The Chinese University of Hong Kong
Department of Biomedical Engineering

Graduate Seminar – PhD Oral Defence

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Date : 2 December, 2021 (Thur)
Time : 2:00 pm
Zoom Link : https://cuhk.zoom.us/j/3773276503?pwd=eW5STkdlSnpmeUJscXgxNnFoek9Ydz09
Meeting ID : 377 327 6503
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Title: Biomimetic Soft Crawling Robot for GI Inspection

Colorectal cancer (CRC) is one of the most common cancer in the world and early screening is an effective way to prevent CRC. However, the discomfort caused by conventional endoscopy and its long learning curve may depress the promotion of early screening. Although many novel robotic endoscope platforms are developed to shorten the learning curve, the interaction between inspection instrument and the human colon are barely discussed. Considering the soft and elastic nature of the human colon, we proposed a novel biomimetic soft robot platform for gastrointestinal tract inspection (Earthworm-like GI soft robot) and presented the modeling and control method of the robot. The main contributions of this thesis are: (1) Developed a novel earthworm-like pneumatic robotic endoscope system that is compatible with inspection in a complex environment. (2) First case of interaction model for a soft balloon and soft tube interaction. (3) First case of elasticity perception for a soft environment using an interacting balloon with an external pressure sensor. First, inspired by the muscle structure of earthworms and locomotion of inchworms, Earthworm-like GI soft robot consists of an expandable head and rear as the anchoring section, and an extendable and bendable middle section. It is activated by a pneumatic system. Compared with the existing robotic endoscopic platform, Earthworm-like GI soft robot has the simplest structure with higher locomotion efficiency. The maximum crawling speed can be up to 3.5mm/s in a soft silicone tube and 1.52/s in an ex-vivo pig colon which means it can finish a 1.5-meter colon inspection within 17 mins. Second, the anchoring model, kinematic model, and dynamic model in the quasi-steady-state of the robot are formulated. The anchoring model combines hyperelastic membrane theory and continuum method to find out the relation between the inner pressure of the anchoring section and the anchoring force. Third, we use CPG to control the locomotion of the robot. In the light of the worm-like locomotion is a rhythmic movement in the aspect of neuroscience, we applied five CPG models to the five chambers of the robot and connected them into a CPG network which makes its locomotion easier to control. At last, we divined the relation between the anchoring pressure changing ratio and ambient environment elasticity. We let the earthworm-like GI soft robot crawl through an elasticity varying soft tube and successfully estimate the elasticity distribution of the soft tube. Results show that the earthworm robot could well estimate the elasticity of the tube, with an overall estimation error of less than 9%.

In conclusion, the presented endoscopy platform has simpler control and higher safety consideration among its design and performance test which allows it can lower the discomfort during colon inspection and the manpower requirement for promoting CRC early screening.

***** ALL ARE WELCOME *****

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