

Objective Surgical Skill Assessment of Computer-Aided Hysterectomy Procedures



JOHNS HOPKINS
MALONE CENTER for
ENGINEERING in HEALTHCARE

Computer Integrated Surgery II Spring, 2019
Elif Bilgin under the auspices of Anand Malpani, PhD and Molly O'Brien, BS

Introduction

- This is a project that strives to evaluate the skill level of the surgeon carrying out a hysterectomy procedure using the da Vinci Surgical System in the OR of Johns Hopkins Hospital. We have collected motion data from the robot to be used to solve the classification problem of "Expert vs. Trainee".

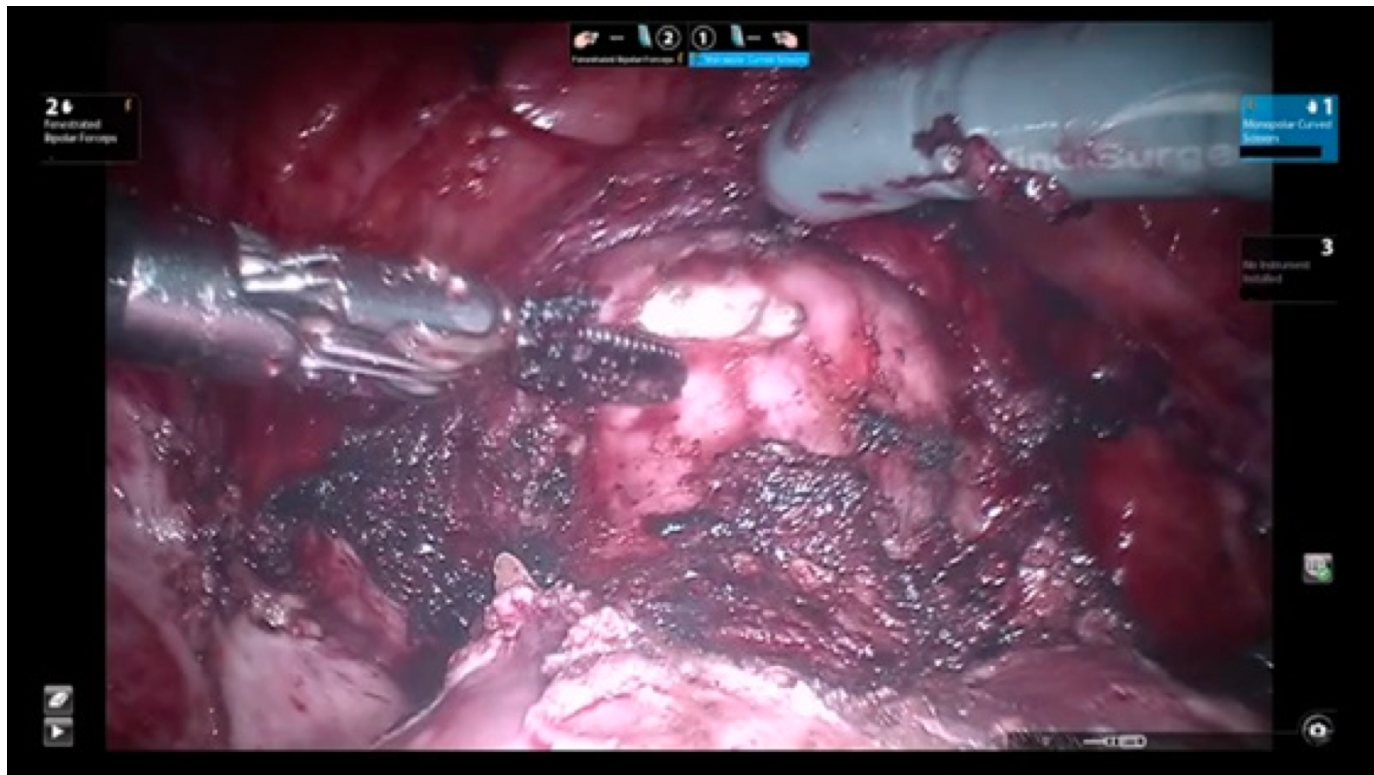


Figure 1: Hysterectomy procedure, colpotomy step. (Image provided by mentors)

Outcomes and Results

- Built a dataset of 19 features, based on 29 surgeries, accumulating a total of 49 data points.
- Expert and Novice distribution in the dataset was near 50%.
- Average colpotomy duration varied from a min of 183.82 to a max of 1028.17.

Feature	Expert	Novice
BIPO_COAG_DURATION	386.00	143.94
MONO_COAG_DURATION	932.17	1180.54
MONO_CUT_DURATION	688.85	610.28
ENERGY_DURATION	1996.14	1931.80
TOTAL_PATH	25293.57	23189.79
BIPO_COAG_PATH	635.37	261.85
MONO_COAG_PATH	1395.30	1578.48
MONO_CUT_PATH	888.67	828.12
ENERGY_PATH	2890.73	2668.23
ENERGY_FREQUENCY	9.33	10.25

Table 1: Average values for Expert and Novice surgeons for statistics collected.

- It was noted that in the case of expert surgeons, the average total path travelled, energy usage duration and energy path travelled were longer compared to novice surgeons.

Key Terms

- Hysterectomy** is the process of the removal of the uterus.
- Colpotomy** is a step in the hysterectomy procedure where the connective tissue attaching the uterus to the vaginal opening is removed to release the uterus before removal.

