EIS2022

2022 EXETER INTERNATIONAL SYMPOSIUM

Exeter International Symposium on Small-Scale Robots

20-22nd June 2022, Exeter, UK

UNIVERSITY OF EXETER

Applied Dynamics and Control Lab

Dear colleagues,

It gives us a great pleasure to present our warm invitation to participate in the 2022 Exeter International Symposium on Small-Scale Robots (EIS2022), which will be held (online) in Exeter in 20-22 June 2022.

This symposium aims to provide a forum for researchers to present, discuss and disseminate recent advances in developing small-scale robots, and the scope of this symposium includes, but is not limited to the following areas:

- Dynamics and control of small-scale robots
- Soft miniature robots
- Swarm of micro/nanorobots and collective behaviours
- Bio-inspired design of micro/nano-scale robots
- Mechatronics systems for small-scale robots
- Sensing and monitoring at small scale
- Actuation of miniature robots
- Autonomous robotics at small scale

This online event is structured into several general sessions across three days in which invited (senior) and contributing (junior) lectures are given. It is expected that the symposium participants will enjoy and benefit from this event as it will provide a platform for sharing the cutting-edge research and networking with the research leaders in small-scale robotics.

We warmly welcome you to this symposium and hope you enjoy and benefit from this event.

Yours sincerely,

Yang Liu (University of Exeter)
Kevin Chen (Massachusetts Institute of Technology)
Xiangzhong Chen (ETH Zürich)

Chairs of EIS2022

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This event is proudly co-organized by Applied Dynamics and Control Lab at Exeter, Soft and Micro Robotics Laboratory at MIT and Multi-Scale Robotics Lab at ETH Zürich.

Organising Committee

Yang Liu	University of Exeter, UK
Kevin Chen	Massachusetts Institute of Technology, USA
Xiangzhong Chen	ETH Zürich, Switzerland
Jiajia Zhang	University of Exeter, UK
Jiyuan Tian	University of Exeter, UK
Kenneth Afebu	University of Exeter, UK

Scientific Committee (alphabetized by surname)

Morteza Amjadi	Heriot-Watt University, UK
Quentin Boehler	ETH Zürich, Switzerland
Manish Chauhan	University of York, UK
Kevin Chen	Massachusetts Institute of Technology, USA
Xiangzhong Chen	ETH Zürich, Switzerland
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Joseph Páez Chávez	Escuela Superior Politécnica del Litoral, Ecuador
Salvador Pané i Vidal	ETH Zürich, Switzerland
Zhike Peng	Ningxia University, China
Shyam Prasad	Royal Devon University Healthcare NHS Foundation Trust, UK
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Yao Yan	Uni. Electronic Sci. & Technology of China, China
Shan Yin	University of Exeter, UK
Daniil Yurchenko	University of Southampton, UK
Li Zhang	The Chinese University of Hong Kong, China

Abstract Submission

Please submit your abstract submission form by email to y.liu2@exeter.ac.uk **by 1 June 2022**.

Registration

Symposium registrations for speakers and attendees are **FREE**.

Registration here

We warmly welcome researchers, postdocs and PhD students who are interested in this field to register and attend this online event.

Key Dates

1 April 2022	Abstract Submission Opens
1 April 2022	Registration Opens
1 June 2022	Abstract Submission Deadline
19 June 2022	Registration Deadline
20-22 June 2022	EIS 2022

Conference Format

- The symposium will take place **online via Zoom** in 20-22 June 2020.
- **Invited lecture (academics) – 25 mins plus 5 mins Q&A**
- **Contributing lecture (postdoc/PhD) – 10 mins plus 5 mins Q&A**
- All time slots are subject to British Summer Time (BST).
- Zoom link for all sessions: Enter here.
- Zoom Meeting ID: 525 335 1196.
- Password will be received after registration.

Further details will be available on the EIS webpage: https://blogs.exeter.ac.uk/adce/eis2022/.

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Invited Lectures

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Electrifying Small-Scale Robots

Salvador Pané i Vidal

Magnetic micro- and nanorobots are small-scale vehicles that can move in fluid environments by means of external magnetic fields. One of the ultimate goals of magnetic small-scale robotics is to develop machines that can deliver drugs or realize other medical missions in confined spaces of the human body. Other applications include water remediation or “on-the-fly” chemistry. The recent rapid developments in small-scale robotics are undeniably related to advances in material science and manufacturing. In this talk, we will present small-scale robots that integrate magnetoelectric building blocks for remote electrical stimulation. The micro- and nanomachines consist of multiferroic composite materials, which have the ability to generate an electric field under the application of an external magnetic field. The magnetoelectric small-scale swimmers comprise a magnetostrictive component that allows for both the magnetic locomotion of the device, and the activation of the piezoelectric component. The wirelessly activated electrical polarization can then be used for cell electrostimulation, drug delivery, or for triggering redox chemical processes.

Speaker Biography: Prof. Dr. Salvador Pané i Vidal (Barcelona, 1980) is currently a Professor of Materials for Robotics at the Institute of Robotics and Intelligent Systems (IRIS) and co-director of the Multi-Scale Robotics Lab at ETH Zürich. He received a B.S. (2003), M.S (2004) and a PhD in Chemistry (2008) from the University of Barcelona (UB). He has authored or co-authored more than 160 articles in international peer-reviewed journals and books for education in science. In 2013 and 2017, Dr. Pané was awarded the highly competitive Starting Grant from the European Research Council (ERC) and the Consolidator Grant, respectively. From 2015 to 2019, he was the Chair of the COST Action “e-MINDS. He is also co-founder of the startup Magnes AG and Oxyle AG. In 2019, Prof. Pané was honored with the Big-on-Small Award at the International Conference on Manipulation, Automation and Robotics at Small Scales (MARSS). He has also received the ERC Proof-of-Concept grant (2019).

Magnetic Soft Microrobots for Endovascular Interventions

Ali Hoshiar

Controlling soft robots inside body which can perform minimally invasive surgery has been a decades long dream for both engineers and clinicians. Over the past decade many soft robotics systems have been developed for minimally invasive surgery. In these systems, a configuration of the electromagnets is located around the patent body to control the magnetic field in 3D and steer the soft robot. The soft robot is remotely steered and controlled by the human in the loop to perform the minimally invasive surgery task. The soft microrobot is attached to the tip of the guidewire, and it is magnetically steered by changing the direction and intensity of an external magnetic field. Steerability was confirmed by two-dimensional in vitro tracking and using a three-dimensional (3D) phantom of the coronary artery to verify steerability in 3D space. We have designed several generations of soft magnetically guided continuum robots. In this talk, I will show our microrobot design, and control strategy. Magnetically actuated soft robots can improve the treatment of disseminated intravascular coagulation.

