

STRONG
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Strengthening Maritime Technology
Research Center

Winter School on
Advanced Autonomous Marine Operations
Programme

Heriot-Watt University, UK

5th to 9th February 2018

06—09 February 2018
Edinburgh, Scotland,
United Kingdom



STRONG
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ADVANCED AUTONOMOUS MARINE OPERATIONS

WINTER SCHOOL

ORGANIZER



www.strongmar.eu

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<http://www.strongmar.eu/site/advanced-autonomous-marine-operations-57>



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1. Welcome

Dear all participants,

Welcome to another Winter School in the **STRONGMAR** series.

The aim of **STRONGMAR** is to create solid and productive links in the global field of marine science and technology between INESC TEC and established leading research institutions in Europe, that are capable of enhancing the scientific and technological capacity of INESC TEC and linked institutions, thereby helping raising research profile of its and its recognition as a European maritime research centre of excellence.

The training strategy of the **STRONGMAR** project is based on technical presentations and demonstrations covering multidisciplinary aspects of marine science and technology, followed by sessions focused on specific fields of expertise, allowing researchers to improve their knowledge and preparing them for the research and implementation challenges in the harsh sea environment. This training strategy targets not only theoretical training but also practical aspects with hands-on laboratory demonstrations, enabling direct application of the knowledge acquired and improvement of understanding of the actual requirements of the stakeholders, allowing attendees to design solutions with higher economic potential. Interchange and interaction among different fields of expertise is fundamental to address the ocean challenges, due to the multidisciplinary nature of the application area. Cross-fertilization among fields of expertise is also key to stimulate the design of better specific solutions.

This winter school (**Advanced Autonomous Marine Operations**) will cover the following broad topics: basics of deep learning and its application in robotics; deep learning based perception for sonar and video images; sequence modelling; sequence to sequence models and learning from sensor data; motion control and advanced path planning of robots and AUVs based on deep reinforcement learning; hands-on training on design and development of deep neural networks.

The **STRONGMAR** team.

2. Travel Information and Venues

The Winter School will take place in the Edinburgh Conference Centre, Edinburgh Campus, Heriot-Watt University, Edinburgh, UK.



2.1. Travel Information

Edinburgh International Airport is served by scheduled national and international flights. The airport is on the west side of the city, just three miles from the Edinburgh Campus of Heriot-Watt University.

The taxi journey from the airport to the campus takes about 10 minutes and costs about £15 for a single journey. It is recommended that several people share one taxi to easily arrive at the University.

The bus journey from the airport to the city centre takes about an hour. The Airlink bus takes you to the city centre (£4.50 single, £7.50 return), then you can take a Lothian Buses service 25, X25, 34, 45 or N25 (night bus) from the city centre to the campus (terminating at Riccarton). Alternatively, you can take an Edinburgh Trams service from the airport to Haymarket (£5.50 single, £8.50 return), then take a Lothian Buses service 25, X25 or N25 to the campus (terminating at Riccarton).

University map: <http://www.hw.ac.uk/documents/edinburgh-campus-map.pdf>

2.2. Accommodation

- **Marriott Courtyard Edinburgh West**

<https://www.marriott.co.uk/hotels/travel/edihw-courtyard-edinburgh-west/>

A brand-new hotel located on the campus of Heriot-Watt University in Edinburgh, Scotland. Offering an accessible location near the airport and 4-star accommodations.

- **Premier Inn Edinburgh Park Hotel**

<https://www.premierinn.com/gb/en/hotels/scotland/lothian/edinburgh/edinburgh-park-the-gyle.html>

Close to a big shopping centre with easy tram links directly to Edinburgh Airport and city centre.

- **Novotel Edinburgh Park Hotel**

<https://www.accorhotels.com/gb/hotel-6515-novotel-edinburgh-park/index.shtml>

The 4-star Novotel Edinburgh Park hotel is a two-minute walk to Edinburgh Park tram and train station providing easy access to the Airport and Edinburgh city centre.

