ECE Graduate Research Seminars-Summer 2024

In Person Sessions: June 3-4, 2024

Remote Sessions: June 17-18, 2024

June 17, 2024-Afternoon Session

Name: Matthew Peck
Area of Research: Software Engineering
Name of Supervisors: Roy Eagleson

Design of Extended Reality Environments for Sonification Testing and Training

As Extended Reality (XR) technologies become increasingly common and adopted in consumer applications, opportunities for their use in professional settings expand. Virtual Reality (VR) in particular, provides novel opportunities for task simulation with a high degree of portability and immersion. In medicine, VR Head-Mounted Displays (HMDs) permit robust experiential learning through simulated procedures and interactable objects in virtual environments. These spaces afford schools the opportunity to optimize use of expensive equipment and materials like cadavers and ultrasound machines for training purposes, while increasing student access to simulations of these critical medical tools and experiences.

Sonification, the generation of sound signals directly by input data to communicate information to a user through the auditory system, is a possible method by which to enhance these simulated learning experiences. Through comparison of speed and accuracy metrics on a simulated medical task with different established sonification techniques employed, we can evaluate the effects these methods have on training students in medical procedures. Sonification is also used to reduce the amount of information practitioners must absorb through visual media in surgical scenarios. By employing a variety of sonification techniques in a simulated task for which data is already available, we may investigate the efficacy of VR environments as testing grounds for novel sonification methodologies.

Name: Donya Bayat
Area of Research: Power Systems Engineering
Name of Supervisor: Firouz Badrkhani Ajaei

Optimal Energy Management Strategy of EV Charging Station with PV and BES

The merging of electric vehicle (EV) charging stations with photovoltaic (PV) panels and battery energy storage (BES) systems introduce an innovative approach to sustainable infrastructure development. This integration establishes a microgrid within the station, fostering intelligent coordination with the public power grid. This study proposes a blend of energy management strategies implemented at two operational stages. Initially, a day-ahead optimization strategy, grounded in mixed integer linear programming (MILP) and accounting for ESS degradation costs, is designed to maximize the station's profitability. This strategy considers factors such as time-of-use (TOU) electricity pricing, PV generation subsidies, PV feed-in tariffs, and charging revenue. Expanding on the day-ahead plan, a real-time adjustment strategy rooted in MILP is devised to ensure energy balance in real-time while minimizing adjustment costs. The results demonstrate that the proposed method significantly reduces operating costs and maximizes EV charging profits compared to uncontrolled EV charging methods.

Name: Mohsen Kaveh
Area of Research: Power Systems Engineering
Name of Supervisor: Firouz Badrkhani Ajaei

Rotary DC Charging Station: Design and Control

DC fast charging stations are becoming more popular to facilitate the growing use of electric vehicles (EVs) in the world. However, space limitations in big cities and residential areas restrict the number of charging stations that are currently installed. To solve this issue, this research is dedicated to designing a rotary parking tower equipped with fast chargers on the moving platforms. The final system is a hybrid microgrid comprised of a battery energy storage system (BESS) and a photovoltaic (PV) system to facilitate islanded operation of the charging station along with grid-connected operation. Different topologies for this application are reviewed, and the technically and economically viable solution is chosen. Moreover, control of this system is a challenge that is addressed in this study by developing a Hierarchical Control System for the Hybrid Microgrid. This control system consists of a centralized upper-level controller and local controllers for individual microgrid components to optimally coordinate the operation of microgrid components.

Name: Khaled Ghambirlou
Area of Research: Power Systems Engineering
Name of Supervisors: Gerry Moschopoulos

Voltage Sag Investigation for Induction Motor Startup in Distribution Systems using Solid State Transformers

The rising demand for electrical energy has introduced significant challenges to the power grid, particularly concerning power quality issues like voltage sag in industrial and distribution systems. Voltage sags during Induction motor startup can delay power restoration and lead to widespread system failures, making it essential to address these issues effectively. A novel approach to studying voltage sags induced by typical industrial loads using solid-state transformers (SSTs) instead of traditional transformers is presented. In this study, an induction motor startup model is employed to simulate voltage sags, accurately reflecting the characteristics influenced by conventional industrial loads. The advanced capabilities of SSTs are utilized to mitigate these voltage sags effectively. The role of SST technology in actively regulating voltage during motor startup through reactive power control is emphasized in this paper.

MATLAB/Simulink is used to implement and test the chosen distribution system. This simulation environment allows for modelling and analysis of the voltage sag phenomena. Results will be compared with previous studies on voltage sag during motor startup, highlighting the improvements and effectiveness of SSTs in regulating voltage during power quality issues. This investigation aims to demonstrate the potential of SSTs in enhancing the stability and reliability of power systems during the challenging conditions of motor startup.

Name: Seyyed Ali Sadat
Area of Research: Power Systems Engineering
Name of Supervisors: Joshua Pearce

Revolutionizing Microgrid Systems: Optimizations and Applications

Solar photovoltaic (PV) technology is essential for transitioning towards a low-carbon future. However, optimizing its performance under diverse conditions is crucial for maximizing energy generation and ensuring system reliability. While several software tools exist for simulating hybrid energy systems (HES), they often suffer from limitations such as high costs, lack of multi-objective optimization, and inability to incorporate innovations. To address these limitations, this research introduces and validates Solar Alone Multi-objective Advisor (SAMA), as the first open-source microgrid optimization software. SAMA utilizes metaheuristic algorithms to optimize HES sizes economically based on load profiles and meteorological data. Validation exercises against the industry-standard Homer Pro software demonstrate SAMA's effectiveness across various climatic conditions and geographical locations. SAMA offers unique features including multi-objective optimization, levelized emission optimization, and flexibility in utility billing structures and pricing methodology. Its open-source nature promotes accessibility and customization, making it suitable for a wide range of applications from renewable energy systems to policy formulation. This research, underpinned by the significance of microgrid optimization, renewable energy, and energy policy, addresses pivotal research questions regarding accessibility, innovation, reliability, off-grid solutions, profitability analysis, and policy analysis. By providing comprehensive solutions through SAMA, this work contributes to advancing knowledge in microgrid optimization and renewable energy. SAMA's release under the GNU GPL v3 license fosters collaboration and continuous improvement, positioning it as a transformative tool for addressing evolving energy challenges.