Seminar Presentation:
A Holistic Data Acquisition Framework for Robotic Surgical Skill Assessment

Student: Giacomo Taylor
Mentors: Dr. Jeremy Brown, Dr. Anand Malpani
STATEMENT OF NEED

- Robotic minimally invasive surgery has become the standard of care in many specialties including cardiothoracic surgery, urology, gynecology, etc.

- Robotic surgical training still mostly follows the Halstedean apprenticeship model: subjective assessment of recorded training videos, direct observations, discussion... time and labor intensive -> costly, slow
The goal of our project is to develop an intelligent system that can objectively assess robotic surgical skill using performance data about how surgeons move their hands, connected instruments, and how the instruments interact with the surgical workspace.

Develop a hardware + software platform that collects motion data from da Vinci and physical interaction data (forces on task board and accelerations of tool). This will combine two previously developed surgical skill assessment platforms.

Collect pilot data from users of various robotic surgical skill levels

Search for patterns in data to prepare for machine learning applications
PAPER SELECTION

BACKGROUND

- Collected and used kinematic data to classify surgeons as “skilled” or not
- Lays groundwork for long term training evaluation, judging efficacy of training

- Kinematics based methods are self-contained to the surgical system, no need for additional sensors
- Position and velocity data allows for larger, more in-depth feature set
  - Can allow for contextualization or more intuitive results
RELEVANCE

- Reduces need for human raters to assess basic psychomotor skill development (save time, money, objectivity)
- Improved trainee learning due to real-time feedback on skill
- Complementary to Dr. Brown’s work analyzing relation of surgical workspace interaction forces to surgical skill
• Describes a Da Vinci kinematic data acquisition system similar to what we will use (minimum deliverable)

• Implements ML features and techniques we may draw from as suggestions (maximum deliverable)
COLLECTION METHODOLOGY

- Surgery residents & fellows of varying training levels
- Used the Da Vinci SI system/API with no workflow modification
- Collected motion data for benchmark tasks
- OSATS scores from clinical collaborators for ground truth
- ~30min/trial; 2 “experts,” 6 “trainees”
OSATS

“Objective Structured Assessment of Technical Skill”

Six skill-related variables, each graded on a 5 point Likert-like scale

DATA PROCESSING

- Ground truth ratings binarily separated as expert (OSATS 13) vs trainee (OSATS <10)

- Focused on three main categories of interaction:
  - Master workspace management
  - Camera field of view adjustment
  - Instrument safety (FOV considerations)

- 2 seconds of data (Cartesian pose, velocity, gripper angle) for each clutch event

- 0.5 seconds for each camera event

- Binary SVM classifier, polynomial kernel (with no dimensionality reduction)
RESULTS

- Both master workspace & camera manipulation classification experienced good results:
  - Accuracy of about 87-95%
  - Precision of 87%
  - Recall up to 100%

- Unsafe motion and collision data analysis is “ongoing”
THE GOOD AND THE BAD

**PROS:**
- Da Vinci SI model is actuated by lead screws, interfering with interaction force measurements
- Getting kinematic data through software does not require workspace modification; allows for larger scale data collection
- Paper provides nice visuals that helps describe the data
- Experimental setup mimics actual surgical task

**CONS:**
- Only extracted data around “events,” i.e. pedal pressed/released
- Could’ve explained OSATS specifications more
- No mention of subtractive balancing or other method of evening data
- Discussion of “unsafe motions” section is lacking
OVERALL

- Paper was very helpful to our project
  - Describes similar system
  - Provides suggestions of ML features, techniques to look into
- This paper will continue to be a valuable resource to us as we continue, especially the next phase of our project