Engineering and Physical Sciences Research Council

University of Exeter

Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Metamaterial Skins for Sensory Surfaces

Lead Supervisor: Alex Powell

Co-Supervisors: Simon Horsley

Webpage: https://researchpubs.exeter.ac.uk/userprofile.html?uid=32698

Project details: This project will develop a sensory surface for smart vehicles, appliances or robot manipulators that combines proprioception, touch, and multiple other senses. This surface will be in the form of a metamaterial, the physics of which enables exceptional control over the flow of electromagnetic signals across its surface. The advantage of this 'Meta-Skin' is its simplicity - a dense network of 'meta-atom' sensors over an extended surface will be capable of proprioceptive shape determination, damage detection, proximity warning of nearby objects, and various other forms of sensing using only a single electrical connection. If such a skin were made using discrete sensors and circuits (the current industry standard) then it could be very complex and costly. It would require many data bus lines, signal conditioning circuits and local processing for filtering. Additionally, its power consumption would make it expensive and inefficient. Even if the wiring is built into the structure, multiple sensors will add a lot of complexity to an otherwise simple object. Our approach is quite different and exploits recently developed techniques using metamaterials and the electromagnetic signals that they support. Instead of a custom circuit board or embedded wiring, we employ a metamaterial, composed of 'meta-atoms' - coupled, passive (unpowered), electromagnetic resonators like split-rings. This Meta-Skin requires electrical connection and processing only at the feed points, each of which can address potentially hundreds of sensing locations. Meta-Skin derives its properties from the fact that it is able to support electromagnetic surface waves that are confined to the metamaterial as standing waves. Our innovation is to exploit the properties of these standing waves to provide information about the condition and environment of the surface. Distortions to the surface, damage to meta-atoms or the presence of nearby objects will modify its standing waves in predictable ways, and the extent of that modification can be controlled by careful design of the meta-atoms and their configurations. This project will build on existing work at Exeter and with collaborators at the University of Oxford to develop and integrate sensors with these meta-skins to increase the types of stimuli they can perceive. This will combine ideas from metamaterials, shape-morphing structures and potentially other advanced materials to develop sensors for pressure (touch), shear-force, temperature, humidity and more. The first year of the project will focus on developing one of these sensors, and then integrating it with the existing meta-skin. Further sensors will then be designed, and used to create a multi-sensory surface. For the final stages of the project, there is the option work with collaborators at Oxford to then apply these meta-skins to robot actuators or components of an intelligent vehicle, and test them in a 'real world' scenario. This project will work with collaborators at top universities and UK industries and will be taking fundamental physics towards an exciting and impactful real-world application.

Project Partners: QinetiQ, & University of Oxford.

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Project Specific requirements: 2:1 minimum in relevant STEM fields.

Potential PhD programme of study: PhD in Physics

Department: Physics and Astronomy

Location: Physics building, Streatham campus

Please direct project specific enquiries to: Contacts should go to me at a.w.powell@exeter.ac.uk

Please ensure you read the entry requirements of programme to which you are applying.

To apply for this project please click here.