ECE Graduate Research Seminars-Summer 2024

In Person Sessions: June 3-4, 2024

Remote Sessions: June 17-18, 2024

June 4, 2024-Morning Session

Name: Jiazhi Chen
Area of Research: Communication Systems and Data Networking
Name of Supervisor: Xianbin Wang

Efficient Task Offloading via Task-Specific Trusted Collaborator Selection in Mobile Collaborative Systems

Given the limited onboard resources and real-time operational constraints, dynamically offloading tasks of mobile devices involving multiple dependent subtasks to groups of other mobile devices becomes critical to improve task completion performance and entire collaborative system efficiency. However, due to diverse task completion goals and potential interdependencies among subtasks, the offloading complexity is significantly increased, leading to resource wastage and even task failures. Simultaneously, malicious devices may sneak into offloading processes, thereby undermining system reliability. To tackle these challenges, efficient and trustworthy offloading strategies between tasks and resources with the consideration of dynamic capability and reliability requirements during the collaborator selection process are needed. Therefore, we explore trust-based offloading strategies in this presentation to address the matching problem between tasks and resources in unreliable mobile environments.

Name: Mohamed Ahmed T A Elgalhud
Area of Research: Software Engineering
Name of Supervisor: Katarina Grolinger

Integrating Few-Shot Learning and Meta-Learning in Distributed Environment for Load Forecasting: Distributed Model-Agnostic Meta-Learning

Forecasting electricity load is crucial for various purposes such as operational planning, optimizing energy usage, and facilitating proactive decision-making, which collectively contribute to environmental sustainability. While machine learning (ML) has shown considerable success in load forecasting, conventional ML techniques typically involve transferring data from dispersed sensors to a centralized node for model training. This approach relies heavily on the availability of extensive datasets for effective training. Federated learning offers a decentralized alternative, allowing model training without the need to share raw data among nodes. However, even federated learning necessitates substantial datasets for effective training, which may not always be accessible, particularly in scenarios involving new buildings or tenants. To address this limitation, this study proposes a novel approach that integrates few-shot learning and meta-learning methodologies into distributed learning. This hybrid approach aims to enable effective learning from small datasets in a distributed manner. The proposed method leverages the Model-Agnostic Meta-Learning (MAML) technique and devises a distributed learning strategy tailored for limited data scenarios. This involves refining the fine-tuning phase of MAML to accommodate the distributed environment. Specifically, the approach incorporates an additional meta-training stage across multiple nodes to generate a unified predictive model capable of serving all nodes effectively. The effectiveness of this approach is evaluated through experiments conducted on load forecasting tasks across various forecasting horizons. Comparative analyses are performed against a centralized model and local models approaches.

Name: Finn Hafting
Area of Research: Robotics and Control
Name of Supervisor: Joshua Pearce

Leveraging Open-Source Process Control with BREAD

When choosing a system to automate industrial pilot projects or lab experiments, scientists and researchers use supervisory control and data acquisition (SCADA) systems to monitor critical parameters like temperature and control actuators like heaters to meet desired setpoints. Existing SCADA systems are proprietary and expensive like the National Instruments' (NI) CompactRIO system and Opto 22's groov EPIC system. Due to their high costs, they are often difficult to access in low-resource settings. The Broadly Reconfigurable and Expandable Automation Device (BREAD) system was created to address the SCADA needs of researchers with plug-and-play functionality at a fraction of the cost of its proprietary equivalents. As an open-source project, users have free access to a continually updated repository of circuit designs, software, and CAD models so they can further customize their system and contribute their designs to the project. Additionally, the functionality of BREAD can be rapidly expanded by integrating existing open-source designs. The potential of BREAD as a small-scale SCADA system was demonstrated by: Implementing stirring control and optical density sensing in a photobioreactor to cultivate microalgae and measure real-time growth; Using the same hardware to first control and monitor a 1.5 L bioreactor to grow yeast before scaling up to a 10 L bioreactor with heating, pH, and stirring control as well as monitoring of dissolved oxygen; Controlling eight different heating zones in a pyrolysis reactor to break down complex plastic waste into lubricants and fuel; and seamlessly integrating a chemical deconstruction reactor with the bioreactor and pyrolysis reactor systems into a single controller without needing to change the hardware. With an inexpensive, easy-to-use, open-source system like BREAD, it is becoming easier for scientists and researchers to access SCADA systems that suit their needs. With BREAD, users can reduce project costs without sacrificing functionality.

Name: Lance Siquioco
Area of Research: Microsystems and Digital Signal Processing
Name of Supervisor: Jayshri Sabarinathan

Photonic Crystal Lorentz Force Magnetic Sensor

Micro-scale magnetic sensors with high sensitivities are used widely in commercial applications including navigation systems, biomedical devices, and telecommunications. Micro-optomechanical magnetic sensors further define a promising area of research due to their low mode volume leading to smaller footprints and higher efficiencies. Previous work in our group has demonstrated a novel out-of-plane magnetic sensor; however, this configuration has issues with thermo-mechanical forces and buckling affecting the vertical displacement and sensitivity of the sensor. In my thesis work, I have designed a novel "in-plane" Lorentz force magnetic sensor based on a photonic crystal directional coupler with high in-plane sensitivity in a small mode volume.

Name: Ziqi Yang
Area of Research: Robotics and Control
Name of Supervisor: Mehrdad Kermani

An introductory review of Impedance Control on Robotic Manipulator

With decades of development in robotics manipulators for industrial applications, traditional methods of employing manipulators in large manufacturing plants have proven limited in satisfying the growing need for safe Human-Robot Interaction (HRI). Consequently, transformations have been made to accommodate the increasing demand for collaborative robots. One fundamental concept in collaborative robotics is the achievement of safe HRI through Impedance Control (IC), which aims to establish compliant mechanical interactions between manipulators and their surrounding environment. This presentation provides an overview of basic concepts and principles, implementation strategies, and offers guidance and insights to aid in the identification of appropriate strategies and solutions.

Name: Giorgio Antonini
Area of Research:
Name of Supervisor: Joshua Pearce and Domenico Santoro

Mobility and Sustainability Combined: Portable Open-Source Solar-Alkaline Electrolysis for Wastewater Treatment

The increasing global demand for sustainable and green solutions to address wastewater treatment challenges encouraging innovative developments in the field. The work proposed focuses on the realization of an open-source photovoltaic box which will power up chemical and environmental studies over wastewater using alkaline electrolysis. A new 3D-printed alkaline electrolyzer will be sustained by solar panels, studying impacts on materials, gas produced and wastewater. The pilot system is optimized over SAMA software to size it. The system will be completely off grid making it able to be deployed in different locations and directly in wastewater plants too. 3 bifacial photovoltaic panels of 2 meter by 1 of 400 Watt each are placed on it and able to be opened, operating in an optimized angle. The alkaline electrolyzer is 3D-Printed in PETG and covered with epoxy resin to make it waterproof and chemically resistant to KOH and wastewater. Testing will be done over municipal wastewater of secondary treatment studying results for gas production, power consumption and effects of electrolysis on wastewater. The study emphasizes the importance of real-time monitoring and data collection during electrolysis process. Open-source sensors and monitoring systems are integrated into the system for temperature, pressure, pH, turbidity and dissolved oxygen to have a deeper analysis of water quality parameters. This research contributes to the ongoing dialogue on sustainable water management and sets a precedent for the integration of innovative technologies in wastewater treatment systems.