School of Computing, Engineering, and the Built Environment
Edinburgh Napier University

PHD STUDENT PROJECT

Application instructions:
Detailed instructions are available at :
https://www.napier.ac.uk/research-and-innovation/doctoral-college/how-to-apply

Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.

Project details

Supervisory Team:

- DIRECTOR OF STUDY: Dr Chan Hwang See (Email: c.see@napier.ac.uk)
- 2ND SUPERVISOR: Dr Naser Ojaroudi Parchin and Dr Zhiyuan Tan

Subject Group: Cyber Security and System Engineering

Research Areas: Computer Science: Internet of Things, Engineering: Communications Engineering, Electrical Engineering, Electronic Engineering, Systems Engineering

Project Title: Wireless Power, Sensing and Communication Network

Project description:

In the upcoming era of sixth-generation (6G) networks, it is predicted that a wide range of low-power devices will have the capability to efficiently sense their surroundings and transmit data on a large scale. A wireless power, sensing, and communication network (WPSCN) serves as the essential infrastructure that allows devices to wirelessly communicate with each other, exchange data, and receive wireless power to ensure uninterrupted operation. With wireless power technology in place, the need for physical connectors and cables to charge devices is eliminated, offering users enhanced convenience and flexibility in device placement and usage, especially in environments where wired connections are impractical or hazardous.

The implementation of sensing technology within the network empowers devices to gather data from their environment and share this information with other devices

within the network. This real-time data sharing enables monitoring, control, and decision-making in diverse applications such as smart homes, industrial automation, and healthcare. Additionally, communication capabilities within the network facilitate the exchange of data, commands, and information among devices, thereby fostering collaboration and coordination. This collaborative approach can lead to increased efficiency, reduced energy consumption, and improved productivity across various industries.

By integrating sensing, communication, and power transfer functionalities into a unified solution for next-generation wireless networks, a seamless and comprehensive solution is created that enhances connectivity, efficiency, and overall user experience. While traditional approaches to deploying large-scale sensor networks often involve extensive cabling for power supply and data collection, or the use of battery-operated wireless sensors that pose environmental challenges due to the disposal of billions of batteries annually, these methods are not always ideal. Although necessary in certain situations where manual monitoring is not feasible due to real-time data requirements or harsh environmental conditions, the high cost, installation complexity, and maintenance demands associated with these traditional methods often do not justify their use over manual inspections and monitoring. To address these challenges, the concept of energy harvesting was introduced as a sustainable solution to alleviate the environmental impacts of traditional sensor network deployments.

The project's aim is to develop an autonomous wireless sensor network system with energy transfer and harvesting, communication and sensing capability. This work will focus on the development of RF energy harvesting systems for battery-less wireless sensor network. This research work will require to design, develop and implement a generic low-cost smart sensing environment and communication protocol for monitoring the nation's ageing infrastructure and harsh environment. Due to the complexity of the monitoring system requires the following published literatures to be explored: sensor systems, energy harvesting/transfer/storage technologies, antennas, wireless communications, autonomous systems, information management, programming and design tools, trust security and privacy, systems theory, human factors and social issues. It is also important that the system allows communication between different infrastructure owners. Hence there is a need to take a holistic approach rather than an infrastructure specific approach to tackle this problem.

References:

Z. Meng, K. Zhang, Z. Li, G. Feng, N. Gao and Z. Zhang, "Sensing With Wireless Power and Data Transfer—Design of a Multisensor Augmented RFID," in IEEE Sensors Journal, vol. 23, no. 24, pp. 31148-31158, 15 Dec.15, 2023, doi: 10.1109/JSEN.2023.3328024.

J. V. de Almeida, X. Gu and K. Wu, "SWIPT Base Stations for Battery-Free, Wirelessly Powered IoT Networks: A Review on Architectures, Circuits and Technologies," in IEEE Microwave Magazine, vol. 25, no. 6, pp. 22-40, June 2024, doi: 10.1109/MMM.2024.3378610

Z. Zhou, X. Li, G. Zhu, J. Xu, K. Huang and S. Cui, "Integrating Sensing, Communication, and Power Transfer: Multiuser Beamforming Design," in IEEE Journal on Selected Areas in Communications, doi: 10.1109/JSAC.2024.3413996.

Candidate characteristics

Education:

A first degree (at least a 2:1) ideally in Electrical & Electronic Engineering or Computer Science or Wireless Communications

Subject knowledge:

A good fundamental knowledge of Electromagnetism, antenna, battery, supercapacitor, renewable energies, cyber security, radio propagations and microwave theory.

Essential attributes:

- Experience of fundamental antenna design and modelling
- Competent in Electromagnetics Theory and Fields
- Programming skills
- Knowledge of renewable energies, wireless sensor network, Microwave/millimetre wave transmission systems and devices, cyber security, power analysis and wireless communication theory/principles
- Good written and oral communication skills

Desirable attributes:

- This project is suitable for applicants with interests and good back ground in renewable energies, radio propagations, electromagnetic and electromagnetics design and particularly in electromagnetic wave propagation, antenna and antenna arrays for communications systems and energy harvesting systems