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

PHD STUDENT PROJECT

Funding and application details

Funding status: Self funded students only

Application instructions:
Detailed instructions are available at https://blogs.napier.ac.uk/scebe-research/available-phd-student-projects/

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: Hongnian Yu (Email: H.Yu@napier.ac.uk)
- 2ND SUPERVISOR: Dr Yuyang Zhou and Dr Keng Goh

Subject Group: Cyber-security and system engineering

Research Areas: Control Systems, Cybernetics, Dynamics, Robotics

Project Title: Modelling and adaptive robust control of an unmanned electric Underactuated bicycle

Project description:

In response to the imperative to achieve net-zero emissions and effectively combat environmental concerns, there is a growing consensus on the need to prioritize e-bicycles over conventional automobiles. E-bicycles present a sustainable and energy-efficient mode of transportation, substantially reducing emissions and energy consumption. Encouraging e-bicycle usage for short trips and urban commuting can significantly diminish the collective carbon footprint associated with personal travel. By actively promoting e-bicycle adoption and developing supportive infrastructure, we can actively steer our transportation systems towards a future where e-bicycles take center stage, contributing to our efforts to attain net-

zero emissions and foster a cleaner and more sustainable environment. This project is cantered on the modelling and adaptive robust control of unmanned electric underactuated bicycles, navigating through uncertain environments. This project, while challenging, represents an innovative and exciting endeavour. This research will focus on the following key tasks:

1) System Modelling: create a comprehensive dynamic model of the unmanned electric bicycle, covering aspects such as bicycle kinematics and dynamics, accounting for its underactuated characteristics, mass distribution, inertial properties, motor and battery attributes, wheel and tire dynamics, and environmental factors like friction and wind.
2) Controller Design: propose and implement adaptive control algorithms capable of accommodating variations in system parameters and external disturbances. Adaptive control mechanisms will enable real-time adjustments based on environmental changes. This will include algorithms for estimating dynamic parameters, like variations in mass distribution, tire properties, and friction coefficients. Moreover, we will develop robust control strategies to ensure system stability and performance in the face of uncertainties, allowing the adaptive robust control system to adapt to changes in the system's behaviour, such as parameter variations, external disturbances, and unexpected events.
3) Stability and Performance Analysis: The project will involve an in-depth analysis of control system stability to guarantee the unmanned bicycle's stability across various conditions. We will also assess performance metrics, focusing on tracking accuracy and the system's ability to reject disturbances.
4) Simulation and Experimental Testing: construct a simulated environment to rigorously test the control algorithms and evaluate their performance in diverse scenarios. Additionally, we will implement the control algorithms on embedded hardware for real-time control of the unmanned bicycle. Systematic testing will be conducted on a physical prototype, including controlled experiments and real-world testing.
5) Documentation and Reporting: Throughout the project, we will maintain comprehensive documentation, including model equations, control algorithms, and testing results. We will prepare reports and necessary documentation for stakeholders and regulatory authorities.

References:

Candidate characteristics

Education:

A first-class honours degree, or a distinction at master level, or equivalent achievements in Computing, or Computing Engineering, or Electronics and electrical engineering, or Robotics, or Control Engineering, or Mathematics

Subject knowledge:

Qualifications: Prospective candidates for this research should have a strong background in robotics, control systems, mechanical engineering, or a related field. An understanding of underactuated systems, adaptive control, and robust control strategies

Essential attributes:

- Experiences in modelling of a dynamic system
- Good written and oral communication skills

- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

- Knowledge of control engineering
- knowledge of robotics