Mixed Reality Surgical Team Training: Project Proposal

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This Project is mentored by Professor Peter Kazanzides and Dayeon Kim

Overview

This project will be focusing on building a prototype of endoscopic surgery training simulator. The simulator will sense the endoscopic instrument and render the model of the instrument in the form of the point cloud.

At the concept design level, Virtual body structure will be rendered together with the model and the interaction between tools and virtual organs will be implemented in order to fully simulate the real surgical process.

At the CIS2 project level, our team aims to finish the real-time high accuracy 3d point cloud obtaining and achieving a "collision detection" level interaction between virtual organs and instruments.

Relevance and importance

Endoscopic surgery is important in modern medicine but training surgical specialist in endoscopic surgery is difficult due to the limitation of patient resources, and safety issues.

The current training process involved the animal model (Pig). Animal model is not a great solution due to their expense and ethics problems.

Virtual Reality/Augmented Reality technology has been introduced to surgical training for a while. Many research teams have already designed and validated the effectiveness of VR/AR simulators. Ryan et, al (2015) introduced an Augmented reality-assisted urologic training tool. Graham S. Goh et, al (2021) introduced a VR/AR training and simulation system in knee arthroplasty. And Ehsan et, al (2020) introduced an Interactive Mixed Reality Platform for Bedside Surgical Procedures in Neurosurgery.

Standing on the shoulder of previous works, this project is aiming to construct a general endoscopic training platform in order to break the limit of specific surgical procedure training.

With the help of a mixed reality simulator, the training cost is looking to drop significantly, and training outcome is looking to remain the same or even better (Joshua et, al, 2021) (Tobias Fritz et, al 2019).

Deliverable

Min

1. Point clouds of hand-held (and robotic) instruments from sensorized phantom. 3/25
2. 2D video from the perspective of the endoscope output to the standalone monitor.4/8

Expected

1. Overlay the patient's 3D model with the obtained point cloud. (Proof of concept). 4/22
2. Collision detection between the tools and virtual organ model.4/28

Technical approach

1. Point clouds of hand-held (and robotic) instruments from sensorized phantom:

Passive method: Using 4 cameras fixed at corners of the phantom, 2 for each side. Then using the conventional triangulation method to obtain the point cloud. P: Cheap; High Accuracy; C: Might encounter problems for thin tools.

Active method: Using 2 Time of Flight RGBD cameras to obtain the point cloud, 1for each side. P: Easy for obtaining point clouds C: Low accuracy on close range; Relatively expensive

Note: The team will proceed with half of the design (i.e 2 RGB cameras and 1 TOF RGBD camera to save money) and decide which way to continue at the end of the 2nd milestone and then carry on with the selected method. The other half of the design will be installed after decided.

2.2D video from the perspective of the endoscope output to the stand-alone monitor

If endoscope fixed on the da Vinci Robot: Forward Kinematics provided from robot. Registration between robot and phantom is needed. Render the point cloud accordingly.

If endoscope is hand-held: AR-tag attached to the endoscope to localize the position and pose of endoscope. Render the point cloud accordingly.

3.Overlay the patient's 3D model with the obtained point cloud. (Proof of concept)