The Problem

- The aim of this project is to automatically assess skill in robot assisted hysterectomy procedures.
- With the increase in use of surgical robotic systems, there is more opportunity for capture and analysis of complex surgical data. This allows for the objective computer-aided technical skill evaluation for scalable, accurate assessment; individualized feedback, and automated coaching.
- Currently, there does not exist a uniform benchmark of assessing surgical skill. Research has been done mainly on VR simulations using various features such as task completion time, path length, moving time, velocity, idle time and energy activation. There is only a handful of research papers published on using data directly from the operating room, which distinguishes this project.
- The ability to objectively assess the skill level of surgeons is critical for training future surgeons and revolutionizing this process.

The Solution

- For this project, we decided to build a dataset to be used for a feature-based classification problem of "Expert or Trainee". This dataset comprises of the surgery date/time, surgeon expertise level (0 or 1, for expert or trainee), for each interval of colpotomy data. We then ran multiple classification algorithms on this dataset such as Random Forrest, Logistic Regression, K-Nearest Classifier. We also did a parameter sweep to improve accuracy.

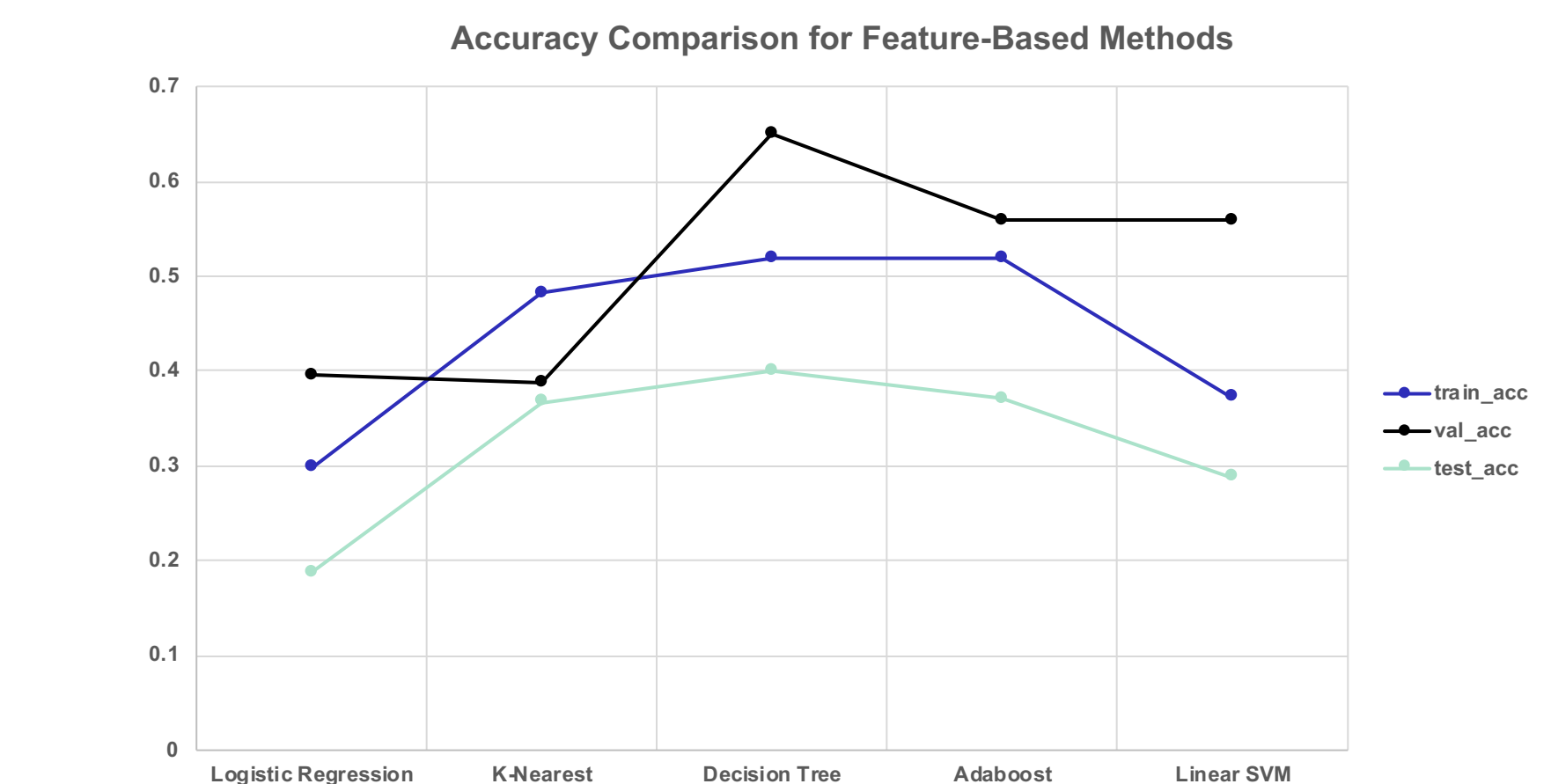


Figure 2: Percentage accuracy findings for ML methods.

Future Work

- Collection of skill scores from surgeons based on video footage corresponding to the colpotomy step motion data.
- Use the feature-based machine learning algorithm results and the neural network results along with the scoring from surgeons to regress a "skill score" for each user.

Lessons Learned

- A consensus being established on what the best approaches and benchmarks are necessary for research to build on one another. Currently, there does not exist a "ground truth" in skill assessment.

Support by and Acknowledgements

- Thank you to Saranga Arora, JHU BME and Chi Chung Grace Chen, MD MHS, JHU Gynecology & Obstetrics.
- Thank to Molly O'Brien for providing her Neural Network implementation.

