Robotics and Autonomous Systems Thesis Defense

Magnetic Tissue Retraction for Endoscopic Surgery

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Abstract

The Endoscopic Submucosal Dissection (ESD) method is increasingly becoming the method of choice for surgeons attempting to remove precancerous and early-stage cancerous lesions in the lining of the Gastrointestinal (GI) tract. Being an endoscopic procedure, it is less invasive than most other procedures used for tumor removal. However, this procedure has a steep learning curve and a high number of surgical complications. The primary reason for this is the limited ability of the surgeon to retract mucosal (stomach lining) tissue while they dissect under it. Unlike in traditional surgery, the surgeon lacks a second hand to leverage tissue during dissection in endoscopic procedures.

This study proposed the deployment of an endoscopic clip to the surface of the lesion. The clip had a permanent magnet connected to it. In addition, a large permanent external magnet mounted to the end-effector of a robotic arm was positioned above the magnetic clip to pull the internal magnet and retract tissue. Magnetic Force simulations were conducted in the design processes for the magnets to determine whether sufficient force for tissue retraction was being achieved. The use of fiber optic shape sensors to track and localize the internal magnet was also explored. Experimental validations of the external and internal magnet designs as well as tracking of the internal magnet were performed in surgical trials on ex-vivo and live porcine models.

Compared to traditional ESD, the use of magnetic retraction in ESD significantly improved tissue exposure for dissection, decreased the required time for the dissection stage of the ESD procedure, and reduced the incidence of surgical complications. Therefore, this technology holds substantial potential for enhancing ESD procedures, advancing the non-invasive treatment of colorectal cancer, and potentially improving patient outcomes significantly.

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