Robo-ELF:
Ergonomic Controller & Computer Vision Tools

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Introduction

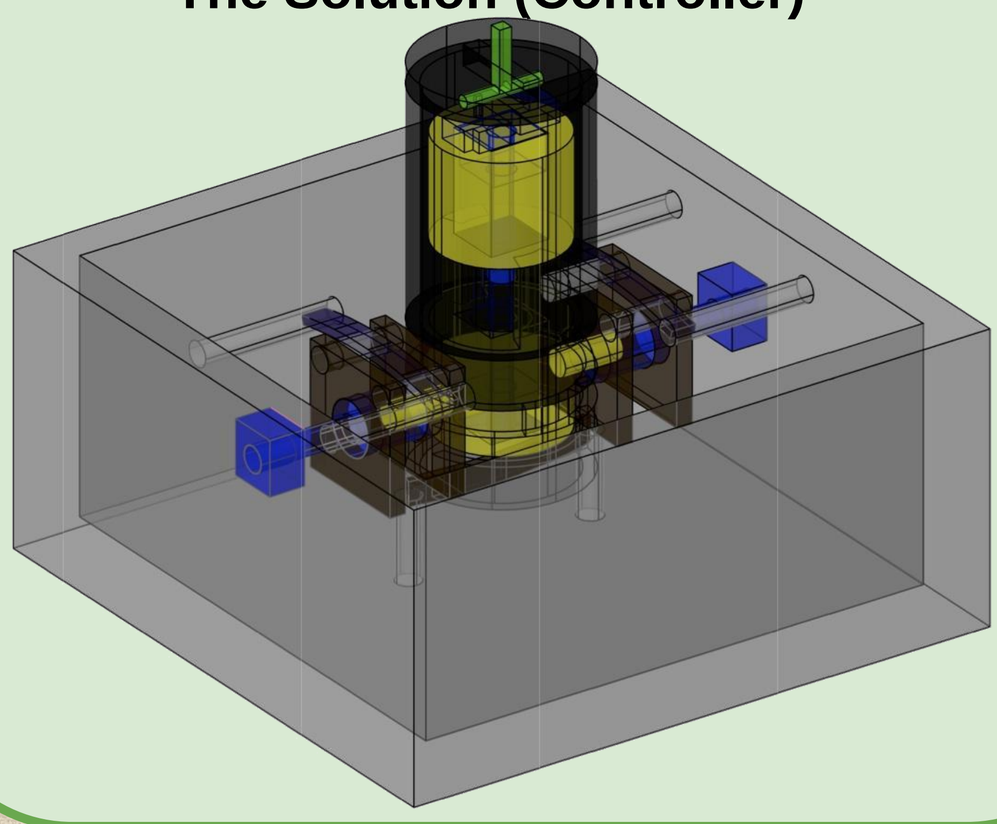
Robo-ELF is a robotic **E**ndo-**L**aryngeal **F**lexible scope driver for minimally invasive laryngeal surgery. The robot keeps the scope steadily in place during surgery and also allows the surgeon to accurately manipulate the flexible endoscope using a controller. The goal of this study was to improve two major aspects of Robo-ELF: the controller and vision tools.

- We developed an ergonomic joystick that is optimal for manipulating fine movements of the robotic flexible endoscope system.
- Computer vision software was developed to obtain quantitative endoscopic measurements from monocular scope images.