2.3. Heriot-Watt University

With a history dating back to 1821, Heriot-Watt University is a research-led university located in Edinburgh, UK. Currently Scotland's most international university, delivering degree programmes to 31,000 students globally and with campuses in Edinburgh, Scottish Borders, Orkney, Dubai and Malaysia. The university is consistently highly ranked, having been The Sunday Times' Scottish University of Year between 2011 and 2013. The university has a strong track record in attracting funding for research from national Research Councils, UK government departments, charities, the European Commission and industrial sponsors. In the REF 2014 survey of all UK universities, 82% of our research was found to be world-class. In our joint submissions with Edinburgh University we were 1st in the UK for General Engineering, 2nd in the UK for Architecture, Built Environment and Planning, and 5th in the UK for Mathematical Sciences. We hold the Bronze Award from the Athena SWAN Charter, recognising excellence in championing employment of women in the fields of science and technology, engineering and mathematics.



2.4. Edinburgh Centre for Robotics



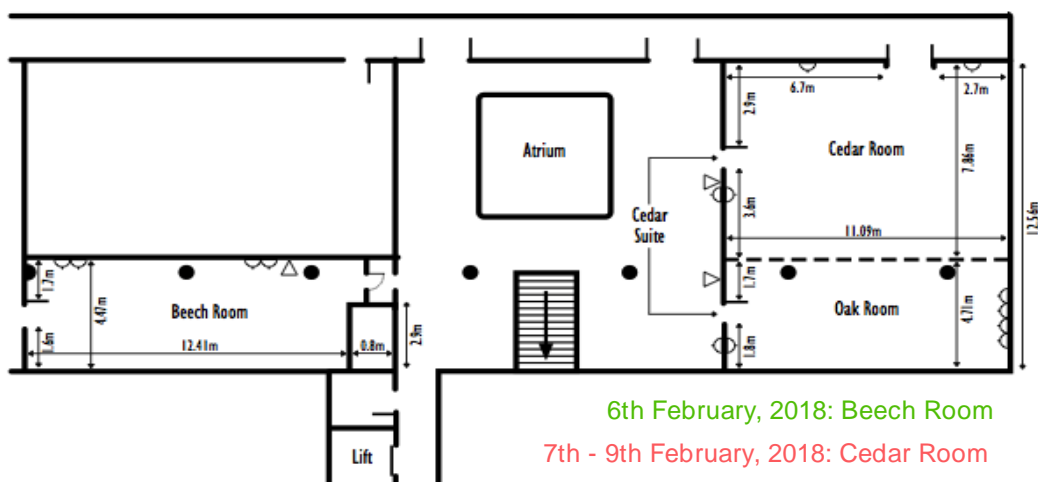
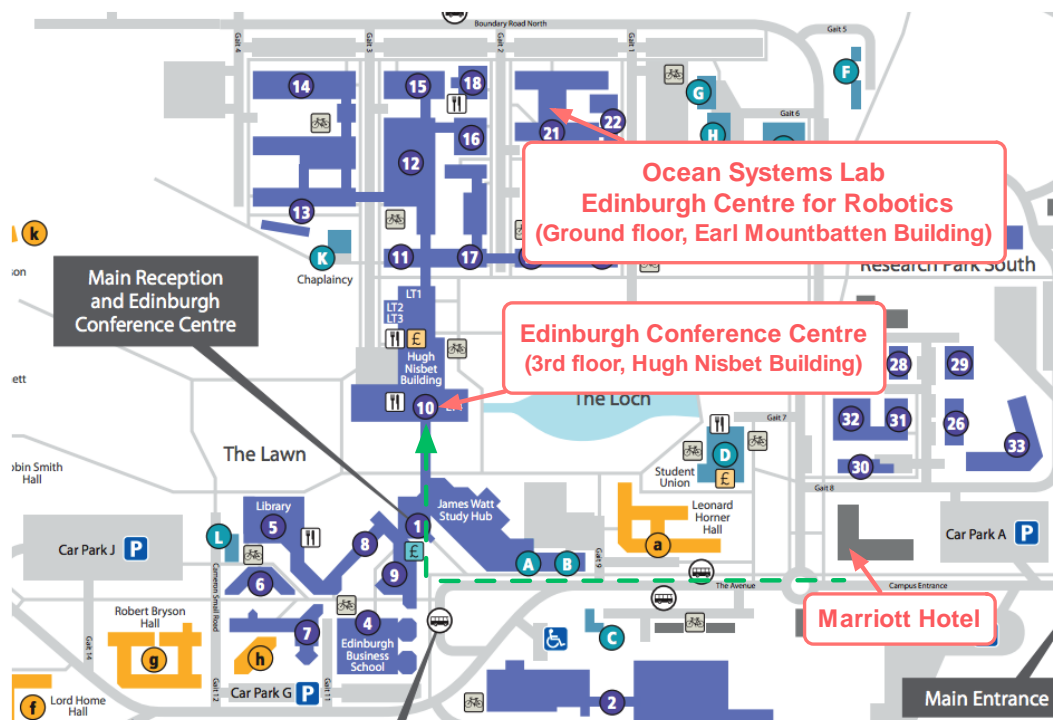
The Edinburgh Centre for Robotics is a £35 Million joint venture between Heriot-Watt and Edinburgh Universities, supported by EPSRC, Industry and the Universities. It captures the expertise of over 30 principle investigators of international standing in 12 research laboratories and institutes across the full range of engineering and informatics disciplines. It includes an EPSRC Centre for Doctoral Training in RAS developing innovation-ready postgraduates, and the ROBOTARIUM £7.2 Million national capital equipment facility. The Centre focuses on autonomous robot interaction with environments, people, systems and each other. Research is conducted using state of the art humanoid and field robotic platforms, in interactive spaces with fabrication facilities for soft embodiments, embedded micro-sensors and dedicated computing. Centre partners include world leading companies in the oil and gas, assisted living, transport, defence, medical and space domains.

