Royal Academy of Engineering

Research Internship Scheme 2024/25

Project List

Autonomous drone for emergency response: simulation and testing

Location: University of York

Reference: RISAH-2425-2101 Host: Professor Ana Cavalcanti

Duration: 3 June – 23 August 2024

Abstract: Emergency services can benefit from assistance from autonomous drones to reach difficult-to-access areas faster and without putting the lives of emergency personnel at risk. Interactions between autonomous drones and humans and fragile environments, however, raise significant concerns. We must use the most modern technology to develop trustworthy drones. In this project, we will use RoboStar technology to support the development of a drone that can search for victims and provide medical assistance. We will use automated techniques to develop simulations and carry out tests using a programming approach widely adopted in robotics.

Project description: Autonomous drones can support emergency services in reaching difficult-to-access areas and can help them treat more injured people. We must, however, use the most modern design and verification technology to ensure trustworthiness. In this project, we will use RoboStar (robostar.cs.york.ac.uk) technology to support the development of software for a drone that can search for victims and provide medical assistance. The detailed tasks with schedule are as follows.

- Week 1: Studying the requirements of the application based on an example provided by one of our industry collaborators and the robotics literature.
- Weeks 2 and 3: Defining a design using a diagrammatic notation like UML, but tailored for the definition of robotic control software, namely, RoboChart [1]
- Week 4: Use of an automatic code generator to run animations of the RoboChart model to validate it. The coding language will be C++ or Rust, depending on the interests and expertise of the intern.
- Weeks 5 and 6: Study of ROS (Robotic Operating Systems) [2], a middleware that is widely used in the robotics community.
- Week 7: Developing an ROS simulation to automatically generate C++ code.
- Week 8: Studying the RoboStar automatic test generators.
- Weeks 9 and 10: Evaluating the simulation using the automatically generated tests.

Weeks 11 and 12: Writing a short report describing the results and the lessons learned, in terms of the use of RoboStar technology and ROS.

Depending on how the project goes and the availability of the intern to work in York, there may be time to run the automatically generated code and tests also in an actual drone and run supervised tests in the lab with our technicians.

The overall result of the project is thoroughly tested code for the application, and to demonstrate the low cost of applying RoboStar technology to a significant application of great societal interest. The project may also lead to improvements of the RoboStar tools [3].

References

[1] A RoboChart tutorial is available (https://robostar.cs.york.ac.uk/notations/robochart-tutorial/), and additional publications and examples can be found at https://robostar.cs.york.ac.uk/notations/. Some publications are
* A. Miyazawa, A. Cavalcanti, P. Ribeiro, W. Li, J. Woodcock, J. Timmis: RoboChart Reference Manual. University of York (2016).
* A. Miyazawa, P. Ribeiro, W. Li, A. L. C. Cavalcanti, J. Timmis: Automatic Property Checking of Robotic Applications. In: The International Conference on Intelligent Robots and Systems.

[2] There is extensive documentation about ROS, including teaching material we have at York. A good source is https://wiki.ros.org/ROS/Tutorials.

[3] The RoboStar tool is available from https://robostar.cs.york.ac.uk/robotool/. A tutorial is available at https://robostar.cs.york.ac.uk/robotool/tutorial/. We also have teaching materials that we can provide to the intern.

Preferred intern working pattern: The most productive and potentially enjoyable working pattern will be in person in the lab every day or most days, at least for a significant amount of the core hours: from 10 to 4. In this way, the intern will have the opportunity to integrate fully with the RoboStar team and take advantage of their expertise. There is, however, plenty of flexibility. We can change the start dates by agreement. It is also possible to work from home, if the intern come to the office at least once a week and attend the meetings in person.

A shorter programme of work can be pursued if the intern is not available for full-time work and for the full term of the internship. We note, however, that completing the programme puts the intern in a strong position to contribute to a research paper that we can publish together. This is potentially a very attractive addition to the intern's CV.

Can the internship be carried out from home (remotely): Yes

Will remote working equipment be provided: Yes

Two posts are available for this project.

Spatial forecasting of wave spectra for offshore wind

Location: University of Exeter

Project: RISAH-2425-2106 Host: Dr Ajit Pillai

Duration: 5 June – 20 August 2024

Abstract: Floating offshore wind farms rely on accurate models of the winds, waves, and currents. Prior to construction, these inform the platforms and turbines' designs, and throughout the wind farm's life they are necessary to plan inspection and maintenance operations. This engineering internship will assess new wave modelling methods at proposed offshore wind farm sites in the Celtic Sea. Using data collected from these sites, the intern will be responsible for extending a machine learning wave forecasting methodology beyond averaged statistical parameters to operating with spectral data, providing a more complete wave forecast that can better guide engineering decisions.