Speaker Biography: From 2015 to 2019, Dr Hoshiar worked as a Postdoctoral Researcher in GNU (S. Korea), DGIST-ETH (S. Korea), and University of Leeds (UK). Currently, he is an Assistant professor (Lecturer) in mechatronics and robotics at the University of Essex, faculty of computer science and electronic engineering (CSEE), and a member of robotics and embedded system research (RES) group. He is working on medical small-scale robots and published 32 peer-reviewed journal papers in micro/nanorobotics, including Soft Robotics, IEEE Transaction on Mechatronics, IEEE Robotics and Automation letters, Nanoscale. His research interests include medical micro/nanorobots, magnetic manipulation, electromagnetic actuation systems, magnetic particle imaging (MPI) systems, swarm microrobotics, soft magnetic miniature robots and soft small-scale robots.

Liquid Metals Enabled Soft Electromechanical Actuators

Shiyang Tang

Gallium (Ga) based liquid metals, such as eutectic gallium indium (EGaIn) and gallium-indium-tin (Galinstan), are a remarkable family of functional fluidic materials that offer extraordinary functionalities yet remain a largely unexploited field of research. Leveraging the unique properties of liquids, such as surface tension, capillary action, reconfigurability, nearly unlimited stretchability, and viscosity has enabled the development of a wide range of soft actuators, presenting the vast potential to revolutionise wearable devices, manufacturing, reconfigurable electronics, and robotics. Particularly, liquid metals can actuate electrically for realising electromechanical functions. Such actuators are simple, highly responsive, highly controllable, and reversible, which has led to the creation of useful devices such as reconfigurable antennas, artificial muscles, electrical switches, and soft robots, just to name a few. In this talk, Dr Shiyang Tang will briefly introduce his recent progress in the research of liquid metal enabled soft electromechanical actuators for developing innovative applications in microelectromechanical systems, flexible devices, and robotics.

Speaker Biography: Dr Shiyang Tang currently is an assistant professor in the Department of Electronic, Electrical and Systems Engineering at the University of Birmingham, UK. He received his BEng (1st class honours) in Electrical Engineering and PhD in Microelectromechanical Systems (MEMS) from the RMIT University, Australia, in 2012 and 2015, respectively. He was the recipient of the Discovery Early Career Researcher Award (DECRA) from the Australian Research Council, and the Vice-Chancellor's Postdoctoral Research Fellow from the University of Wollongong, Australia. Dr Tang's research interests include liquid metal enabled micro-/nano platforms and intelligent microfluidics. He has published more than 90 papers and many of them are in high-impact journals.

Magnetic Actuation for Small-Scale Robotics

Quentin Boehler

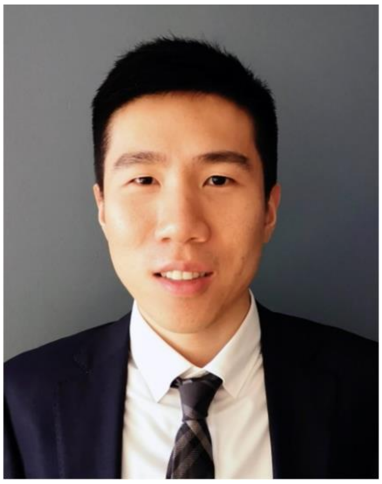
The last decade has seen an increasing interest in the use of magnetic actuation to steer soft and rigid robots at multiple scales. This relies on the generation of magnetic fields with an electromagnetic navigation system to apply torques and forces on systems composed of magnetic material. This technology is particularly promising to remotely control the deformation of soft structures such as continuum robots, and at a small scale. We have been investigating several medical applications that will benefit from this approach including neurovascular procedures, fetal surgeries, and ophthalmic surgeries. Our research also focuses on the development of simulation frameworks and modelling tools to better characterize and design soft magnetic tools.

Speaker Biography: Quentin Boehler was born in Strasbourg in 1990. He received a M.S. degree in mechatronics from INSA Strasbourg in 2013, and a Ph.D. degree in robotics from ICube laboratory, University of Strasbourg in 2016 in collaboration with the LIRMM in Montpellier. His thesis focused on tensegrity mechanisms and variable stiffness devices with application to MR-compatible robotics and was awarded the best thesis award from the research commission of the University of Strasbourg, and the first prize at the 2016 Ph.D. thesis awards from GDR Robotique. He joined the Multi-Scale Robotics Lab in 2017 as a postdoctoral associate. He is currently a senior scientist, and his research is on magnetic actuation for medical robotics, including the development and analysis of electromagnetic navigation systems, and of soft magnetic robots.

Agile, Robust, and Multifunctional Micro-Aerial-Robots Powered by Soft Artificial Muscles

Kevin Chen

Recent advances in microrobotics have demonstrated remarkable locomotive capabilities such as hovering flights, impulsive jumps, and fast running in insect-scale robots. However, most microrobots that are powered by power-dense rigid actuators have not achieved insect-like collision resilience. In this talk, I will present our recent effort in developing a new class of microrobots – ones that are powered by high bandwidth soft actuators and equipped with rigid appendages for effective interactions with environments. Towards improving collision robustness of micro-aerial robots, we develop the first heavier-than-air aerial robot powered by soft artificial muscles that demonstrates a 20-second hovering flight. In addition, our robot can recover from an in-flight collision and perform a somersault within 0.16 seconds. The robot's maximum lift is comparable to that of the best rigid-powered sub-gram robots. This work demonstrates for the first time that soft aerial robots can achieve agile and robust flight capabilities absent in rigid-powered micro-aerial vehicles, thus showing the potential of a new class of hybrid soft-rigid robots.



Speaker Biography: Kevin Chen is currently the D. Reid Weedon, Jr. '41 Career Development Assistant Professor at the Department of Electrical Engineering and Computer Science, MIT, USA. He received his PhD in Engineering Sciences at Harvard University in 2017 and his bachelor's degree in Applied and Engineering Physics from Cornell University in 2012. His research interests include developing high bandwidth and robust soft actuators for microrobot manipulation and locomotion. He has published in top journals including Nature, Science Robotics, Advanced Materials, PNAS, Nature Communications, IEEE TRO, and Journal of Fluid Mechanics. He is a recipient of the TRO 2021 best paper award, the RAL 2020 best paper award, the IROS 2015 best student paper award, and a Harvard Teaching Excellence Award.

Using Bio-Inspiration and Embodied Intelligence to Improve the Adaptability of Robots and Performance of Sensors and Actuators

Sara Adela Abad Guaman

One of the greatest challenges of robotics is adaptability to the environment. Due to the increasing occurrence of man-made or natural disasters in the last decades, there is a growing demand for robots for hazardous or demanding tasks such as rescue, farming, healthcare, or bringing supplies. Highly variable environment conditions, safe human-robot interaction, and space constraints are some of the critical challenges that limit the use of robots for these applications. As a researcher, I am working on improving the mobility of robots using embodied intelligence. I have developed a bioinspired robotic hoof that is inspired on the mountain goat hoof. The findings reveal that the hoof may improve adaptability through a stick and slip behaviour which resembles the Anti-lock Braking System (ABS) systems in cars.

