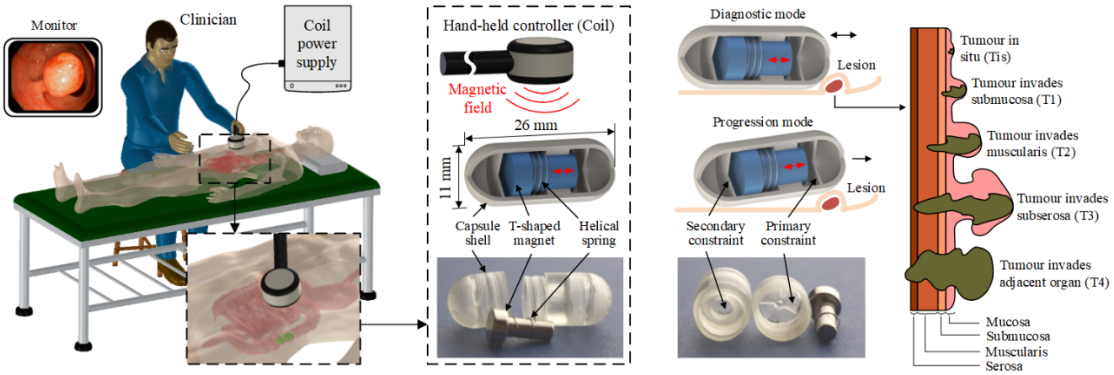
Utilising the Vibro-Impact Self-Propelled Capsule for Lower Gastrointestinal Endoscopies

Yang Liu
Exeter Small-Scale Robotics Laboratory, Engineering Department, University of Exeter, Exeter, UK
Email: y.liu2@exeter.ac.uk

Capsule endoscopy has become established as the primary modality for examining the 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 vibro-impact self-propelled capsule robot was developed by the Exeter Small-Scale Robotics Laboratory at the University of Exeter for lower gastrointestinal (including the small and large intestines) examinations. In this talk, I will introduce this research work from the principle, including mathematical modelling, numerical analysis, control and optimisation, experimental investigation, to proof-of-concept validation in an *ex vivo* intestinal environment. I will particularly focus on studying how nonlinear dynamics could help with the design and control of the robot as well as the diagnosis of early bowel cancer. 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 six metres and capsule speed of just 2 mm/s, small intestinal transit could be reduced to no more than 50 minutes. Compared with the conventional capsule endoscopy, this technique may offer the potential for a "live" and controllable examination.



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Bio-sketch of Yang Liu

Dr Yang Liu is an Associate Professor in Dynamics and Control in Engineering Department at the University of Exeter, Exeter, UK, and an Honorary Lecturer in Endoscopy Department at the Royal Devon University Healthcare NHS Foundation Trust, Exeter, UK. He obtained his B.Eng. degree in Automation from Hunan University, Changsha, China in 2003, M.Sc. degree in Control Systems from the University of Sheffield, Sheffield, UK in 2005, and Ph.D. degree in Control Engineering from Staffordshire University, Stafford, UK in 2010. After joining the University of Exeter in 2016, he has been leading the Exeter Small-Scale Robotics Laboratory working on dynamics and control of non-smooth dynamical systems. He has published more than 90 academic papers including 76 high impact peer-reviewed journal papers, e.g., in *Phil. Trans. R. Soc. A*, *Int. J. Mech. Sci.*, *Nonlinear Dyn.*, and *Commun. Nonlinear Sci.*, and two patents. His team has been awarded the Lab Science Bursary Award in the 2019 British Society of Gastroenterology Annual Meeting and the Ali H. Hayfeh Prize at the 2nd International Nonlinear Dynamics Conference in 2021.