Continuum Robots with Equilibrium Modulation (CREM)

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Summary

The A.R.M.A. Laboratory of Vanderbilt University has developed a novel continuum robot design enabling multi-scale motion at the macro and micro scale. The unique design allows miniaturization with minimal added cost thereby potentially giving rise to a new generation of surgical robots capable of both macro-motion for surgical intervention and micro-scale motion for cellular-level imaging or intervention. Micro-motion is achieved through a unique method for altering the equilibrium pose of the robot via material re-distribution throughout the length of the robot. This process ushers in a new class of surgical robotics termed continuum robots with equilibrium modulation (CREM).

Addressed Need

The prevalence of robotic slave arms in tasks requiring high accuracy and precision such as surgery is due to their superior dexterity compared to humans, yet these systems are still limited in their applications due to: i) the requirement of a large workplace environment, ii) the inability to reliably perform tasks at the micrometer scale, and iii) their inability to traverse curved passageways, which result in increased invasiveness in surgical contexts. The present continuum robot technology's novel method of equilibrium modulation can be used for both macro-manipulation as well as micro-manipulation on the scale of few micrometers without the need for reconfiguration of the system, expanding the capabilities of robotics in minimally invasive surgery (MIS) and industrial applications.

Technology Description

The technology revolves around continuum robots with equilibrium modulation. The flexible architecture of previous continuum robots allowed them to achieve snake-like motion for macro-manipulation. By placing small elastic wires inside the actuation tubes used for macro-motion and creating coordinated changes in the locations of these wires, the static equilibrium of the adjacent plates can be changed, creating motion at the micrometer scale while maintaining the ability to perform macro-motion. This embodiment is packaged into a miniature design allowing small confined spaces to be traversed and worked in with reliability and precision. Once in place, the robot can use its continuum modulation capabilities to support micrometer scale image-based inspection, biopsy, and micro-scale intervention.

Unique Features

- CREM robots are capable of both macro and micromovement and manipulation without the need for modification to the system
- The present technology is able to achieve motion resolutions of 1 micron or less using inexpensive actuators
- The ability to traverse tortuous anatomical and industrial pathways and achieve high levels of precision will reduce the need for invasiveness in deep anatomical procedures

Intellectual Property Status

- Issued US Patent: US 10,967,504
- US continuation filed: US 20210205981A1
- Article: https://engineering.vanderbilt.edu/news/2019/robot-prototype-shows-promise-for-

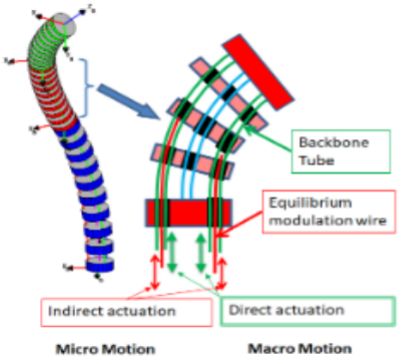

Figure 1: The robot is able to achieve large scale motion using the tubular secondary backbone while also achieving micromotion through the wires (red) that can slide in and out of the backbones.

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