Project Description: This internship will apply novel environmental modelling techniques to challenges in the offshore wind sector. The intern will build this machine learning-based spectral forecasting model and validate it against both conventional physics-based forecasts and an existing machine learning-based averaged wave parameter forecast for areas of interest in the Celtic Sea. This internship will support ongoing research with Celtic Sea Power who will provide access to data, and the UK Met Office, with whom new methods are being developed. This is broken into 5 tasks:

Task 1: Training and data preparation
As part of the data preparation step, the intern will work closely with the supervisor and the University of Exeter Renewable Energy Group to familiarise themselves with data processing and wave spectra using Matlab and Python, and resource characterization from an offshore wind farm perspective. The objective is to both familiarise the intern with the models and measurements used in offshore wind farm design, and to process all raw data for use in latter stages of the internship. During this phase, material from Exeter's Renewable Energy taught undergraduate and Masters programmes will be made available to the intern to help accelerate their learning and understanding in this field. [Weeks 1-2]

Task 2: Wave spectra parameterisation
Once the data has been prepared during the first phase of the project, this phase of the project explores wave spectra and different methods to parameterise the wave spectra. The aim of this task is to identify suitable methods for parameterising wave spectra, and to identify the conditions where specific parameterisation schemes may be more appropriate by comparing these against the measured spectra. The machine learning framework (Task 3) is sensitive to the number of variables; it is therefore advantageous to use parameterisation schemes rather than empirical spectra. [Weeks 3-5]

Task 3: Machine learning model development

The main aim of this internship is to extend a machine learning wave forecasting model to operate with spectra. This task, therefore, builds this model using the data from Task 1 and the parameterisation strategy identified in Task 2. The work will be completed first, considering only a single location and then moving to spatial forecasts. [Weeks 4-8].

Task 4: Model comparison
Task 4 will compare the outputs of the model from Task 3 against both conventional physics-based forecasts and the existing machine learning model for wave parameters. The comparison process will quantify the accuracy of the model and identify specific environmental conditions that the model both does and does not capture well, using the data analysis training completed in Task 1. This task will also use engineering models to characterise how the forecasts impact loads on offshore structures in a preliminary study. [Weeks 8-10]

Task 5: Reporting
Task 5 will prepare a final report detailing the analysis undertaken as well as a summary presentation to be presented to both members of the University of Exeter Renewable Energy team, but also interested industry parties including Celtic Sea Power, SimplyBlue Energy, and the UK Met Office. [Weeks 11-12].

Preferred intern working pattern: This internship is based within the University of Exeter's Renewable Energy Group based on the Penryn Campus in Cornwall. The internship would be desk based, however, is flexible to accommodate changes in the start dates and working pattern based on the intern's circumstances. The university does not have core hours and there is flexibility for the intern and supervisor to select working hours that suit the intern and supervisor. If necessary, the role can be carried out remotely. There is a final dissemination event that will be held in person on the Penryn Campus involving several stakeholders for which the candidate would need to travel if not locally based.

Can the internship be carried out from home (remotely): Yes

Will remote working equipment be provided: Yes

Two posts are available for this project.

Using Apple AirTag technology for source-less radiation protection training

Location: University of Bristol

Project: RISAH-2425-2116 Host: Dr Peter Martin

Duration: 3 June – 3 September 2024

Abstract: Radiation is all around us because of naturally occurring radioactive materials, or NORM, from cat-litter to low-sodium salt, and rocks to various items of food. However, while these items give off safe and very low levels of ionising radiation, greater levels are found and used across science, industry, and manufacturing – with training people to safely handle and protect themselves from radiological hazards being a major challenge, taking time, expense and risking potential contamination. Could Bluetooth sensors combined with smartphones provide a low-cost training solution to enable safe radiological protection and response training?

Project description: While near-field communication (NFC) and Bluetooth technology has existed for decades as a sensory, detection, and security tool, it has only been in recent years, with the development and release of Apple's AirTag technology, that its use across the consumer market has exploded.

Many people are continually losing possessions and have become dependent upon the accurate, 'crowd-source' nature of the collaborative technology to find items. Can this technology be used as a low-cost means of training first responders, operators, and site personnel in radiation protection and dosimetry? Using the NFC tag can we teach users how to safely operate around radioactive sources without the need to use alpha, beta, or gamma emitters?

Using the API key provided by Apple for their low-cost products, this project will work to develop an iOS App allowing people to rehearse how to safely monitor for contamination and remediate spills – all without the need and inconvenience of using actual emitters. With the support of scientists here at the University of Bristol (UoB), the internship will involve using the freely available Apple codebase to produce several fictitious radioactive sources which can be detected using the Geiger Counter app that you will develop – again with the support of the UoB team. At the end of the project, you will have a system that can be used to train scientists and first responders around the world in how to safely handle radioactive contamination/event, without the need for real radioactive sources. The outcomes of this project will be used not just here in the UK but will be vital in training collaborators at sites such as Chornobyl, where the continual monitoring of differing types of radioactive contamination is vital for their everyday routine clearance activities.

