EPSRC DTP PhD Research Project

Project Title: Artificial Intelligence Design of Tailored Light-Matter Interactions

Primary Supervisor details:

Dr Simon Berry (QinetiQ Principal Scientist, Royal Society Industrial Fellow & Honorary Senior Lecturer)

Additional Supervisory team details:

Prof. Edward Keedwell (Professor of Artificial Intelligence)

Prof. Alastair Hibbins (Professor of Metamaterial Physics)

Department: Physics and Astronomy

Location: Streatham campus, Exeter

PhD Programme: PhD Physics/Computer Science (TBC)

Project Description:

Metamaterials have the potential to be used in a wide range of applications for control of EM propagation, in areas such as stealth, communication and connected devices (e.g. internet of things). The efficient design of these structures often requires significant manpower and computational effort, due to iterative modelling approaches. Artificial Intelligence (AI) has the potential to significantly improve the efficiency of this process [1] and thereby help the future exploitation of these materials. Additionally, AI has also demonstrated the capacity to develop novel systems outside of the typical human-engineered style, showing the potential for developing entire classes of materials that have yet to be imagined.

The density of electromagnetic (EM) energy in the modern built environment is continually increasing as the demand for interconnectivity grows. New technological developments exacerbate the situation, such as future 5G technologies (estimated to be worth up to $1.7 trillion in 2030) that are planned to operate outside the traditional frequency bands (sub – 3GHz) [2], further congesting the commercial EM spectrum and raising the spectre of interference effects. There is hence an increasing need to control EM energy across a wide range of commercial systems and frequency bands.

Recent research has shown the possibility of using deep neural networks and machine learning to optimise the performance of antennas and metamaterial structures, without the time-consuming optimisation required using traditional computational electromagnetic techniques. Research into metaheuristics and hyper heuristics has also shown the ability of AI to speed up the completion of optimisation problems with limited computational budgets. Beyond this, AI techniques have also demonstrated the capacity to create new materials, based on prediction of existing material behaviour, that are radically different from human-engineered solutions and offer a host of exciting possibilities. This research will look at developing the use of AI in creating tailored light-matter interactions, focused within the microwave regime, and could focus on a variety of areas including increased antenna performance, control of EM energy propagation or transformation optics. The overall approach would be to look at creating improved performance with the use of AI in a more efficient manner than traditional computational EM optimisation techniques, both in terms of the time and effort taken, and the performance of the final materials produced.

This work will be undertaken in collaboration with a QinetiQ Royal Society Industrial Fellow based at the University of Exeter and both the Computer Science and Physics Departments.

This project has a direct link into industry through Dr Simon Berry and is linked to a recently established Royal Society Industrial Fellowship supported by both QinetiQ and the University of Exeter. Were this work to be successful there is a direct exploitation route available within QinetiQ to improve the electromagnetic modelling capability that currently exists.

References:

[1] Ghorbani et. al., 'Deep neural network-based automatic metasurface design with a wide frequency range', Scientific Reports, 11, 7102 (2021)

[2] 'Enabling 5G in the UK', Ofcom discussion document, March 2018

Project specific enquiries:

IIf you have project specific enquiries please contact the lead supervisor named above.