevice Undergraduate Researcher

Project:  
This research project involves working in an interdisciplinary team to develop new nanoscale devices and characterizing the material properties of quantum-confined materials. The student will work in the Nanodevice Fabrication Group (website: nanodevice.fas.sfu.ca) in the School of Engineering Science, Simon Fraser University, Burnaby, BC, Canada. Potential projects include electrical characterization of MoS2 piezoelectric sensors, preparation of graphene by exfoliation to make conductive electrodes, and fabrication of nanodevices using cleanroom fabrication methods.

Responsibilities:  
Students will join weekly team meetings to receive feedback and guidance during the research project. Students will also work closely and be trained by graduate students and other research interns.

Qualifications:  
- Experience with nanomaterial preparation, material characterization (e.g. photoluminescence, SEM, etc.), or background in semiconductor device physics would be an asset.  
- Responsibilities will include a subset of the following, depending on time and project of interest:  
  - Prepare nanomaterials using cleanroom facilities.  
    - Characterize optical properties of nanomaterials.  
    - Characterize electrical properties of nanomaterials using a probe station.  
    - Develop methods to modify the electrical/optical properties of nanomaterials using material treatments.  
    - Fabricate semiconductor devices incorporating nanomaterials using cleanroom equipment.  
    - Work with collaborators to perform structural characterization of nanomaterials.
Project 2.

Supervisor: Dr. Majid Bahrami  
Professor and Canada Research Chair in Alternative Energy Conversion  
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Title: Next-Generation Thermal Energy Storage Systems for Smart Thermal Grids

Language: English

Project:  
A research project is underway in collaboration with major industrial and municipal partners to develop new thermal energy storage technology with enhanced durability, energy storage density and efficiency. Such technology is key in the development and proliferation of smart, sustainable (carbon-neutral) thermal grids utilize various energy sources to provide heating, cooling and air conditioning at the urban scale. Sustainable thermal grids are in turn a major milestone in our way to sustainability most notably because they provide great flexibility for peak-shaving and orchestrating various energy sources as well as facilitating the use of low-grade waste heat. This project entails data collection from a local district energy network and development of data-driven thermal models to study the integration of renewable energy sources and the energy storage requirements of the network. In parallel, new material will be developed for modular thermal energy storage systems that meet such requirements.

Responsibilities:  
After getting acquainted with the work environment and the project and receiving general laboratory safety and job-specific trainings, the student will work with graduate students and other researchers at LAEC to perform the tasks described above. Weekly group meetings provide a communication channel for the student to report their progress, participate in discussions and learn about other research activities of the group. Regular meetings with research partners provide an invaluable opportunity to meet people from the industry and learn how academic research can contribute to tackling real-world challenges.

Qualifications:  
The successful candidate will process large datasets from a local district energy network to extract useful information such as temporal thermal load profiles and usage patterns. Advanced programming and data analysis skills (preferably MATLAB) are therefore essential. The successful candidate will also participate in laboratory tests of the developed energy storage material and systems; the main task would be the control and automation of the experiments through software such as LabView. The prospective candidate must have a strong background in thermodynamics, fluid mechanics and heat transfer. Strong communication skills (oral and written) and commitment to the professional etiquette are required.

About LAEC:  
The Laboratory for Alternative Energy Conversion (LAEC) aims to enhance the efficiency of energy conversion devices such as heat exchangers, fuel cells, batteries, and air-conditioning systems. A wide range of fundamental and applied problems at various scales – materials, components and systems – are investigated at LAEC using a combination of analytical, computational and experimental methods.
Project 3.

**Supervisor:** Dr. Krishna Vijayaraghavan  
Associate Professor  
Management Information Systems  
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**Title:** Modeling and Control of Two Phase Cooling System

**Project:**  
Cooling of electronic circuits is a crucial for reliability and longevity. This is particularly challenging due to the anticipated explosion in the use of electronic control for electric vehicle, battery management systems and processors. Current air cooling strategies are unlikely to meet the thermal management requirements for future high heat dissipating silicon-based electronics. This is becoming increasingly evident with fast rising heat fluxes and shift to multicore processors. In addition to thermal management of such non-uniform power maps, the energy spent in cooling at the system level is an additional concern. Thus, a shift to single phase and two-phase liquid is inevitable. Evaporate cooling of processors can significantly improve the cooling rate, while reducing the power needed to operate the cooling systems. One of the challenges here would be to accurately sense the "quality" of the two phase flow and to control the flow rate to ensure optimal performance. This is required to ensure that the coolant delivery successfully absorbs the dissipated heat while minimizing the possibility of dry-out. This is a problem in thermodynamics and in control systems.

**Project PI:** To address this challenge, a new collaborative project is proposed between Dr. Vijayaraghavan at SFU and Dr. Sharma at IIT-Ropar.

**Responsibilities:**  
The selected student will begin by performing CFD simulation in multiphase flow and develop a reduced controllable model for the vapour quality and heat dissipation as a function of flow rate. A simple control system will be implemented on the reduced model and the feasibility and robustness of the control scheme will be evaluated.
**Project 4.**

**Supervisor:** Dr. Keval Vora  
Associate Professor  
School of Computing Science  
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**Title:** N/A

**Project:**  
Streaming graph processing aims to maintain approximate results of the most updated version of the graph so that they can be quickly adjusted as graph structure changes. Despite the effectiveness of this approach in processing very large graphs (e.g., Facebook-scale), it is not generally applicable when edge deletions are present - existing approximations can lead to either incorrect results or poor performance.

This project presents KickStarter, that, for a general class of monotonic graph algorithms, is able to trim the approximations to a subset of vertex values whose use preserves correctness of results and yet maintains high performance. The key idea behind KickStarter is to identify values that are (directly or transitively) impacted by edge deletions and adjust those values before they are fed to the subsequent computation.

**Responsibilities:**  
The student will identify and exploit the monotonicity in multi-valued variables across graph algorithms. To achieve this, the student will first investigate several graph algorithms to understand their convergence behavior.

Then, the underlying monotonicity will be formalized by capturing the partial/full ordering across multi-valued variables. This monotonicity will help determine how structural changes in graphs impact the multi-valued variables. After characterization, the student will capture the dependencies across iterative updates by implementing the algorithms on KickStarter and hinting the runtime about how values propagate. The graph algorithms will be provided to the student as a starting point for research. The student will closely work with the team to develop his/her solutions and incorporate them in KickStarter.

**Qualifications:**  
The student must have a strong background in C++ programming (must be comfortable with pointers) along with basic knowledge about linux. The student must be a quick-learner since he will be working with well-established open-source codebases. Optionally, basic knowledge about graph processing and algorithms will be useful.