ECE Graduate Research Seminars-Summer 2024

In Person Sessions: June 3-4, 2024

Remote Sessions: June 17-18, 2024

June 4, 2024-Afternoon Session

N**ame: Md Motakabbir Rahman**
Area of Research: Power Systems
Name of Supervisor: Joshua Pearce

Adaptable Open-Source Solar Powered DC Nanogrid for Application-Specific Designs
This research outlines the development and analysis of a modular open-source solar photovoltaic-powered DC nanogrid system for sustainable and accessible off-grid power solutions, particularly in remote and isolated applications. By combining a do-it-yourself (DIY) PV system with batteries, the nanogrid will empower users to generate, store, and utilize their electricity, reducing reliance on traditional grid infrastructure and promoting energy independence. The core functionality of the nanogrid system lies in its capacity to supply DC power to loads operating at varying voltage levels. This adaptability is achieved through the utilization of a parametric energy management system (EMS), which dynamically selects optimal operational modes based on the DC bus voltage and battery state of charge. Through simulation results, the effectiveness of the EMS in coordinating the PV-battery system amidst dynamic solar power generation and load fluctuations is validated. Its modular design will pave the way for a customizable solution for diverse applications that require different operating DC voltages, power, and battery backup requirements. By openly sharing design specifications and operational details, the modular PV-powered nanogrid system will foster customization, adaptation, and continuous improvement to address evolving energy challenges and meet specific user requirements.

Name: Zhichen Yan
Area of Research: Software Engineering
Name of Supervisor: Yimin Yang

Exploring the Potential of One-Dimensional Time Series Data in Transformer Model Training: Using Pre-trained Large Language Models to Predict the Impact of Gusts on Buildings

The Transformer model is a deep learning model that employs attention mechanisms, primarily used in natural language processing and computer vision. Among these, large language models excel at generating or understanding natural language text. Unlike the traditional use of large language models, they hold great potential in capturing continuous contextual relationships in one-dimensional time series data. The force conditions of buildings under the influence of gusts are characterized by weak magnitude but high frequency and amplitude changes, making analysis and prediction using conventional physical models very challenging. However, the subtle relationships can be expected to be uncovered by large language models using the approach of learning contextual semantics. We use continuously collected gust data samples as input to train the model on the real-time force conditions of buildings. This allows us to predict the impact on buildings under random gust influences, providing a promising practical approach for multi-variable to multi-variable training methods in one-dimensional data.

Name: Haojin Deng
Area of Research: Software Engineering
Name of Supervisor: Yimin Yang

Unleash the Power of Context in Contrastive Learning: A Comparative Study of Context-Enriched, Self-Supervised, and Supervised Approaches

Contrastive learning has established itself as a cornerstone of modern representation learning, with self-supervised and supervised contrastive learning being two well-studied paradigms. This presentation introduces a third paradigm: context-enriched contrastive learning. This approach extends traditional contrastive learning by incorporating external contextual information, thereby enriching the learned representations. We present a formal definition of context-enriched contrastive learning and discuss its theoretical underpinnings. A comparative analysis with supervised contrastive learning is provided, highlighting the key differences in their objectives, optimization strategies, and the nature of the information leveraged during training. We demonstrate, through empirical studies, that context-enriched contrastive learning can achieve superior performance in various tasks by effectively utilizing contextual information. Our findings suggest that this approach offers a promising direction for developing more robust and interpretable representation learning models especially in multimodal learning.

Name: Nima Asgari
Area of Research: Power Systems
Name of Supervisor: Joshua Pearce

Optimization of Sustainable Greenhouses and Vertical Growing Structures by Employing Semi-Transparent Photovoltaic Panels and Heat Pumps in Canada

In recent years, researchers have made significant attempts to integrate HPs and PV technologies into greenhouses, predominantly in European countries and China, with a particular emphasis on Mediterranean climates. Studies focusing on colder climates are scarce. This study seeks to address this gap by integrating semi-transparent photovoltaic (STPV) modules and heat pump (HP) technologies into Canadian controlled environments (CEs), optimizing for energy efficiency, economic viability, and agricultural productivity. By collecting experimental data from various setups—unconditioned, conditioned by conventional heaters, and HP-conditioned with STPV—the study will develop open-source physical and economic models. These models will facilitate comparative analyses of different CE configurations, considering variables such as crop type, HVAC technology used, and the transparency of STPV modules. Comprehensive energy, environmental, and economic assessments will be conducted to evaluate system performance and identify optimization opportunities without compromising crop yield. The research will introduce a platform for designing sustainable CEs, offering insights for both farmers and investors to retrofit existing structures or build new ones that maximize energy generation and economic return while supporting agricultural production in Canadian climates.

Name: Shafquat Rana
Name of Supervisor: Joshua Pearce

Solar Photovoltaics integration with Heat pumps and Thermal Batteries: Proposing a Sustainable and Economical Model to Supply Thermal Loads and Electrical loads for Decarbonization of Residential Sectors in Canada.

The focus of this research is directed towards meeting the thermal energy needs of residential areas. It's worth noting that a significant portion of carbon emissions, approximately 80%, stems from the energy sector, with building energy consumption contributing to 17% of this figure. Within the residential sector, our particular emphasis lies in addressing the 13% of energy demand, with space heating and water heating constituting 63.6% and 17.2% of this demand, respectively. The residential sector presents a promising opportunity for decarbonization, as it represents a low-hanging fruit in our sustainability endeavors, where the collective impact of small individual actions can lead to substantial positive changes. The study is dedicated to integrating solar photovoltaics, heat pumps, and thermal batteries, aimed at providing sustainable solutions for fulfilling the thermal and electrical requirements of residential areas, while concurrently mitigating carbon emissions. The primary objective of this study is to advance the decarbonization of the residential sector by employing renewable energy resources in tandem with mechanical components, specifically heat pumps and thermal batteries.

Name: Dawei Lui
Area of Research: Robotics and Control
Name of Supervisor: Josuha Pearce

Distributed manufacturing of an open-source tourniquet testing system

An open-source, Arduino-based, 3D-printable tourniquet tester has been developed. Common tourniquets can be used to stop bleeding in human limbs, thereby increasing the survival rate of the injured. However, in some low-resource or conflict-prone areas, tourniquets are difficult to obtain. The open-source medical device organization Glia developed a 3D-printed tourniquet aimed at providing easily accessible tourniquets for resource-poor areas, but its effectiveness needs to be verified by a tourniquet tester. Before this, there was no universally recognized effective tourniquet tester, and the production standards for tourniquets were also unclear. Therefore, it is necessary to develop an effective, low-cost, and easily accessible tourniquet tester. In this study, a 3D-printable tourniquet tester was developed, featuring low cost, easy operation, and portability, which helps with acquisition and use in resource-poor areas. In the study, multiple groups of experiments proved that the tester can measure the pressure caused by tourniquets and has similar functions to a blood pressure cuff on measuring pressure. In subsequent research, data from human experiments is needed to further prove the effectiveness of the tester.