2.5. Ocean Systems Laboratory

The Ocean Systems Laboratory is a multidisciplinary science and engineering research centre, leading centre of excellence in underwater robotics and underwater signal & image processing. The 25-strong team specialises in subsea robotics and signal processing for Ocean applications. Particular strengths are in: autonomous systems (novel planning, obstacle avoidance, world modelling, operator dialog and visual servoing methods for Autonomous Underwater Vehicles, integrated within open system architectures); Sensor modelling and analysis (novel navigation algorithms, developed to share information from multiple sensors); Experimental Validation (tank facilities and vehicles enable to validate the theory and simulation findings in real experiments; autonomy and the linkage of perception and action; sonar modelling, design and signal processing (including biologically inspired device); computer aided detection/classification in sonar and video; data fusion; navigation data processing (e.g. using SLAM methods); automated mission planning; data visualisation; intelligent diagnostic systems; augmented reality methods for training, mission analysis and operation. The laboratory partners with industrial and research groups on multiple projects supporting Offshore, Naval and Marine Science applications.

2.6. Venue

Lectures will be delivered in the Beech (6th February) and Cedar (7th and 8th February) rooms in the Edinburgh Conference Centre (ECC), Hugh Nisbet Building, Heriot-Watt University, Edinburgh.



6th February, 2018: Beech Room

7th - 9th February, 2018: Cedar Room

Edinburgh Conference Centre

3. Programme

3.1. Schedule

	Monday 5 Feb	Tuesday 6 Feb Beech Room	Wednesday 7 Feb Cedar Room	Thursday 8 Feb Cedar Room	Friday 9 Feb
09:00 - 09:30	Arrival and Preparation	Registration			Departure or Thematic Workshop
09:30 - 11:00		Opening and Welcome Prof. David Lane, HWU Prof. Yvan Petillot, HWU Deep Learning for Robotics Sen Wang HWU	Recurrent Neural Networks for Sequence Modelling Yishu Miao Oxford and DeepMind	Deep Reinforcement Learning and Its Application to Robotics Linhai Xie Oxford	
11:00 - 11:30		Coffee break	Coffee break	Coffee break	
11:30 - 13:00		Deep Learning for Robot Vision Ruihao Li Essex	Recurrent Neural Models for Robotic Perception Ronald Clark Imperial	Adaptive Control for Marine Robots using Deep Reinforcement Learning Ignacio Carlucho CIFICEN	
13:00 - 14:00		Lunch	Lunch	Lunch	
14:00 - 16:30		Hands On: Design and Training of Deep Neural Networks	Hands On: Design and Training of Deep Neural Networks	Hands On: Design and Training of Deep Neural Networks	
Evening			Invited Dinner		

3.2. Lectures

- Tuesday 6 February 2018 – Perception (Beech Room, ECC)

Opening and Welcome

-- Prof. David Lane, HWU/Prof. Yvan Petillot, HWU

Opening and Introduction

Deep Learning for Robotics

-- Sen Wang, HWU

This talk will introduce deep learning and its application in robotics. It will focus on the basics of deep neural networks, especially Convolutional Neural Networks (CNNs). Then we will briefly review its recent applications in robotics, such as object/target recognition in sonar and video, semantic segmentation, localisation and mapping and control.