On the human-robot interaction area, I am the leader researcher in the INSTINCT project that aims to develop a system to provide haptic (touch sense) feedback to surgeons when they are performing Minimally Invasive Surgery (MIS). In this project, a haptic soft membrane sensor has been developed to measure the object-soft membrane sensor interaction force. This information can then be fed through a haptic actuator to the clinician, so the clinician can evaluate the type of tissue that the sensor is interacting with. The key novelty of this sensor is its capability of changing on demand its sensing range without retrieving the sensor. This characteristic has the potential to decrease the risk of infection, tissue damage, or blood loss during MIS.

Speaker Biography: Dr Abad Guaman started her academic tenure-track position at the UCL Department of Mechanical Engineering in June 2022 as a Lecturer. Her expertise and research interests are focussed on using embodied intelligence and a bio-inspired approach to improve robots' adaptability to the environment and the performance of sensors and actuators. Prior, she became a Research Fellow (Postdoc) in Soft Robotics and Haptics in the same department in 2019. This year, Dr Abad Guaman was also awarded her PhD in Design Engineering oriented to Robotics from Imperial College London. In 2013, she obtained a MSc in AI at Southampton University and a BEng degree in Electronics and Control at Escuela Politecnica Nacional (Ecuador). Dr Abad Guaman was also awarded a UCL Institute of Healthcare Engineering Impact fellowship in 2020 and a UCL Policy Engagement and Impact fellowship in 2021. She has published in flagship robotics journals and conferences including IEEE Transactions on Robotics, IEEE Robotics and Automation Letters and IROS.

Utilising the Vibro-Impact Self-Propelled Capsule for Small-Bowel Endoscopy

Yang Liu

Capsule endoscopy has become established as the primary modality for examining the small intestinal mucosa. However, its reliance on peristalsis for passage through the intestine causes variable locomotion speeds, which can lead to incomplete visualisation of the mucosa and potentially missed pathology. Also, lengthy videos resulting from long transit times (5-8 hours) can be both time-consuming and burdensome for clinicians to examine. A resonance enhanced self-propelled capsule robot was developed by the Applied Dynamics and Control Lab at the University of Exeter for small-bowel examination. In this talk, I will introduce this research work from mathematical modelling, numerical analysis, control and optimisation, experimental investigation, to proof-of-concept validation in an *in-vitro* intestinal environment. The driving principle of this technique is that rectilinear motion of the robot can be generated using a periodically driven internal mass interacting with the main body of the robot as a 'hammer', in the presence of intestinal resistances. The robot can perform either forward or backward progression by modulating its excitation amplitude and frequency. Early proof-of-concept tests in a laboratory environment were carried out for different capsule-intestine contact conditions, achieving the maximum forward and backward speeds at 2 mm/s and 1 mm/s, respectively. Assuming a maximum small intestinal length of 6 metres and capsule speed of just 2 mm/s, small intestinal transit could be reduced to no more than 50 minutes. Comparing with the conventional capsule endoscopy, this technique may offer the potential for a 'live' and controllable small-bowel examination.

Speaker Biography: Yang Liu is currently a Senior Lecturer in Engineering at the University of Exeter, and an Honorary Lecturer in Endoscopy Department at the Royal Devon & Exeter NHS Foundation Trust. He obtained his BEng in Automation from Hunan University (China), MSc in Control Systems from the University of Sheffield (UK), and PhD in Control Engineering from Staffordshire University (UK). After his PhD, he joined the Centre for Applied Dynamics Research at the University of Aberdeen (UK) as a postdoctoral research fellow. In 2013-2016, Dr Liu worked in the School of Engineering at Robert Gordon University (UK) as a Lecturer in Mechanical Engineering. Dr Liu's team has been awarded the Lab Science Bursary Award (BSG2019), the Young Delegates Award (IFToMM), the Best Student Paper Award (ICAC) and the Ali H. Nayfeh Prize (NODYCON2021). His research interests include nonlinear dynamics and control, medical micro-robots, capsule endoscopy, and detection of early bowel cancer.

Towards Autonomous Locomotion in Cluttered Terrain using Insect-Scale Robots

Kaushik Jayaram

Animals such as mice, cockroaches and spiders have the remarkable ability to maneuver through challenging cluttered natural terrain and have been inspiration for adaptable legged robotic systems. Recent biological research further indicates that body reorientation along pathways of minimal energy is a key factor influencing such locomotion. We propose to extend this idea by hypothesizing that body compliance of soft bodied animals and robots might be an alternate yet effective locomotion strategy to squeeze through cluttered obstacles. We present some early results related to the above using Compliant Legged Autonomous Robotic Insect (CLARI), our novel, insect-scale, origami-based quadrupedal robot. While the distributed compliance of such soft-legged robots enables them to explore complex environments, their gait design, control, and motion planning is often challenging due to a large number of unactuated/underactuated degrees of freedom. Towards address this issue, we present a geometric motion planning framework for autonomous, closed kinematic chain articulated systems that is computationally effective and has a promising potential for onboard and real-time gait generation.

Speaker Biography: Kaushik Jayaram is an Assistant Professor in Robotics in the Paul M Rady Department of Mechanical Engineering at the University of Colorado Boulder. Previously, he was a post-doctoral scholar in Prof. Rob Wood's Microrobotics lab at Harvard University. He obtained his doctoral degree in Integrative Biology in 2015 from the University of California Berkeley mentored by Prof. Bob Full. He graduated with a dual degree – (undergraduate) in Mechanical Engineering and (Masters) in Manufacturing from the Indian Institute of Technology Bombay in 2009, with interdisciplinary research experiences at University of Bielefeld, Germany and Ecole Polytechnique Federale du Lausanne, Switzerland. Kaushik's research combines biology and robotics to uncover the principles of robustness that make animals successful at locomotion in natural environments, and, in turn, inspire the design of next generation of novel robots for effective real-world operation. His work has been published in a number of prestigious journals and gained significant popular media attention.

Functional Nanomaterial Composites for Soft Sensing and Actuation

Morteza Amjadi

Soft machines have many applications, ranging from multifunctional wearable medical devices for feedback therapy to prosthetics, non-invasive surgical tools, and soft robots for safe human-robot interaction. High-performance flexible sensors and actuators are the key components of soft machines. In this talk, I will cover our latest research activities on the development of functional nanocomposites based wearable strain sensors for human motion detection and soft robotics. I will demonstrate how bioinspired structures can help to improve the sensing performance of wearable sensors. The next part of my talk will focus on the development of programmable soft actuators based on composite materials. Finally, I will address challenges associated with the design of integrated soft machines capable of multimodal sensing and controlled stimulation.

Speaker Biography: Dr Morteza Amjadi is an assistant professor of Mechanical Engineering at Heriot-Watt University, UK. He received his Dr Sc. in Mechanical Engineering jointly from Max Planck Institute for Intelligent Systems and ETH Zurich in 2018. He obtained his M.Sc. in Mechanical Engineering from Korea Advanced Institute of Science and Technology (KAIST) in 2014. Prior to joining Heriot-Watt, he was a postdoctoral researcher in the Physical Intelligence Department at the Max Planck Institute for Intelligent Systems. Dr Amjadi leads the Integrated Soft Machines Lab to design multifunctional soft machines utilizing novel mechanical designs, advanced materials, bioinspired structures, and digital manufacturing processes. He has published over a dozen papers in high-impact journals including Advanced Materials, ACS Nano, Advanced Functional Materials, and Advanced Science. In 2018, he has been nominated for the prestigious Otto Hahn Medal, awarded by the Max Planck Society to young scientists for their outstanding scientific achievements.

