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Hosted by Prof. Xinge YU

Multifunctional Untethered Medical Robots for Active Targeting from a Scale Perspective

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Abstract

Active targeting is a technique that delivers medication to specifically target and interact with diseased tissues or cells. It can significantly improve the efficacy and reduce the side effects of treatments by ensuring that therapeutic agents are delivered directly to the site of interest. However, due to the complicated anatomy of the human body, such as from the cell membrane (nano), mucus layer (micro), to the gastrointestinal tract (macro), it poses challenges to achieve the target site through various physiological barriers across different scales. Medical robots, as active biomedical devices with specific propulsion units, have emerged with the potential to mitigate these challenges due to their well-controlled features enabled by various actuation mechanisms. This talk will discuss some representative robotic devices for potentially active targeting drug delivery at different scales. At the microscale, we have developed a bioinspired fillable microrobotic system with robust payload capacity, strong protection, and targeted locomotion for on-demand drug delivery. It incorporates an internal chamber for loading large drug quantities and spatial drug separation, and a near-infrared-responsive top-sealing layer offering strong drug protection and on-demand release. A corresponding dip-sealing strategy was developed to encase and protect the loaded cargo while maintaining the geometric and structural integrity of the loaded microrobots. From the macroscale, soft robots in millimeter size can navigate through the complex structures of the human body, such as the gastrointestinal tract, by adapting their shape and motion to the surrounding environment. We have developed a 4D printed multimaterial soft actuator design (MMSA) whose actuation is initiated only by a combination of triggers (i.e., pH and temperature). The utility of the 4D MMSA is demonstrated via a series of cargo capture and release experiments, validating its ability to demonstrate active spatiotemporal control. Developing medical robots at various scales provides a versatile avenue for creating a new generation of biomedical devices for targeted drug delivery, offering enhanced precision and control in overcoming physiological barriers and ensuring effective treatment.

Biography

Dr Rujie Sun is currently a Lecturer (Assistant Professor) in Digital Health & Biomedical Engineering Group (DHBE), within the School of Electronics and Computer Science (ECS) at University of Southampton. He is also an academic visitor in the Department of Physiology, Anatomy and Genetics at University of Oxford. Before that, he was a Research Associate in Molly Stevens' group at Imperial College London from 2019 to 2023. He received his Ph.D. degree at Bristol Composites Institute, University of Bristol, UK in 2019. From 2016 to 2017, he was a research scholar in John Rogers' group at University of Illinois Urbana-Champaign, USA. Dr Sun's Multiscale Intelligent Biodevices Lab are focusing on the development of next-generation medical devices integrated with biosensing, actuation, therapy, and AI-assisted control. He has published over 30 papers in areas of medical robotics, flexible sensing and energy harvesting, in top journals and conferences with over 2000 citations including Advanced Materials, Science Advances, Applied Energy, Advanced Healthcare Materials, etc. His research interests include medical robotics, intelligent metamaterials, and bioelectronics.