Deep Learning for Robot Vision

-- Ruihao Li, University of Essex

Visual perception has been investigated in robotics research community for many years. So far significant progress has been made and geometric based techniques have become mature. Recently there is a trend to merge data driven approaches, such as deep learning, with visual techniques in order to gain better performance. In this talk, we will introduce visual depth estimation techniques using deep learning approaches. Then ego-motion estimation and relocalisation with both supervised and unsupervised deep learning will be discussed. Finally, we will link semantic segmentation using deep learning approaches in computer vision with

emergent semantic SLAM techniques to shed light on simultaneous estimation of ego-motion and high-level environment structures.

- **Wednesday 7 February 2018 – Sequence Modelling (Cedar Room, ECC)**

Recurrent Neural Networks for Sequence Modelling

-- Yishu Miao, University of Oxford and DeepMind

Most of the sensor data and time-series signals in robotics are sequential. In order to model the correlation and learn the relationship in a sequence, Recurrent Neural Networks (RNNs) have been widely used. In this talk, we will introduce the basics of various kinds of RNNs for sequence modelling. We will start from the simple Recurrent Neural Networks and their advantages and disadvantages. Long Short Term Memory (LSTM), the most popular RNN model by now, will then be discussed. Some applications based on sequence-to-sequence models are introduced.

Recurrent Neural Models for Robotic Perception

-- Ronald Clark, Imperial College London

Visual perception models are needed to enable mobile robots to actively explore a scene and understand their surroundings. Lifelong machine perception has thus long been a goal of computer vision for robotics. However, traditional perception models have fallen short of this goal; requiring extensive hand engineering and being plagued by issues of robustness and adaptability. In this talk we will look at ways in which new machine learning methods (specifically deep neural models) are used for robot perception with the goal of eliminating the restrictions incurred by traditional approaches. We will look at how recurrent neural networks (RNNs) can be used to model, recognise and interpret a robot's environment and how they can aid in creating dense, semantically annotated reconstructions of the world. We will specifically focus on applying these models in real-world environments with low-cost cameras, fast motion and changing lighting conditions.

- **Thursday 8 February 2018 -- Control and Planning (Cedar Room, ECC)**

Deep Reinforcement Learning and Its Application in Robotics

-- Linhai Xie, University of Oxford

Deep Neural Networks (DNNs) have spawned the renaissance of Reinforcement Learning (RL) in recent years and led us to Deep Reinforcement Learning (DRL) which has demonstrated impressive performance in many complicated tasks. In this lecture, I will introduce some basics of RL, one of its popular method named Q-learning and how to combine it with DNN to solve a real robotic problem. I will also briefly describe the current application of DRL in different robotic areas e.g. manipulation and navigation.

Adaptive Control for Marine Robots using Deep Reinforcement Learning

-- Ignacio Carlucho, CIFICEN

Autonomous control of underwater vehicles is an extensive area of research. However, the difficulties in modelling and the variable operative conditions have made researches turn to artificial intelligence techniques to try to achieve a higher level of autonomy. In this sense, deep

reinforcement learning is a promising field, since it gives the agent the ability to learn from raw sensory input data by successive interactions with the environment. Therefore, making this control paradigm extremely powerful, and of high relevance in control applications in the underwater domain.

3.3. Labs

Deep Learning hands-on: design and training of deep neural networks for pose estimation of a robot by using GPU servers.

4. Speakers



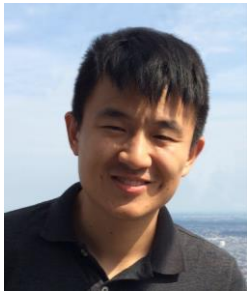
Prof. David Lane is Professor and Founding Director in the Edinburgh Centre for Robotics, Heriot-Watt University. Previously he established Heriot-Watt's Ocean Systems Laboratory with an international reputation in marine robotics, publishing nearly 200 cited publications with international funding from the UK, EU, US and Japan. He has been a visiting Fellow at the Woods Hole Oceanographic Institution USA, visiting Professor at Florida Atlantic University, Scientific Advisor to the NATO Undersea Research Centre, La Spezia Italy. From 2001-2010 he founded and as CEO led SeeByte Ltd/Inc to a multi-million \$ UK/US company in defence and offshore markets. He has been elected to fellowship of the Royal Academy of Engineering, Royal Society of Edinburgh, Institution of Engineering and Technology, Society of Underwater Technology and Royal Geographical Society. He was appointed Commander of the Order of the British Empire for services to Engineering in the 2016 Queen's New Year Honours list.



