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Da Vinci Mentor Project Summary
Tetelman and Branford Class of 1960 Fellowships

Introduction

In May 2015 I traveled to the Robotics and Control lab at the University of British Columbia to began developing a new training program for the da Vinci Robot (image 1). The robot is used in minimally invasive surgery. At the surgeon console, a doctor viewing the surgical scene (image 2) manipulates two robotic master arms (image 3). Movement of these arms is scaled and translated into movement of tiny surgical instruments (slaves) located within the patient's body.

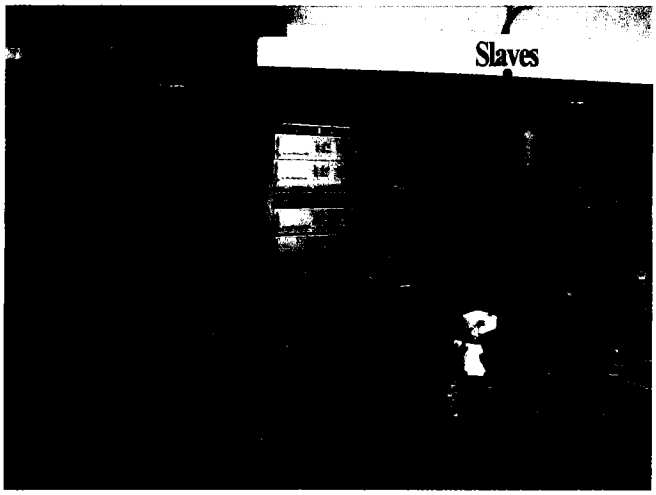

Image 1: Da Vinci Robot with critical components indicated.

The current process to become a da Vinci surgeon is inefficient because it requires existing surgeons to mentor novices. This training takes significant amount of time, time that could be spent in surgery or developing new techniques. We want to create a program that uses kinesthetic and visual guidance to train novice surgeons.

Image 2: Surgical scene with appended gaze pointers and surgical instruments

Goal of the project

We aim to design and test a basic training program that uses playback of recorded master motion and surgical scene to train novices. Novices will sit at the surgeon console with hands on master end effector (image 3). As the end effector moves according to the recorded motions, novices will feel and see the motion that the surgeon went through to carry out the task. Using this method, a surgeon will be able to record his own motions and then replay them to train a novice. In addition, we will record and playback the surgeon's point of focus in an attempt to indicate the next surgical movement.

Challenges Faced

There were two main challenges that were faced. First, most research regarding the da Vinci focuses on the slave arms. Consequently there is little documentation on the masters. Thus, a lot of energy was spent investigating existing research and control of the masters. Though this approach provided some answers, ultimately additionally energy was spent creating new recording and control code to capture the motion recordings and control the arm movement.

The second challenge faced was data synchronization. The playback of the surgical scene with appended point of focus and the motion of the masters would need to be synchronized, otherwise during playback one stream might lag in relation to the other. Over a 10 or 20 second motion and video file, this wouldn't be an issue. However, some of the recordings were up to 5 minutes long. Thus, a system that would cue playback speed and location of one stream based on the other seemed necessary. The first two approaches to solving this problem failed because of their slow processing speed and poor controllability. The third approach, using OpenCV, a set of C++ and python libraries that allow for easy access and control of video images and processing, proved to be efficient and convenient to work with. To solve this challenge, a program was written using OpenCV that estimates video playback speed based on desired motion rate, then readjust video rate every second based on cues from the motion.

Image 3: Operator grips the end effector of the left master

Accomplishments

We built a system that can gather and playback motion, surgical scene, and gaze data. Basic tests suggested that this or a similar tool used in an appropriate fashion could help train novice surgeons. Additionally, these test indicated that point of focus often marks the next event and thus can be used to alert a trainee to the next event.

Further Study

The program is limited in its abilities. It primarily records motion and then plays the motion back. Effectively, it drags a novice's hands through the motion that the surgeon went through. Additional features can be added to move the hands in a way that requires more involvement of the trainee. Perhaps the playback program can correct the novice's motion instead of driving it. Other, non-technical improvements can be made. The interface used by the surgeon to make recordings and by the novice to playback the motion and video is primitive. This interface should be redesigned with usability instead of functionality in mind.

Currently there are plans for the project to be further developed as a capstone engineering project for UBC undergraduates.

Acknowledgments

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