A Cost-Effective Smart Soft-Endorobot for Colonoscopy

Luigi Manfredi

Colorectal cancer is the third most common cause of cancer death worldwide with about 2M new cases per year and a mortality rate close to 50%. Early detection is key, being colonoscopy the gold standard procedure for its dual capability to inspect the colonic mucosa and remove polyps which may eventually become cancerous. The first colonoscopy with polypectomy was performed in 1969, and since then, the mechanical design of the colonoscope has not changed much. This procedure causes pain and discomfort, it is a medical procedure very difficult to learn and perform, and the outcome is related to the experience of the clinicians.

The design of a novel device for colonoscopy faces many challenges because of the limited available space, the slippery colonic mucosa, and the tortuous shape of the human colon. The design of a device for colonoscopy faces many challenged because of the limited available space, slippery colonic mucosa, and tortuous shape of the human colon.

This abstract presents a cost-effective smart endorobot for colonoscope designed by using soft material. The device relies on a patented double balloon inchworm locomotion solution with high-definition camera and biopsy instrumentation. The balloon secures anchorage to the device during its locomotion as well as stability to perform clinical tasks. The use of soft material reduces the production costs, making the device cost effective. Experiments show high dexterity to navigate narrow corners and low pressure against the colonic wall. The mechanical design, together with the control strategies are presented.

Speaker Biography: Dr Luigi Manfredi was a PhD student and Post-Doc at the Biorobotics Institute in Pisa, Italy, before joining the University of Dundee in 2011 as Project Coordinator and Senior Post-Doc of CODIR, a European Research Council (ERC) Advanced Grant, and then as Co-investigator on CARPE, an ERC Proof of Concept Grant. He won the prestigious Surgical Innovation Award sponsored by Covidien (Baltimore, 2013) and the runner-up prize for the Emerging Technology Award (Boston, 2016), both at SAGES Congress, USA. His research is focused on soft materials for smart endorobots, and he won the Dundee Venture Competition 2020 (staff category), with his proposal for a low-cost and single-use soft colonoscope.

FireFly: An Insect-Scale Aerial Robot Powered by Electroluminescent Soft Artificial Muscles

Suhan Kim

Light production in natural fireflies represents an effective and unique method for communication and mating. Inspired by bioluminescence, we develop a 650 mg aerial robot powered by four electroluminescent (EL) dielectric elastomer actuators (DEAs) that have distinct colors and patterns. To enable simultaneous actuation and light emission, we embed EL particles in a DEA that has highly transparent electrodes. During robot flight, a strong (>40 V/µm) and high frequency (400 Hz) electric field is generated within the DEA, exciting the EL particles to emit light. Compared to a regular DEA, our new design and fabrication methods require small additional weight (2.4%) and actuation power (3.2%) without adversely impacting the DEA's output power or lifetime. We further develop a position and attitude tracking method using vision-based color detection. We demonstrate a series of controlled hovering flights and compare camera-tracked results with that of the state-of-the-art Vicon motion tracking system. The root-mean-square (rms) position and attitude errors are 2.55 mm and 2.60°, respectively. This work illustrates a novel and effective design for communication and motion tracking in extreme payload-constrained microscale aerial systems, and it further shows the potential of achieving coordinated swarm flights without using well-calibrated in door tracking systems.

Speaker Biography: Suhan Kim is a PhD student in the Department of Electrical Engineering and Computer Science (EECS) at MIT. He received his master's degree in Mechanical Engineering at Carnegie Mellon University (CMU), and bachelor's degree in Mechanical and Aerospace Engineering at Seoul National University (SNU). Suhan previously worked at Micro Robotics Lab (MRL) at CMU, and Soft Robotics and Bionics Lab (SRBL) at SNU.

3D Reconfigurable Microrobot Swarm Mimicking Schooling Fish

Fengtong Ji

Swarm behaviours are natural strategies for performing cooperative work. From living bacteria to synthetic microrobots, various kinds of swarm behaviours have been realized to present directional motion and controllable patterns on solid substrates or liquid-air interfaces. However, such a wall-bound dependence may limit the performance of swarming microrobots, e.g., 3D motion control and enhancing catalysis. Moreover, because of the less dependence, maintaining a large number of particles as a dynamically stable swarming entity in 3D spaces remains the central problem. Herein, a tornado-shaped microrobot swarm mimicking schooling fish is established in an aqueous environment under a hybrid source of magnetic actuation and laser irradiation. The programmable magnetic field initiates the in-plane rotation of a 2D microswarm; then the laser irradiation transforms the 2D microswarm into a 3D microswarm tornado (MST). The MST performs reversible anti-gravity mass transportation during its reconfigurable generation, comprised of rising, hovering, oscillation, and landing stages. The MST shows characteristics similar to the calmness at the centre of a natural tornado. When the MST is implemented in an environment of a chemical reaction, it accelerates the global reaction while holding the local reactants due to the flow difference in different regions. Subsequently, the previously trapped substances are released on demand by reprogramming the precessing field as an oscillating field. The MST serves as a model for 3D reconfigurable microrobot swarms and mimicking natural swarm behaviours, aiming at taking effects in catalytic and nanoengineering applications.

Speaker Biography: Fengtong Ji is a Postdoctoral Fellow at The Chinese University of Hong Kong. He received his Ph.D. in Mechanical and Automation Engineering from The Chinese University of Hong Kong, M.E. in Mechatronic Engineering and B.E. in Mechanical Design, Manufacturing and Automation (Honors Class) from Harbin Institute of Technology. His research interests concentrate on micro/nanorobot, collective behaviour, nanoengineering, active matter and applied physics.

Surface Structured Liquid Metal Hybrid Composite Films for Flexible Pressure Sensor with High Sensitivity and Large Dynamic Range

Guolin Yun

Conductive elastic composites composed of conductive fillers and polymer matrices are showing an increasing number of applications in the fields of soft robotics, flexible sensors, wearable devices, and stretchable electronics. Under mechanical deformation, the conductive filler network in the matrix shifts to change the conductive pathway among particles and thus, electrical conductivity of the composite. For most conductive composites, their conductivity changes monotonically with strain. Here, I create a composite that exhibits an unconventional strain response; its electrical conductivity increases sharply under both compressive and tensile loads. The Ecoflex-based composite contains spike-shaped nickel microparticles and liquid metal microdroplets. Owing to the elastomeric mechanical properties of Ecoflex, the composite has an extremely high stretchability and pressure sensitivity, which is ideal for tactile sensing and mechanical responsiveness. Based on the composite films with a grooved and pyramidal surface structure, I demonstrate a pressure sensor with extremely high sensitivity and dynamic range, which provides advantages for its applications in soft robotics and stretchable electronics.