The Problem

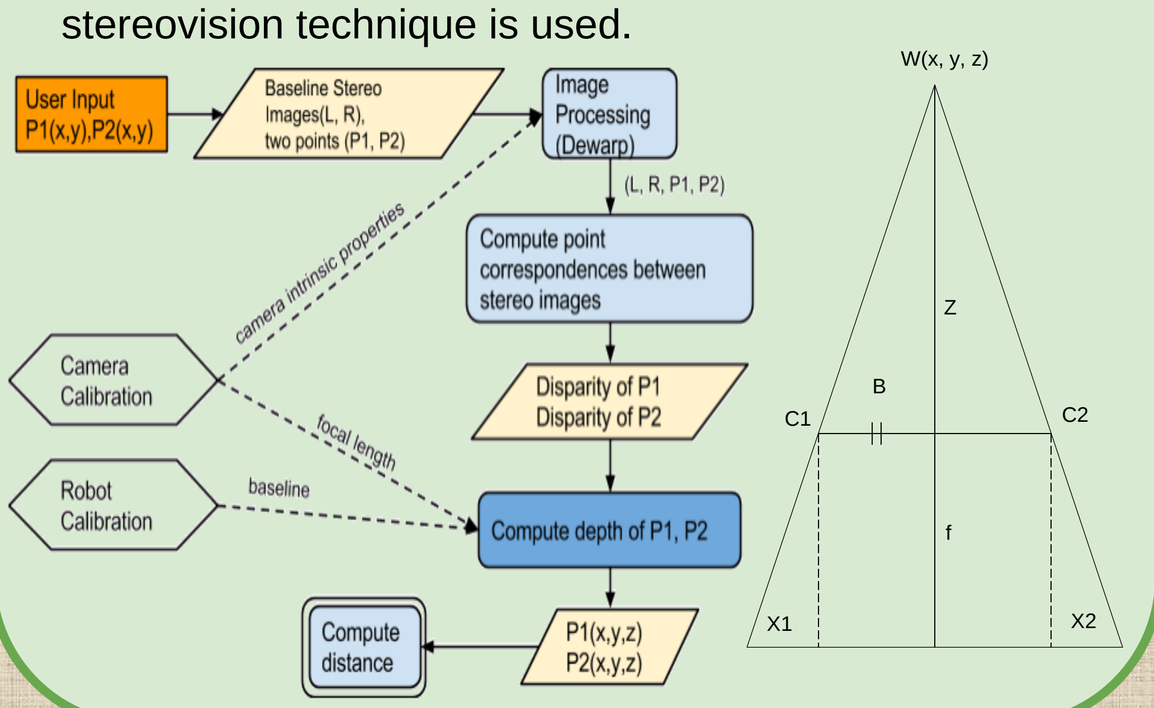
- Current controller prototype of the Robo-ELF has bulky size and poor ability to decouple different motions. The unintuitive controller design increases the difficulty of use.
- Increasing sizes of endotracheal tubes are inserted and pressure leak tests are performed to obtain endo-laryngeal measurements. The current standard is not only uncomfortable for the patients but also inaccurate as the procedure itself may alter the larynx.

The Solution (Controller)



The Solution (Computer Vision)

- To obtain 3D measurements from scope images, stereovision technique is used.

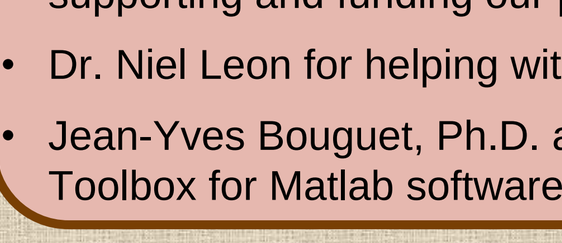


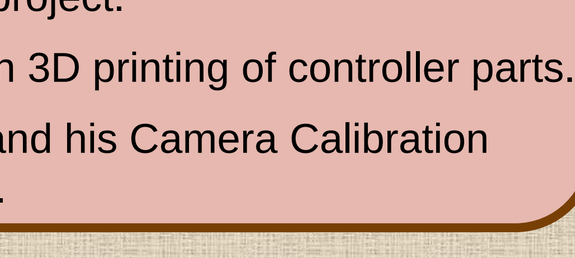
Outcomes and Results (Controller)

- The controller design is very compact (5” X 5” X 8”) and requires only one hand to operate, allowing surgeon to use the other hand to use surgical instrument simultaneously.
- The controller has intuitive manipulation, as the motion of the controller is parallel to that of scope.
- Gimbal mechanisms are implemented for self-reorientation and haptic feedback functions.
- Pair of potentiometers is mounted on each degree of motion to ensure redundant reading as well as analog sensing of rotation

Outcomes and Results (Computer Vision)

- 3D measurements are obtained
- Inconsistent measurements due to **noisy baseline** values





Future Work

- Feedback from surgeon and analyze pros and cons of the controller design.
- Obtain more reliable and accurate 3D measurements by moving to active stereo approach using a endoscope+laser system. *(Already started)*

Credits

- Jong Heun Kim: Design of the controller.
- Tae Soo Kim: Computer vision software development.
- Steve Park: Manufacturing of the controller.

Lessons Learned

- Plan ahead for unexpected delays when ordering and printing parts
- Better plan for unresolved/unforeseen dependencies

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