Prof. Yvan Petillot is a Professor of Robotics and Computer Vision at Heriot-Watt University. He is a leading member of the Oceans Systems Laboratory, the director of the Institute for Sensor Signals and Systems and the deputy director of the joint research institute in Signal and Image Processing (ERP-SIP) with Edinburgh University. He was a Royal Society Industry Fellow in collaboration with SeeByte Ltd, a company he co-founded in 2001 and in which he was Chief Technical Officer until 2010. With over 15 years' experience in Robotics, Image Processing and Autonomous Systems in the maritime domain, he has made very significant contributions to target detection and classification multiple vehicle collaboration and autonomous inspection and manipulation. He created the first European Competition in Underwater Robotics in 2006 and successfully transferred MOD funded collaborative framework for multi-vehicle collaboration to a product sold to the US and UK Navies.



Sen Wang is an Assistant Professor in Robotics and Autonomous Systems at Heriot-Watt University and a faculty member of the Edinburgh Centre for Robotics. Previously, he was a post-doctoral researcher at the University of Oxford. His research focuses on robot perception and autonomy using probabilistic and learning approaches, especially autonomous navigation, robot vision, SLAM and robot learning. His research has been published in a number of flagship venues, including IJRR, ICRA, IROS, CVPR and AAAI, and been awarded a Best Paper Award and an Outstanding Paper Award.



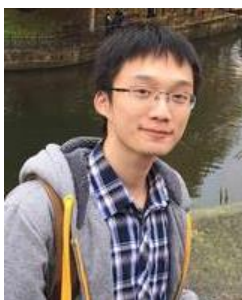
Ruihao Li received the B.Sc. degree in automation from Beijing Institute of Technology, Beijing, China, in 2012 and the M.Sc. degree in control science and engineering in National University of Defense Technology, Changsha, China, in 2014. He is currently pursuing the Ph.D. degree in robotics at the University of Essex, UK. His research interests are in SLAM, deep learning and semantic scene understanding.



Yishu Miao received his M.Sc. from Tsinghua University and currently is a final year PhD student in the Machine Learning and Computational Linguistics research group at the University of Oxford. His research interests include deep generative models, neural variational inference and the corresponding applications. He has been program committee members of major machine learning conferences, e.g., NIPS, ICLR, ACL and EMNLP, workshop organiser at ICML 2017 and conducted two research interns at DeepMind.



Ronald Clark is a Dyson Research Fellow at the Dyson Robotics Lab, Imperial College London, headed by Prof. Andrew Davison. He did his PhD in the Department of Computer Science at the University of Oxford. His current research interests are in mobile perception including robust 3D reconstruction on mobile devices, ego-motion estimation and localization using deep learning based methods.



Linhai Xie is a final year PhD student in the Department of Computer Science at University of Oxford, supervised by Prof. Niki Trigoni, Dr. Andrew Markham and Dr. Sen Wang. He has published his research at major robotics conference RSS, IROS and ICRA on SLAM and deep reinforcement learning based robot control and navigation.



Ignacio Carlucho is a PhD Student at the INTELYMEC group in the National University of Central Buenos Aires. His main interests are cognitive control techniques for marine robotics. He is currently working with deep reinforcement learning for control of underwater vehicles.



Chris Xiaoxuan Lu is currently a third-year PhD student in the Department of Computer Science, University of Oxford. Before that, he obtained his MEng degree at Nanyang Technology University, Singapore. He actively works on deep learning based sequence modelling for IoT and mobile devices. His research interest lies in Cyber-Physical Systems, which use networked smart devices to sense and interact with the physical world.

5. Invited Dinner

Date: 7th February, 2018

Venue: The Scotch Malt Whisky Society, 28 Queen Street, Edinburgh, EH2 1JX

Start time: 7.30pm



6. List of Participants

6.1. Speakers and trainers

Name	Institution	E-mail
Prof. David Lane	Heriot-Watt University	d.m.lane@hw.ac.uk
Prof. Yvan Petillot	Heriot-Watt University	y.r.petillot@hw.ac.uk
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