Speaker Biography: Guolin Yun joined the NanoEngineering group in Cambridge University, Engineering Department as a Royal Society Newton International Fellow in 2022. Guolin received his B.S. in Theoretical and Applied Mechanics in 2017 from the University of Science and Technology of China (USTC, China) and his Ph.D. in Mechanical Engineering in 2021 from the University of Wollongong (UOW, Australia). His research focus is on the liquid metal-filled hybrid conductive elastomers and their applications in flexible sensors and stretchable electronics.

Finite Element Analysis of a Soft Vibro-Impact Capsule Robot Self-Propelling in the Small Intestine

Jiyuan Tian

The small intestine, an anatomical site previously considered inaccessible to clinicians due to its small diameter and lengthy size, is the part of the gastrointestinal tract between the stomach and the colon. Since its introduction into clinical two decades ago, capsule endoscopy has become established as the primary modality for examining the surface lining of the small intestine. This work aims to study the capsule-intestine interaction through finite element (FE) modelling for a soft capsule robot self-propelled by its internal vibrations and impacts developed in the Applied Dynamics and Control Lab at the University of Exeter. Previous FE investigation focused on studying the capsule-intestine interaction by using a rigid capsule made of polylactic acid. To reduce the potential secondary damage to the intestine caused by the hard shell and optimise the capsule's movement, super-soft silicone rubber was used to coat the capsule shell. In this work, we explored the capsule's progression speed, contact pressure, and intestinal resistances in different coating's elastic moduli and thicknesses by using a three-dimensional FE model. Our extensive studies reveal that a harder coating may lead to a greater capsule-intestine contact pressure, while a thicker coating can reduce such a contact pressure mitigating the secondary damage on the intestine.

Speaker Biography: Jiyuan Tian is currently a Ph.D. student at the University of Exeter, Exeter, UK. He received his B.Sc. degree in Xi'an Technological University North Institute of Information Engineering, Xi'an, China in 2015 and M.Sc. degree in Mechanical Engineering from the University of Exeter, Exeter, UK in 2018. He is the awardee of Ali H. Nayfeh Prize at the International Nonlinear Dynamics Conference in 2021. His work involved capsule-intestine modelling, prototype design and experimentation of the self-propelled capsule robot.

Yaw Control of Insect-Scale Flapping-Wing Robots with Inclined Stroke-Plane

Yi-Hsuan Hsiao

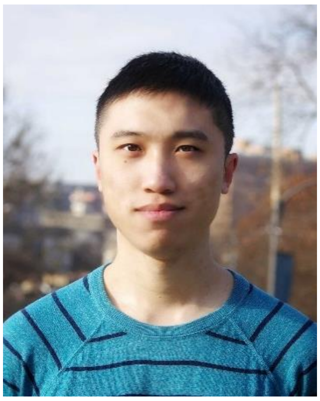
Inspired by the agile and exquisite flying abilities of tiny insects in nature, SoftFly, a sub-gram flapping-wing robot, has demonstrated superb maneuverability such as collision recovery and somersault. However, despite the nimble flying capabilities enabled by the soft actuators, the primary research goals of controlling these artificial insects have been only centering on regulating the roll, pitch, and thrust to attain hovering flight at a translational setpoint. Controlling the heading angle, which is critical to field applications such as visual inspections, remains a major challenge due to the parallel-lift-force configuration. Here, we propose an inclined stroke-plane approach to the four-unit SoftFly by differentially altering the force vectors of individual wing pairs. This method allows us to generate net yaw torque by actuating the diagonal units, and a PD controller is thus articulated to enable the robot to track the designated yawing angles. Flight experiments were performed to validate the effeteness of the proposed control strategy. The results show that the newly designed SoftFly can sustain at a fixed heading angle with a root-mean-square error of 3.8 degrees during a 10 second flight without compromising the control capabilities of roll and pitch. This promising outcome indicates that the sub-gram four-unit flapping-wing robot can independently achieve roll, pitch, yaw, and thrust control authorities, paving the way for utilizing more advanced controllers from the mature quadrotor community in more complex operations.

Speaker Biography: Yi-Hsuan (Nemo) Hsiao is a Ph.D. student in the Department of Electrical Engineering and Computer Science (EECS) at MIT. He is broadly interested in the design and control of micro air vehicles. Yi-Hsuan obtained his bachelor's degree in Mechanical Engineering from the City University of Hong Kong. He is a recipient of the Campbell L. Searle Graduate Fellowship at MIT, and he is awarded the Governmental Scholarship by the Taiwanese Government.

High Lift Insect-Scale Aerial Robot Powered by Low-Voltage and Long-Endurance Dielectric Elastomer Actuators

Zhijian Ren

require higher driving voltages and their power and energy density, lifetime and efficiency remain inferior. These limitations pose substantial challenges in developing power autonomous soft aerial robots. In this work, we develop novel design and fabrication methods to substantially reduce a DEA's actuation voltage, increase its lifetime, and further improve the soft robot's net lift. Specifically, we design a 167 mg soft aerial robot that achieves a high lift-to-weight ratio of 3.7, low hovering voltage of 500 V, and a long lifetime that exceeds two million cycles of actuation. We further build a 680 mg robot that consists of 4 modules which demonstrates the longest (20 seconds) hovering flight with the best performance (maximum position and attitude error are smaller than 2.5 cm and 2°, respectively) among sub-gram aerial robots. This soft aerial robot's performance is comparable to the best rigid-powered sub-gram aerial robots, and it represents an important step towards achieving power autonomous flights in soft robots.



Speaker Biography: Zhijian Ren is a PhD student in the department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology. He received the B.S. degree in automation from Shanghai Jiao Tong University, Shanghai, China, and the M.S. degree in mechanical engineering from Carnegie Mellon University, Pittsburgh, PA, USA. He is currently working with Prof. YuFeng (Kevin) Chen at Soft and Micro Robotics Laboratory, focusing on the actuation, sensing, and control of micro flying robots. He was a recipient of Grass Instrument Company Fellowship and MathWorks Fellowship at MIT. He was the winner of 2021 IEEE Transactions on Robotics King-Sun Fu Memorial Best Paper Award.

Steering Platform for Microswarm Guidance in Multi-Bifurcation Vessels

Benjamin Jarvis

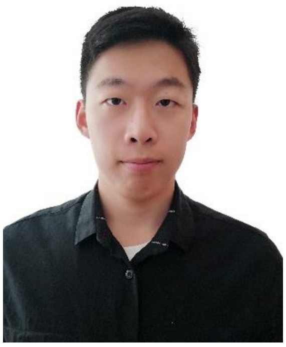
Within medical robotics, there is always a need for tools that cause less trauma. Often this means a smaller tool. Microswarms (collective magnetic nanoparticle control) emerged as a promising miniaturized tool for therapeutic delivery and minimally invasive interventions. The advantage of microwarms is that they are not tethered to an external control or power source. This disconnect allows for less restrictive trajectories throughout the body, amongst other characteristics. The study of microswarms is made easier with simulations. Initial light-weight platforms eventually evolved into precise but computationally expensive methods. The standard for these platforms involves high performance computing with predefined (non-realtime) control inputs, which is a far cry from the real-time human-in-the-loop control required by real-world applications. This presentation details the creation and use of a real time simulator, built for human-in-the-loop studies of microswarms. The platform has been verified against previous experimental results and found to present a small error (8%), which is due to the limitations of the platform imposed by the real time restrictions. The error is small enough to be effectively uninfluential for most purposes. Through completing a parametric study, it was found that fluid flow velocity had the greatest effect on the number of particles reaching the chosen outlet, ranging from 98% for a lower velocity of 0.001m/s to 30% for a higher velocity of 0.025m/s.