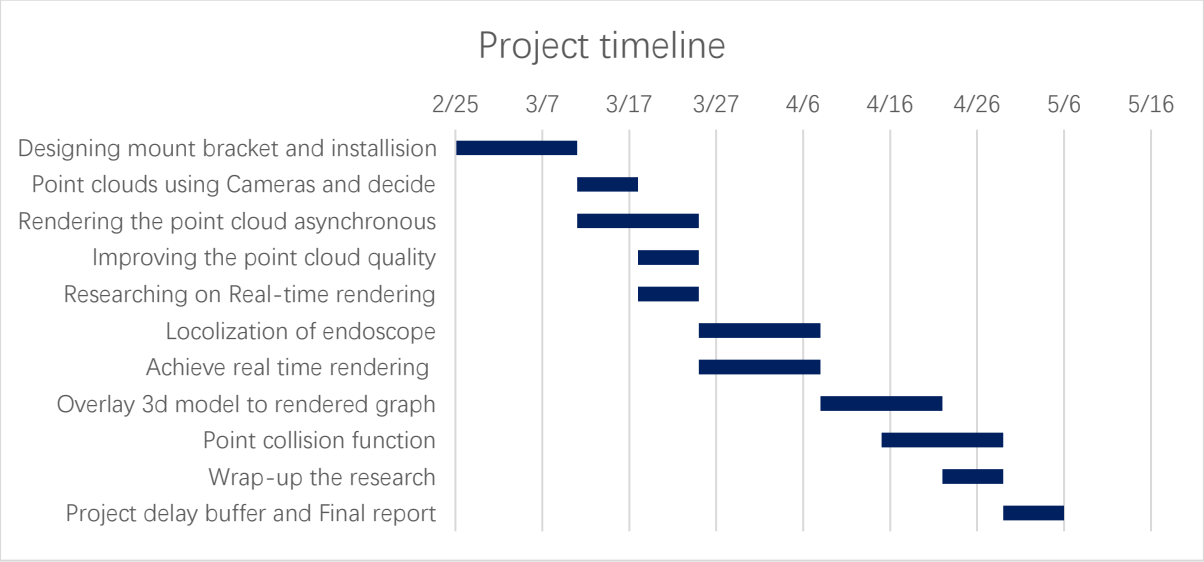
Place some virtual cube/cylinders within the virtual space inside the phantom. Overlay the point cloud on it.

4.Collision detection between the tools and virtual organ model.

Detect how many points are located within the virtual cube/cylinders. If the number of points exceeds a certain threshold, then report the collision. A possible challenge is the quality of the point cloud.

Timeline and Milestone

Gantt Chart



Milestone

Date	Object	Explain
3/11	Have the hardware part finished	Freezing the hardware design.
3/25	Finishing improving the point cloud data.	The algorism of collecting real-time point cloud and filtering out noise should be given by now. Decided between which kinds of camera will be made here
4/8	Finish minimal object	The real-time rendering object should be achieved.
4/28	Finish the expected object	Collision detection achieved

Response plan for delay:

For milestone tasks delay, if milestone tasks delay, then the whole project will have to postpone accordingly. If the accumulation delay was more than 2 weeks, it may lead to sacrificed collision detection deliverables.

For other than milestone tasks delay, the team will carry on and sacrificed the accuracy of result.

Dependencies and Resolving

Items	Sources	Need Date	Status	Priority, Possible effect and Substitution
2 x RGB Cameras and MCU	Purchase	3 /11	Design finished Purchasing parts	**1.** Cannot perform research without it.
ToF RGBD Cameras	SMART Lab	3 /11	Approved by Professor Peter	**2.**Still can perform experiment without it but will not be able to perform comparison
Other RGB/ToF RGBD camera(s)	Purchase	3 /25	Waiting for previous result	**2.** Still can perform experiment without it but will significantly loss the accuracy
Mounting	Fabrication	3 /11	Design	**2.** Have alternative method but will

Bracket for Cameras	on machine shop		finished Purchasing parts	significantly influence accuracy of cameras.
DVRK	LCSR Lab	3/18	Approved by Professor Peter	**2.** Can perform the experiment without it. Only be able to use AR-tag to localization the endoscope.
Abdominal Phantom	LCSR Lab	3 /11	Approved by Professor Peter	**3.** Can perform the experiment without it. Easily find alternatives e.g cardboard box.
Computer	Myself	Now	Available	**1.** Cannot perform research without it.
Endoscopic tools	LCSR Lab	3 /11	Approved by Professor Peter	**3.** Can perform the experiment without it. Easily find alternatives e.g pen
Rendering Software (UE5/Unity)	Online	3 /11	Available online at no cost	**1.** Cannot perform research without it.

Response plan for delay:

All the delay corresponding to dependencies with priority 1 will lead to postpone of the whole project and have no way to go around.

All the delays with priorities 2 and 3 will continue without the dependencies or with substitution. The remedy of priority 2 dependencies when a delay is happening will be considered, the remedy of priority 3 dependencies will not be considered.

Management Plan

Weekly meeting: 3-4 Every Friday with Professor Peter Kazanzides and Dayeon Kim.

Organize extra meetings if needed.

All the File including CAD, code, Data, reference paper and presentation PPT will be documented via google drive and CIS2 website.

Special note:

Changes from the presentation: The Gantt Chart and plan were modified a little bit and the first milestone was postponed one week due to the purchasing dependencies issue. The rest of the project remain the same and was not affected.

Reference

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