Data Collection System for Smart Endoscope Project

Project Proposal

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Goal

The goal for this project is to design and implement a data collection system for the study and development of a fully-autonomous robotic endoscope manipulator. The system includes the hardware(sensors and trackers), the software(data logging and processing), and design documentations(experiment work-flow, instructions, etc.).

Background

This project serves as a preliminary study and a prerequisite for the Smart Endoscope project. The Smart Endoscope project aims to develop a fully autonomous, robotic endoscope manipulator utilizing Galen REMS during Functional Endoscopic Sinus Surgery. In order to make the robot understand the surgical procedure and predict the next motion, machine learning techniques are planned to be used, which requires experimental data. Therefore, this project sets it goal at delivering a functional data collection system that will collect as many kinds of data as possible during the experimental surgeries.

Technical Approach

The system plans to capture and log 5 different types of data during the experiment:

1. Pose and position of the endoscope.
2. Pose and position of the suction tool.
3. Pose and position of the patient's(cadaveric) head
4. RGB video stream from the endoscope.
5. Gaze heat-map of the surgeon's gaze on the monitor.

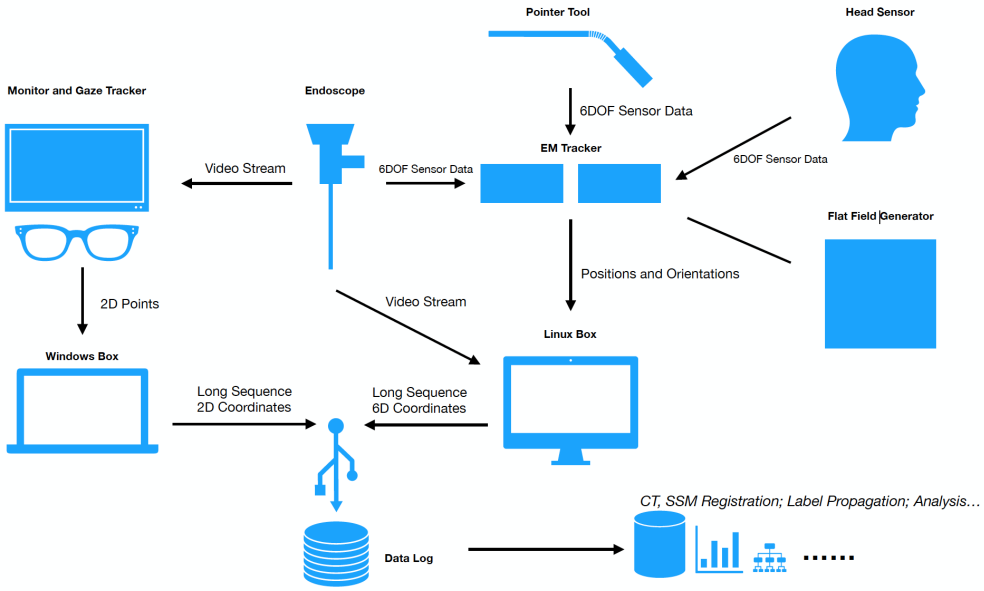

Fig 1. *Data Flow Chart/ Equipment Diagram*

The first three, poses and positions will be captured using an Aurora EM tracking system; the video stream will be recorded by the camera that is already used during normal surgical procedure; while the gaze data will be captured by a Gazepoint gaze tracker. All types of data are planned to be logged with time-stamp using the rosbag package in ROS. A data flow-chart and equipment diagram is shown as **Fig. 1**.

Deliverables and Milestones

Minimal Deliverable — Mar 19th, 2018

- The hardware for collecting all the data

Expected Deliverable — Apr 2nd, 2018

- The hardware for collecting all the data
- The software for logging all the data
- A detailed experimental procedure

Maximum Deliverable — May 11th, 2018

- The hardware for collecting all the data
- The software for logging all the data
- A detailed experimental procedure
- Programs for post processing the data

Milestones

- Feb 26th: Project proposal completion
- Mar 9th: Tool adapters design completion
- Mar 19th: Hardware integration completion
- Apr 2nd: Data logging software completion
- Apr 5th: First Test and Troubleshooting
- Apr 20th: Second Test and Troubleshooting
- May 4th: Third Test and Troubleshooting

*: The schedule is delayed and updated from the presentation due to unexpected late delivery of orders. The current status matches the updated schedule.

Dependencies

Table. 1 shows the foreseen dependencies of this project as well as their solutions, alternative plan and current status. In the Status column, Green meas solved, Yellow means in progress, Red means planed.

	Dependency	Solution	Alternative Plan	Status
1	Tracking Systems	Communicate with Dr. Taylor and Dr. Huang	Borrow similar equipment from Dr. Boctor	Solved
2	CAD Program	Download thru WSE Software Support	Student Design Lab/ CIIS Lab	Solved
3	3D Printers and Machine Shop	Contact WSE Manufacturing	Contact Outside Vendors	Solved
4	Familiarity with Surgical Tools	Communicate with Dr. Inshii and Dr. Iordachita	Contact Dr. Razavi	Solved
5	Continuous Feedback from Mentors	Schedule a weekly meeting	Communication thru Emails	Solved
6	Familiarity with Surgery Process	Contact Dr. Ishii to shadow real cases	Read Papers about FESS	Due Mar 25th
7	Experience with Tracking Systems	Communicate with Dr. Taylor and Dr. Boctor	Contact Equipment Manufactuers	Due Mar19th
8	Experience with ROS	Taking Robot System Programming with Dr. Whitcomb	Contact Paul Wilkening	Due Mar 1st
9	Gazepoint Software Able to Log	Communicate with Dr. Huang, Cong and Xingtong	Contact Gazepoint	Due Mar 19st
10	Availability of Dr. Ishii	Schedule ahead with Dr. Ishii	No Alternative	Due Apr 5th

Table 1. *Project Dependencies*

Management Plan and Reading List

The team member will have multiple weekly meetings with mentors. Besides, schedule and milestones are to be checked regularly. Due to the fact there is only one team member, all work shall be done individually. Therefore, fifteen hours are planned to be spent each week on this project and will be used as a ruler for self-supervising.

A part of the reading list is listed here. More items will be added as the research progresses.

1. Wormald, P. J. (2007). Endoscopic sinus surgery Thieme.
2. Amershi, S., Cakmak, M., Knox, W. B., & Kulesza, T. (2014). Power to the people: The role of humans in interactive machine learning. AI Magazine, 35(4), 105-120.
3. Akgun, B., Cakmak, M., Yoo, J. W., & Thomaz, A. L. (2012, March). Trajectories and keyframes for kinesthetic teaching: A human-robot interaction perspective. In Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction (pp. 391-398). ACM.
4. Cakmak, M., & Thomaz, A. L. (2012, March). Designing robot learners that ask good questions. In Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction (pp. 17-24). ACM.
5. Recording and playing back data: http://wiki.ros.org/ROS/Tutorials/Recording