Speaker Biography: Benjamin Jarvis is a second year PhD student at the University of Essex, Colchester, UK. His research concerns the articulation and control of ferrous micro-robotic swarms using electromagnetic gradient fields, and how this can be used in the wider field of medical robotics. Mr Jarvis' background is in Computer Science, with his final year dissertation focusing on simulation of third generation neural networks.

Liquid Metal Smart Feet Capable of Reversible Underwater Adhesion for Crawling Robots

Hongda Lu

Soft crawling robots have potential applications for cargo delivery, human-robot interaction, surveillance, and rescue in complex environments. However, most existing soft crawling robots either use nonadjustable feet to passively induce asymmetry in friction to actuate or are only capable of moving on surfaces with specific designs. Thus, robots often lack the ability to move along arbitrary directions in a two-dimensional (2D) plane or in unpredictable environments such as wet slippery surfaces. Liquid metal is endowed with electrochemically tunable interfacial tensions, displaying interesting phenomena in forming patterns, jumping of liquid metal droplets, and guiding liquid metal in microchannels. Here, we report the development of liquid metal smart feet (LMSF) that enable electrical control of friction for achieving versatile actuation of prismatic crawling robots on wet slippery surfaces. The functionality of the LMSF is demonstrated on crawling robots with soft and rigid actuators. Parameters that affect the performance of the LMSF are investigated. The robots with the LMSF prove capable of actuating across different surfaces in various solutions. Demonstration of 2D locomotion of crawling robots along arbitrary directions validates the versatility and reliability of the LMSF, suggesting broad utility in the development of advanced soft robotic systems.



Speaker Biography: Hongda Lu received his B.S. in Measurement and Control Technology and Instruments in 2018 from the University of Science and Technology of China (USTC, China). He is currently a PhD student at the University of Wollongong (UOW, Australia) under the guidance of Professor Weihua Li. His research focus is on the development of the integrated and modular systems for synthesising liquid metal nanoparticles and composites and the exploration for the applications of these materials.

A Numerical Platform for Prediction Behavior of Magnetic Microswarms Under the Different Dynamic Magnetic Field Conditions

Kiana Abolfathi

The most critical issue in a swarm system of microrobots is collective behaviour control. Although the swarm microrobots have a relatively simple structure, collective behaviour of them has a high potential to perform complex tasks especially in medical context which range from medical procedures such as surgery, and imaging, to targeted therapy. They can be controlled by off-board propulsion and steered to the deep region. Because of this ability, swarm microrobotics are attention-grabbed for researchers and they are promising non-invasive surgery tools. Due to limitations in experiments in-vitro and in-vivo (optimal time and safety), the numerical platform for predicting the behaviour of swarm micro/-nanorobots in different conditions for steering and shape prediction is crucial. In our studies, we developed a numerical platform to predict the behaviour of thousands of magnetic nanoparticles under the rotating magnetic field. The proposed platform has a high ability to show and generate different shapes of swarms. Based on the obtained results, the swarm behaviour of nanoparticles has been divided into 5 main categories (single aggregation, multi aggregation, free dispersion, chain shape, and boundary shape). The numerical platform based on an oscillating magnetic field also can predict the separation of the aggregated particles. With the proposed platform shape forming and dispersions of particles are numerically controllable. The result showed that this platform has a high accuracy in microswarm steering and shape prediction.

Speaker Biography: Kiana Abolfathi is a PhD student at the university of Essex. She studied M.Sc. in mechanical engineering University of Tehran. She received her B.Sc. of mechanical engineering from Sharif University of Technology (IRAN) in 2018. Her graduate research focuses on developing a swarm of micro/nano-robots for medical application. She is developing a platform for studies of different swarm modes for magnetic nanoparticles.

Variable Stiffness Wires Based on Magnetorheological Liquid Metals

Xiangbo Zhou

Magnetorheological fluid (MRF) has shown its great potential in the development of large mechanical devices, such as dampers, shock absorbers, rotary brakes, clutches, and prosthetic joints. Recently, more research focus has been invested on using MRF to develop soft, stretchable, and miniaturized devices with variable stiffness for realizing functionalities that cannot be achieved using solid smart materials. Here, a variable stiffness wire with excellent electrical conductivity is demonstrated, based on liquid metal magnetoactive slurries (LMMS). Without exposure to a magnetic field, the LMMS wire has an extremely low stiffness, and can be easily stretched while maintaining an excellent electrical conductivity. When applying a magnetic field, the wire becomes much stiffer and can retain pits shape even under a load. The combination of properties of flexibility, high electrical conductivity, and variable stiffness of the wire is harnessed to make a flexible gripper that can grasp objects of various shapes. Moreover, by using gallium instead of its liquid metal alloys, the tunable stiffness range of the LMMS wire is significantly enhanced and can be controlled using both magnetic fields and temperature-induced phase change. The presented LMMS wire has the potential to be applied in flexible electronics, soft robotics and so on.

Speaker Biography: Xiangbo Zhou received the B.S. degree in Measurement and Control Technology and Instrumentation from University of Science and Technology of China, Anhui, China, in 2022. He is currently working toward the Ph.D. degree in Engineering with the School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, NSW 2522, Australia. His research interests include Liquid metals, Elastic conductive composites, as well as their applications in Flexible sensors, Function actuator and Wearable electronics.

Design and Modelling for Chamber-Reinforced Soft Robots with Dimension Scalability

Jialei Shi

Elastomer-based soft robotic devices driven by fluids have prosperously emerged and developed for, e.g., dexterous manipulation, biological locomotion, and safe robot-environment interaction. A safer interaction is especially advantageous in medical procedures, for example, minimally invasive surgeries, where unexpected hard contact between the medical instruments and human organs can be mitigated. To be functionally applicable for this, the soft instruments should have a scalable dimension, with predictable, reliable, and repeatable behaviours. Motivated by this, we created soft manipulators with a miniaturisation capability, of which the diameter can be smaller than 10mm, with omni-directional bending and elongation capabilities. Each actuation chamber is fibre-reinforced to maximise the predictability. In addition, the central channel is preserved for attaching appendages. The design paradigm for this robot is flexible to be tailored based on the assessments of the specific application. To investigate the stiffness controllability of the soft manipulator, we also proposed a modelling method which can be used to describe the distributed and configuration-based compliance. Moreover, the nonlinearity of the robot can also be accommodated. The overall results show that the robot is promising for the further application.

