ROBOTICALLY STEERING FLEXIBLE ENDOSCOPES FOR NOTES

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ABSTRACT

Manually steering the tip of a flexible endoscope to navigate through an endoluminal path relies on the physician's dexterity and experience. A robotic flexible endoscope steering system was developed that uses the endoscopic images to control the endoscope tip orientation towards the direction of the lumen. Two image-based control algorithms were investigated, one is based on the optical flow and the other is based on the image intensity [1]. Both were evaluated using simulations in which the endoscope was steered through the lumen. The RMS distance to the lumen center was less than 25% of the lumen width.

An experimental setup was built using a standard flexible endoscope, and the image-based control algorithms were used to actuate the wheels of the endoscope for tip steering. Experiments were conducted in an anatomical model to simulate gastroscopy. The image intensity-based algorithm was capable of autonomously steering the endoscope tip through an endoluminal path from the mouth to the duodenum. The steering was compared to manual control in an experiment were five subjects performed the same procedure using the conventional endoscope controls. Compared to manual control, the robotically steered endoscope performed 68% better in terms of keeping the lumen centered in the image.

The developed image processing algorithm was also used in an experimental setup where a flexible endoscope was steered in a 'shared control' mode. Using this setup, the endoscope was steered using a haptic device, while haptic feedback was given based on the output from the image-processing algorithm. This way, the endoscope could be controlled by the operator and the image-processing algorithm simultaneously.

The purpose of this setup was to develop an alternative control method for next generation of complex endoscopes that are currently being developed for Natural Orifice Transluminal Endoscopic Surgery (NOTES) e.g., the EndoSAMURAI (Olympus Corp., Tokyo, Japan) and the ANUBIS (Karl Storz GmbH & Co. KG, Tuttlingen, Germany). It is not possible to control these endoscopes by a single physician. Hence, robotically steering such advanced endoscopes using our proposed approach could be a solution.

REFERENCES

[1] R. Reilink, S. Stramigioli and S. Misra, "Image-Based Flexible Endoscope Steering," in Proc. Int'l Conf. on Intelligent Robots and Systems (IROS), Taipei, Taiwan, October 2010. *In Press*