Critical Review

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3/28/12

Team 5: Prototype of microsurgical tool tracker

EN.600.646. Computer Integrated Surgery II

I. Paper

Title: Evaluation of the motion of surgical instruments during intraocular surgery

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Published: Eye (2011) 25, 947-953. 2011 Marcilian Publishers

II. Intent

Ophthalmologic surgery consists series of delicate surgical steps that require bimanual ability and great deal of concentration from surgeon. Surgeon today use 2-channgel surgical microscope to amplify patient's eye to perform their necessary procedures, making patient's out come highly dependent on surgeon's skill. Unfortunately, the ophthalmologic surgery was found to have highest number of incorrect procedures occurring within the operating room in study conducted 2009[1]. It is also notable that, coincidently, ophthalmology is one of the few fields where robot assisted surgery have not been implemented yet. Robot assisted surgery, where surgeon operates with the robotic surgical platform (ex. Da Vinci, Intuitive Surgical Inc.), was proven beneficial and has been a popular alternative to traditional method in fields such as laparoscopy, cardiology and urology. Researchers agree that the development of similar robotic surgical system specifically for the ophthalmologic procedures could improve some limitations seen from a traditional method, such as hand tremor and low precision. Other benefits include the possibility of development in tasks automation and tele-operation. Current robotic system for ophthalmology is designed to assist in a single task, which only emphasizes on tool's degree of freedom. The main obstacle in building a robotic surgical platform is determining the optimum remote center of motion, which is the point where all robot-guided tools pass. The first step for such design is to quantify the range of surgeon's motion around the patient's eye, and create a framework of specifications for the surgical procedures. The purpose of this paper is to accurately analyze the motion of microsurgical tools and fulcrum, the entry site of the tool at the eye, during the intraocular surgery.

III. Technical Summary

The electromagnetic sensors were used to track the motion of all surgical tools and eye. The team of researchers chose electromagnetic sensors over optic or inertial sensors because of their small size and their ability to provide data in a concentrated area. The sensors were connected to the control unit, which outputs 90 positional measurements per second. The active source of magnet used specific-pulsed DC signal to avoid any possible magnetic field distortion from metallic instrument near the testing environment. The sensors were tested for their reliability within the constrained box for short and long translations. The result were claimed to be near perfect, hence reliable for evaluation.

In order to quantify performance of intraocular procedures, the team of researchers recorded motion of surgical tools and fulcrum during anterior (phacoemulsification) and posterior segment (vitrectomy) surgery. Total of five different tools were used, each with two electromagnetic sensors attached at 2.5cm and 7.5cm away from tip. Sensors were also attached at the limbus of the eyeball to quantify motion of eyeball. The procedures were performed to a porcine eye fixed on Styrofoam's human head in a steady-state environment. Two intraocular procedures were divided into five surgical steps for the measurement. The recorded raw data from the sensors for each step were calculated through control unit by the principal component analysis (PCA) to find the angle of rotation and translation. Essentially, PCA, combined with the vector between the sensors and the calculated offset, presented a maximum range of rotational and translation angle for each microsurgical tools and the eye.

The result showed that the angle of rotation is dependent on a specific task among intraocular procedure, microsurgical tool used, and hand performing the task. When using the same tool, maximum angle of rotation during the main task was always larger than during the ancillary task. Furthermore, the dominant hand always had larger range of motion than the secondary hand. These variations in range of motion imply that the optimum robotic surgical assistance should allow a different maximum range of motion for each instrument and surgical task.

IV. Importance and Relevance

The goal of my project 'prototype of microsurgical tool tracker' is to provide a device with optical sensors rigidly attached that outputs positional feedback of the microsurgical tool. Although optical sensors will be used, instead of electromagnetic sensor, to track surgical tools for my project, the paper is relevant in determining orientation of the optical sensors around the eye. The placement of optical sensors, in my case mini endoscope camera with USB interface, is an important factor for effectively detecting the tool. Sensors are required to cover all necessary area around the eye but also avoid any possible interference with the surgeon's hand. Therefore, the analysis in a motion of surgical tool and eyeball would have been useful for my project. Furthermore, the paper is relevant to my project because, in general, both foresee the potential and benefits of quantifying ocular surgical motions in improving quality of ophthalmic care. Such analysis could not only be used for designing highly useful robotic system but also could be used to determine surgical protocol that enhance surgical evaluation by allowing surgeons to assess and compare their performance.

V. Critique

Strength	Weakness
The purpose of the paper was very clearly explained.	The tables of angles are hard to visualize the motion to be useful for determining areas to avoid placing camera for my project.
Performing reliability testing for electromagnetic motion capture before the experiment is noteworthy. It supports the accuracy of the result.	The paper is very open-ended. It does not directly solve or lead to solve a problem that traditional ophthalmologic surgery has.
The method and set-up for the study	The quantified values listed were hard to

were described thoroughly.	visualize and did not help in determining the placement of camera for my project.
The study took into account for more than one procedure, tool and hand.	

As the next step, more motion analysis of different intraocular procedures may be beneficial because the range of motion seem to vary depending on tasks, tools and hand performing. Furthermore, tracking the motion using different sensors may be interesting. All results could be compared and verify the accuracy of collected range of angle in rotation. Finally, study in quantifying motion for extraocular procedures may be useful.

VI. Reference

[1] Neily, Mills, et al. "Incorrect Surgical Procedures Within and Outside of the Operating Room." Archives of Surgery 16 Nov. 2009: Vol. 144, No.11:1028-1034. Web. 12 Feb. 2013