Speaker Biography: Jialei Shi is pursuing his PhD in Soft robotics with the department of mechanical engineering. University College London, UK. He received the B.S. in 2016 and M.S. in 2019, from the Harbin Institute of Technology and Beijing Institute of Technology, respectively. From 2017 to 2019, he was a visiting student at Tsinghua University. His current research interests include design and modelling of soft continuum robots, and its medical application.

Mechanical Reinforcement towards Fully Soft Magnetic Manipulators for Surgical Applications

Zaneta Koszowska

In this work we aim to find an optimal design of the magnetic soft manipulator for Endonasal Endoscopic Surgery (EES). We investigate unstable actuation scenarios in which magnetic torque causes a twist about the main axis of the soft manipulator, instead of desired deflection. This torsional deformation leads to unpredictable control and to a decrease in bending capabilities of the manipulator. In complex procedures such as EES, maximizing number of DOFs is crucial to improve surgical outcomes. This can be achieved only if the twisting motion is eliminated or minimized. To address the issue of twisting, we consider a manipulator design with an elastomeric double helix reinforcement structure. This unique geometry allows us to create a manipulator with variable stiffness between its Y-Z and X-Z planes and low torsional stiffness. We present two designs and determine most optimal solution experimentally under application of magnetic fields. Additionally, we observed independence in motion between the two planes. This allowed us to create a modular design, where two segments are joined together to make a manipulator with variable stiffness along its length for improved manoeuvrability. We hope this work will contribute to design of soft magnetic tools for EES procedures, where high manoeuvrability is required.

Speaker Biography: Zaneta Koszowska received a BEng in Biomedical Engineering in 2018 from Middlesex University London and an MSc in Rehabilitation Engineering and Assistive Technologies from University College London in 2019. In 2019, she joined STORM lab at University of Leeds. Since then, she is pursuing a doctorate degree under supervision of Professor Pietro Valdastri. Her PhD research focuses on design and fabrication of soft magnetic robots for medical applications.

Dual-Arm Platform for Control of Magnetically Actuated Soft Robots

Michael Brockdorff

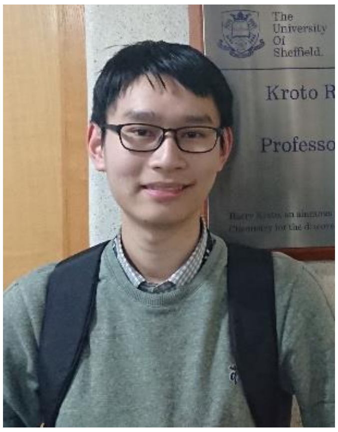
The rise in popularity of magnetic actuation comes from the fact that it allows for the control of wireless magnetic micro-robots and magnetic Soft Continuum Robots (SCRs), which bring about a reduction in size when compared to their non-magnetic counterparts. SCRs have a theoretical infinite number of Degrees of Freedom (DOFs) and thus, can adapt to various nonlinear environments, minimising contact and pressure on surrounding tissue. While successful multi-DOFs magnetic actuation has been demonstrated at small scale, by using systems of coils, large-scale manipulation is yet to be fully proven. Despite their ability to generate both homogeneous fields and gradients, systems of coils are less scalable, compared to permanent magnet based magnetic field control systems. The present work discusses a novel approach for remote magnetic actuation. In the following, we present a full characterization of the dual External Permanent Magnet actuation system. Herein, we discuss how this system can be applied to fully control the magnetic field in a predefined workspace. We discuss how it can generate a homogeneous magnetic field, in every direction and control every independent gradient in the same workspace. We prove how up to 8 magnetic DOFs, 3 independent field components and 5 gradients directions, can be controlled fully independently.

Speaker Biography: Michael Brockdorff received a BEng (Hons.) in Electrical and Electronics Engineering from the University of Malta in 2019 and an MSc in Biomedical Engineering from Imperial College London in 2020. He is currently working toward his Ph.D. degree in Medical Robotics at the University of Leeds. His research interests include magnetic actuation, continuum robots and digital electronics.

Wireless Power Transmission of Self-Folding Origami Robot

Jialun Liu

Origami, the traditional art of paper folding, has been proved as an effective method to produce a 3D functional structure from a planar structure from folding up the quilt to folding the satellite solar panels. Self-folding, an ability of origami robots that can fold themselves into functional structures, enables the potential of autonomous fabrication and deployment of foldable robots. Smart materials, for example, shape-memory polymers (SMP), could be building blocks for self-folding origami robots. By triggering the deformation of the SMP layers of the robot, torques are introduced along the pre-designed creases, resulting in self-folding behaviour. Studies have proved that self-folding origami robots have abilities to perform tasks in harsh environments such as human stomachs, pipelines and so on. In such a dark space, lighting condition is needed to use a camera for imaging or optical sensors for constructing a map of the environment. Also, onboard electronics could provide additional approaches for enhancing robot autonomy and transmitting data to other devices. Here we demonstrate a self-folding origami robot equipped with an LED and a receiver coil. The origami robot is made of a thermo-responsive polyvinyl chloride (PVC) film which sandwiched by two conductive structural layers (Duralar). The robot is wirelessly powered by an induction coil while its locomotion is wirelessly controlled by electromagnetic coils. This untethered robot can fold itself into a functional structure through global heating, move to a certain position, receive the power wirelessly and light up a dark environment.



Speaker Biography: Jialun Liu is a first year PhD student at the University of Sheffield, UK. He is currently working with Dr Shuhei Miyashita and Dr Dana Damian at Sheffield Microrobotics Lab and Sheffield Biomedical Robotics Lab. His research interests include the magnetic localization and actuation of robots, smart materials, physical computation, soft robot and hydraulic systems.

AI Assisted Biomechanical Tissue Evaluation for Early Bowel Cancer Diagnosis using a Robotic Capsule

Kenneth Afebu

To facilitate early diagnosis of bowel cancer, the present study attempts a non-invasive biomechanical tissue evaluation. This novel concept is based on the fact that, similar to downhole rock layers, cancerous lesions right from onset, present biomechanical inhomogeneities that are reflected in the dynamics and long-term behaviours of their impacting system such as a robotic capsule traversing the bowel. Measurable impact dynamics of the capsule when in contact with lesions were thus analysed for the purpose of characterising the lesions. Dynamic displacement signals were analysed in the case of this study. Features that may be indicative of biomechanical changes were extracted from the signals and then employed to develop lesion classifying AI models. Supervised classification using Multi-layer Perceptron (MLP) and Stacked Ensemble (SE) networks was carried out alongside unsupervised classification using k-means clustering on both simulation and experimental data. The SE learner comprised of Support Vector Machine, Decision Tree, Naive Bayes and Random Forest. Out-of-sample cross-validation of the supervised classification using simulation data showed that the SE networks performed better than their comprising individual networks. The MLP network models however showed better performances, hence, were the only supervised models replicated during experimental validation. For the unsupervised classification, both the simulation and experimental results showed that the data are best clustered into two categories representing healthy and malignant (cancerous) tissues. The overall performance of the proposed method indicates its huge potential for hard-to-visualise bowel cancer diagnosis thus improving treatment and survival rate.

