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Meeting global challenges

From 2020, **University of Bristol** will launch a new Master of Science degree programme in Engineering with Management

The School of Civil, Aerospace and Mechanical Engineering at the University of Bristol is one of the top engineering schools in the United Kingdom, well-known internationally for its excellent teaching and world-class research. From 2020, a new Master of Science degree programme will launch in Engineering with Management. Comprising one-year of full-time study, the programme's innovative structure will allow students to study core material on management, design and technology topics in the first semester before dividing into four technical pathways, each with a focus on leading-edge engineering approaches that address fundamental societal challenges.

The initial pathways of Energy for Sustainability, Engineering Modelling and Simulation, Intelligent Manufacturing and Infrastructure Systems draw on the school's extensive research interests and builds on links made with industry and with other research teams around the world. Students studying on the programme are very likely to find themselves working with top researchers and/or with leading companies, especially in the research projects that will form a key part of their studies.

As an example of the global challenges that the programme is designed to address, consider the developments that are needed in energy systems and infrastructure if catastrophic global warming is to be avoided. New low-carbon energy systems need to be constructed, together with infrastructure for water resources, transportation and other applications. Infrastructure such as flood defences also needs to be adapted such that it is more resilient to the effects of climate change. These issues are the focus of the Energy for Sustainability and Infrastructure Systems pathways, which draw on the University's world leading research in areas such as water resources management, smart systems and renewable energy, and on its links to key influencers and decision makers in government and companies. A number of important consulting engineering and renewable energy companies are based in Bristol, and these have been strongly involved in the development of teaching material in these themes. The city of Bristol itself is also a leader in these issues: it was the European Green Capital in 2015, and is recognised as one the UK's leading 'smart cities', in particular owing to the 'Bristol Is Open' joint venture between the University of Bristol and Bristol City Council.

Bristol is also a centre of the aerospace and electronics industries and home of the National Composites Centre, a research and development hub for lightweight structures, all of which make extensive use of leading-edge technologies especially in manufacturing and in engineering modelling and simulation, the topics of the other two pathways. Local companies are leading the development and application of metal additive layer manufacturing, and of supercomputers to engineering simulation - the University hosts world-leading research in composite materials and across a range of computational modelling approaches. Much of the taught material in the Modelling and Simulation pathway has been developed from the needs of the aerospace industry for advanced multi-disciplinary modelling and optimisation techniques, while Intelligent Manufacturing will be supported by staff and companies with expertise in 3D printing, Industry 4.0 and the Internet of Things.

Design, technology, digitalisation and global challenges are important aspects of engineering education for the 21st century, but so too is new thinking about how the subjects should be taught. Moving away from a diet of passive lectures and exams, the new programme is being developed with an emphasis on experiential learning and programme-level assessment, again reflecting such developments across the University's educational programmes. Throughout the MSc programme, emphasis will be placed on learning-by-doing and by reflective practice. In this regard, taught units in the first semester will be complemented by an Integration Project undertaken as a team project with individual submission elements and leading to a business project proposal. More broadly within the University, global challenges are emphasised in the University's 'Bristol Futures' initiative in which students can engage with the interdisciplinary themes of Innovation and Enterprise, Global Citizenship and Sustainable Futures.

Design is seen today as a key competence in achieving competitive advantage and crucial to innovation and problem-solving. It is a foundation

for the new programme. University of Bristol is noted for its design expertise across aerospace, civil and mechanical engineering, and its Engineering Design undergraduate degree regularly leads UK league tables for general engineering degrees (while its students have been responsible for a host of start-ups such as additive manufacturer EngX and the indoor agricultural company LettUs Grow). As an example of the way the University works with industry, this degree programme is supported by companies including Arup, Atkins, Babcock, DNV-GL, GKN, Renishaw and Rolls-Royce, who guide the content of the programme, provide students with 'year in industry' placements, and support research and design projects. This type of approach to working with industry is seen to be a key element of future educational provision so we're always looking for companies to provide industrial placements and projects for our enthusiastic and knowledgeable students.

Engineers are in high demand across every sector and this new postgraduate degree programme will expose those already in industry to new technology, systems and an experiential approach to learning that will equip them with the skills needed to meet global challenges.

www.bristol.ac.uk/pg-eng2019

Inspired from nature - robots can now learn to swarm on the go

A new generation of swarming robots which can independently learn and evolve new behaviours in the wild is one step closer, thanks to research from the University of Bristol and the University of the West of England (UWE).

The team used artificial evolution to enable the robots to automatically learn swarm behaviours which are understandable to humans. This new advance could create new robotic possibilities for environmental monitoring, disaster recovery, infrastructure maintenance, logistics and agriculture.

Until now, artificial evolution has typically been run on a computer which is external to the swarm, with the best strategy then copied to the robots. However, this approach is limiting as it requires external infrastructure and a laboratory setting.

By using a custom-made swarm of robots with high-processing power embedded within the swarm, the Bristol team were able to discover which rules give rise to desired swarm behaviours. This could lead to robotic swarms which are able to continuously and independently adapt in the wild, to meet the environments and tasks at hand. By making the evolved controllers understandable to humans, the controllers can also be queried, explained and improved.

Co-led by Dr Sabine Hauert, the engineers took advantage of the recent advances in high-performance mobile computing, to build a swarm of robots inspired by those in nature. Their 'Teraflop Swarm' has the ability to run the computationally intensive automatic design process entirely within the swarm, freeing it from the constraint of off-line resources. The swarm reaches a high level of performance within just 15 minutes, much faster than previous embodied evolution methods, and with no reliance on external infrastructure.

By freeing the swarm of external infrastructure, and by showing that it is possible to analyse, understand and explain the generated controllers, the researchers will move towards the automatic design of swarm controllers in real-world applications.

In the future, starting from scratch, a robot swarm could discover a suitable strategy directly in situ, and change the strategy when the swarm task, or environment changes.