Preferred intern working pattern:

Like all the summer internships that have been, and continue to be run, by Dr Martin within the Interface Analysis Centre (IAC) research group at UoB, a highly flexible approach is always adopted to suit the student in their work. While they are at the university, they are thoroughly immersed in the activities of the group – including seminars, lab meetings, visits, and summer social activities. To get the most from their summer internship, most students work on the UoB Precinct and in IAC labs/offices full-time, although working from home and flexible working to suit the student is always possible! But every student to-date has said that being based on-site amongst an active research community is one of the best bits of the entire project with Dr Martin and the IAC – with many not wanting to leave and be a student again!

Can the internship be carried out from home (remotely): Yes

Will remote working equipment be provided: Yes

Aeroacoustic characterisation of ducted contra-rotating drones

Location: University of Southampton

Project: RISAH-2425-2117 Host: Dr Chaitanya Paruchuri

Duration: 24 June – 15 September 2024

Abstract: Drones have become increasingly prevalent, from capturing stunning aerial photos to aiding in search and rescue missions. However, the noise they generate can be a nuisance and even a safety concern. Researchers have been working to address this issue, and one promising solution is the use of ducted rotors. The noise radiation from two closely coupled propellers has many distinct interacting sources in addition to rotor alone noise in isolation. There is therefore an urgent need to develop prediction tools and develop low-noise concepts for ducted contra-rotating propellers.

Project description: Drones have become increasingly prevalent, from capturing stunning aerial photos to aiding in search and rescue missions. Experts are currently predicting that the size of this sector is expected to quadruple by 2025. It has been estimated that the cost savings from drone technologies to the UK economy will be about £16 billion by 2030. However, the noise they generate can be a nuisance and even a safety concern. Researchers have been working to address this issue, and one promising solution is the use of ducted rotors.

Ducted drones offer increased safety with enclosed rotors, making them suitable for operations in confined spaces and around people, while their improved aerodynamics enhance stability and reduce noise, making them ideal for applications like surveillance and urban environments. Contra-rotating (two rotors rotating in opposite direction) ducted drones especially can achieve higher thrust-to-weight ratios, allowing for better lifting capabilities and payload capacities in various applications. However, the noise generated by these rotor systems is generally significantly higher than single rotor systems due to the mutual interactions that take place both between adjacent blade rows and between the rotors and the duct. Noise is therefore one of the main factors that limit their public acceptability.

This project describes detailed flow and noise measurements in state-of-the-art facilities to gain a fundamental understanding into the aerodynamics and aeroacoustics mechanism of contra-rotating ducted propeller systems. Our project objectives are:

1) To investigate and characterise the various noise-generating mechanisms of ducted contra-rotating propeller systems.

2) To analytically predict the dominant noise source and validate against measured data.

The intern will be using a state-of-the-art drone rig recently built at the Institute of Sound and Vibration Research at the University of Southampton. The intern will be able to work with other motivated PhD researchers and will work as part of our research team. One of the key goals of the project is to give the intern the experience of performing research and show them how to ask fundamental research questions to solve complex engineering problems. The project is divided into specific tasks:

- Understanding noise sources in contra-rotating propellers.
- Understanding the role of ducts in propeller systems.
- Becoming acquainted with drone operation and measurement systems.
- Evaluating acoustic and aerodynamic performance.
- Utilizing prediction models and validation.
- Reporting findings.

The successful completion of this project has the potential to pave the way for advancements in ducted drone technology. The outcomes of this research can be disseminated through publication in conference proceedings scheduled for 2025 in the US.

Preferred intern working pattern:

The internship for this project follows a specific working pattern due to its experimental nature. Experiments occur in two distinct phases during Week 4-5 and Week 9-10 of the 12-week internship. During these experimental phases, the intern is required to be physically present in Southampton for a total of four weeks (including a week for planning and setup) as our research facilities, such as the ducted rotating rig and anechoic chambers, are crucial for this phase. The timing of these testing periods can be adjusted to align with the intern's preparedness.

Following the data collection from experiments, the intern will have the flexibility to work remotely for data processing. During this phase, a minimum of 20 hours per week is expected to make steady progress. The start date of the internship is also adaptable to accommodate the intern's schedule, promoting a wider range of applications from eligible students. This flexibility in working patterns aims to ensure that the internship is accessible and accommodates a diverse pool of candidates.

Can the internship be carried out from home (remotely): No

Will remote working equipment be provided: No

Two posts are available for this project.