Speaker Biography: Dr Kenneth Afebu is a postdoctoral research fellow of the Applied Dynamics and Control Lab at the University of Exeter. He holds a BSc (Hons) in Geology and an MSc in Applied Geophysics from the University of Ibadan, Nigeria, and another MSc in Petroleum and Gas Engineering from the University of Salford, UK. Dr Afebu obtained his PhD on Intelligent Models for Optimisation of the Vibro-Impact Drilling System in 2022 under the supervision of Dr Yang Liu. His work and research experience includes geological and geophysical investigations for structural integrity and mineral exploration, core drilling for mineral deposit assessment, flow dynamics for pipeline monitoring, vibration signal analysis for system characterisation and machine learning with real-life application.

CFD Modelling of Magnetic Microrobots in the Gastrointestinal Circulation for Metastatic Cancer Detection

Andrew Bickerdike

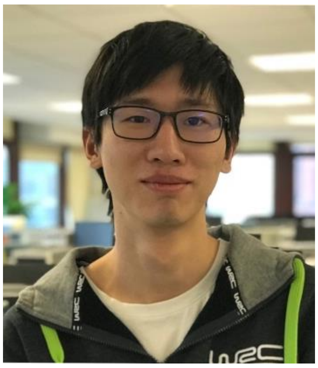
Metastasis of colorectal cancer remains a challenging health condition to diagnose. With early diagnosis of paramount importance for a favourable patient prognosis, it usually involves an invasive colonoscopy procedure, which is not only uncomfortable for the patient, but resource heavy and technically challenging. Alternatively, in recent years medical microdevices have been a highly focussed research topic, suggesting microrobots have the potential to be used in a range of minimally invasive medical applications to treat and diagnose cancer. They can utilise the circulatory system to provide a direct route to the complex, chaotic and unpredictable microvasculature of the tumour. The present work uses Computational Fluid Dynamics (CFD), namely the Hybrid Fictitious Domain-Immersed Boundary coupled with the Discrete Element Method solver implemented into the open-source CFD code OpenFOAM to analyse the deployment and distribution of magnetic microrobots in the gastrointestinal circulation. The dynamic performance of the microrobots is assessed across a range of time and length scales, including the vascular geometries generated from CT scan data. The size, shape and magnetic composition are studied to maximise the hydrodynamic efficiency.

Speaker Biography: Andrew Bickerdike is a first year PhD student at the Applied Dynamics and Control Lab, University of Exeter under the supervision of Dr Yang Liu. He obtained his BEng (Hons) in Mechanical Engineering in 2021 from Newcastle University, UK. His research interests include fluid dynamics in bioengineering, microrobots and detection of bowel cancer metastasis.

Thermo-Responsive Shape-Changing Milli-Robot

Junyi Han

Smart materials give observable responses when stimulated by environmental stimuli which enables miniature robots to interact precisely with the surrounding environments. It also changes their physical properties as responses to stimuli. Here we show a millimetre-sized mobile robot performing rolling at different speeds by changing its shape which is enabled by the temperature-responsive smart material: pNIPAM. Able to change volume in the range of 22°C to 45°C, pNIPAM can produce bending when laminated with another material unaffected by temperature changing. By using a set of electromagnetic coils and a spatially distributed magnetic sensor array that forms a closed-loop system, the robot is able to be navigated to target positions. The average speed of the robot was affected by 6 mm/s between 22°C (20 mm/s) and 45°C (14 mm/s) in rolling mode. This work illustrates how the shape of the robot affects the moving speed and shows the potential of overcoming different terrain conditions.



Speaker Biography: Junyi Han is a second-year PhD student in the Department of Automatic Control and System Engineering at the University of Sheffield. He received his BEng degree in Electrical and Electronic Engineering from the University of Liverpool, and an MSc degree in Robotics from the University of Sheffield. He is currently working with Dr Shuhei Miyashita at Sheffield Microrobotics Lab. His research interests include self-assembly, milli-robots, and smart materials.

Distinct Gaits of Self-Propelled Quadriflagellate Microswimmers

Dario Cortese

Legged animals often coordinate multiple appendages for both underwater and terrestrial locomotion. Quadrupeds in particular, change their limb movements dynamically to achieve a number of gaits, such as the gallop, trot, and pronk. Surprisingly, micron-sized unicellular algae are also capable of coordinating four flagella to produce microscale versions of these gaits for swimming. Here we present a fully-3D model of a quadriflagellate microswimmer comprising five beads and systematically investigate the effect of gait on swimming dynamics, propulsion speed, efficiency, and induced flow patterns. We compare our findings with measurements performed on an upscaled robophysical model in which the four flagella are actuated according to different gaits. We find that by changing gait alone, distinct motility patterns emerge from the same basic microswimmer design. This suggests that different species of morphologically-similar microorganisms (e.g., with identical number and placement of appendages) evolved distinct flagellar coordination and control patterns to perform specific tasks such as free-swimming, single-cell dispersal, feeding, and predator-avoidance. The insights gained by examining the mechanics of such analytically tractable microswimmers can inform and improve the design and control of artificial or robotic swimmers inspired by flagellated organisms that are capable of effective navigation at low-Reynolds numbers.

Speaker Biography: Dario Cortese is currently a Postdoctoral Fellow at the Living Systems Institute, University of Exeter (UK). He received his Ph.D. in Applied Mathematics from the University of Bristol, with a thesis on the Nonlinear Dynamics of Active Liquid Crystals. Previously, he completed his B.Sc. and M.Sc. degrees in Theoretical Physics at the University of Rome – La Sapienza. His research work focusses on modelling the locomotion of swimming microorganisms, and the dynamics of active fluids.

Design and Experimental Investigation of a Vibro-Impact Self-Propelled Capsule Robot with Orientation Control

Jiajia Zhang

This work presents a novel design and experimental investigation for a self-propelled capsule robot that can be used for painless colonoscopy during a retrograde progression from the patient's rectum. The steerable robot is driven forward and backward via its internal vibration and impact with orientation control by using an electromagnetic actuator. The actuator contains four sets of coils and a shaft made by permanent magnet. The shaft can be excited linearly in a controllable and tilted angle, so as to guide the progression orientation of the robot. Two control strategies are studied in this work and compared via simulation and experiment. Extensive results are presented to demonstrate the progression efficiency of the robot and its potential for robotic colonoscopy.

Speaker Biography: Jiajia Zhang got her BEng in 2017 from the University of Science and Technology Beijing in Electronic and Automation and MSc in 2018 from the University of Dundee in Biomedical Engineering. She is currently a PhD student at the University of Exeter under the supervision of Dr Yang Liu working towards medical robotic designs involving vibration system. Jiajia has been awarded a medal for the best student in MSc graduation and the winner of poster competition at the 4th Annual IEEE UK & Ireland Robotics and Autonomous Systems Chapter Conference.