Autonomous Navigation Solution for Medical Microbots With Deep Reinforcement Learning

Goddla, Vikram (School: Detroit Country Day School)

Miniature-sized shape morphing Microbots are increasingly gaining momentum in several medical applications, including targeted drug delivery and the removal of blood clots. There has been significant progress in developing medical microbots with advanced materials and shapes, but navigation of the microbots in the human system continues to remain the biggest challenge. The human system is a complex environment with system dynamics that are difficult to model. Manual and classical feedback control systems are ineffective for medical microbot navigation because they require unrealistic proficiency and precise system modeling. I propose an innovative solution with deep reinforcement learning for autonomous navigation of medical microbots in uncharacterized environments. Reinforcement learning solutions learn in complex environments by mimicking human behaviors of trial and error without requiring a detailed understanding of the environment. I developed the reinforcement learning solution in an integrated in-silico framework featuring a magnetically powered microbot swimming in a vascular-system-like simulation environment. I validated the reinforcement learning control system with in-vitro experiments using magnetically powered helical hydrogel microbots navigating in a polydimethylsiloxane lab-on-a-chip biomimetic environment. The reinforcement learning agent successfully learned to autonomously navigate medical microbots in unknown biomimetic environments without any detailed knowledge of the system. This solution proves that reinforcement learning agents have the capabilities to revolutionize precision medicine by delivering drugs directly to brain tumors, removing unrealized blood clots, and ultimately saving patients' lives in the future.

Awards Won:

Third Award of $1,000