HOLISTIC DATA ACQUISITION FRAMEWORK FOR ROBOTIC SURGICAL SKILL ASSESSMENT

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Mentors: Dr. Jeremy Brown, Dr. Anand Malpani

GOALS

Minimum: hardware & software system capable of collecting synchronized streams of robot kinematic and workspace interaction for time-series data (4/5/18)

Expected: collect pilot data from users of a wide skill range; additional software tools for visualizing data and detecting trends/patterns (4/26/18)

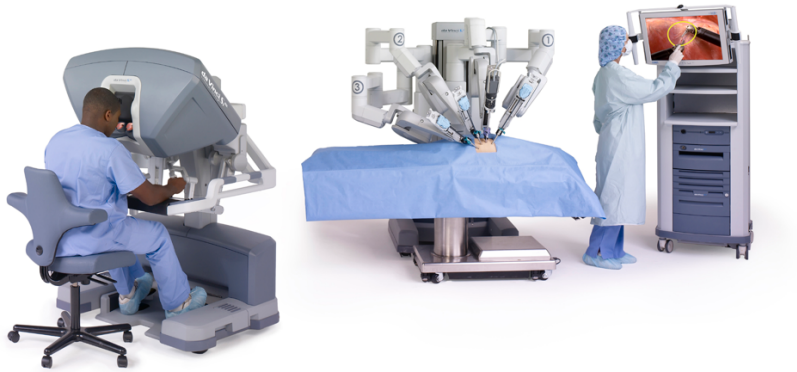
Maximum: perform statistical analyses on pilot data, suggest significant features for use in machine learning applications (5/17/18)

PURPOSE

Robot-assisted minimally invasive surgery (RAMIS) is quickly becoming the prescribed method of treatment for many different routine and non-routine surgical procedures.

- There is a need to ensure that all robotic surgeons have a minimal level of skill proficiency before they operate on patients.
- Current methods of skill assessment rely almost exclusively on structured human grading which can be subjective, tedious, time consuming, cost ineffective (raters are practicing physicians).

The goal of this project is to develop a system that can collect performance data of a surgeon performing RAMIS, collect pilot data, and investigate for trends to make suggestions for future procedures and ML algorithms.



DEPENDENCY UPDATES

Dependency	Proposed Solution	Status
Access to mock OR	Appropriate forms submitted to LCSR office	Complete
DaVinci training	Training session with Dr. Malpani	Complete
Access to existing code repositories	Access to Dr. Brown's code given, access to Dr. Malpani's code given after signing of NDA (API from Intuitive Surgical)	Complete
Smart task board/ Accelerometer	Malfunctioning motherboard, new board is installed, tested	Complete
PC to handle data acquisition	Test system on PC in mock OR, if not operational obtain new PC	Complete** (capture card)
Schedules of clinicians	Need to accommodate busy schedules of clinicians for pilot data	Pending

CAPTURE CARD ISSUE

- Intended use is to record video for human graders to evaluate surgical skill of users.
- Problem – Computer does not recognize current capture card when plugged in.
- Solution – Purchase new capture card, replace current one.
  - Consult with mentors on 4/3/18, purchase by 4/6/18
- Contingency Plan – Project is not dependent on functioning capture card, will continue to test system without recording video

UPDATES TO THE DELIVERABLES/MILESTONES

	Initial Deliverables	Updated Deliverables
Minimum	• Functional computer • Program to integrate two systems • User manual/ documentation	• Functional computer • Program to integrate two systems • **User manual/ documentation**
Expected	• Collect pilot data • Implement machine learning algorithms	• **Collect pilot data** • Program for data visualization, feature extraction
Maximum	• Write new IRB proposal • Evaluate machine learning algorithms	• Statistically significant metrics • Machine learning feature suggestions

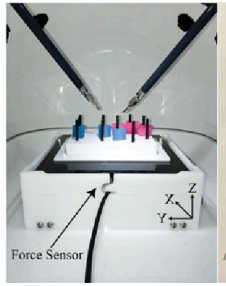
SOLUTION OVERVIEW

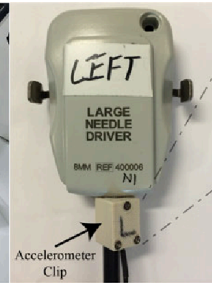
Dr. Malpani

ROS wrapper

(written by Anton Degeut)

Dr. Brown



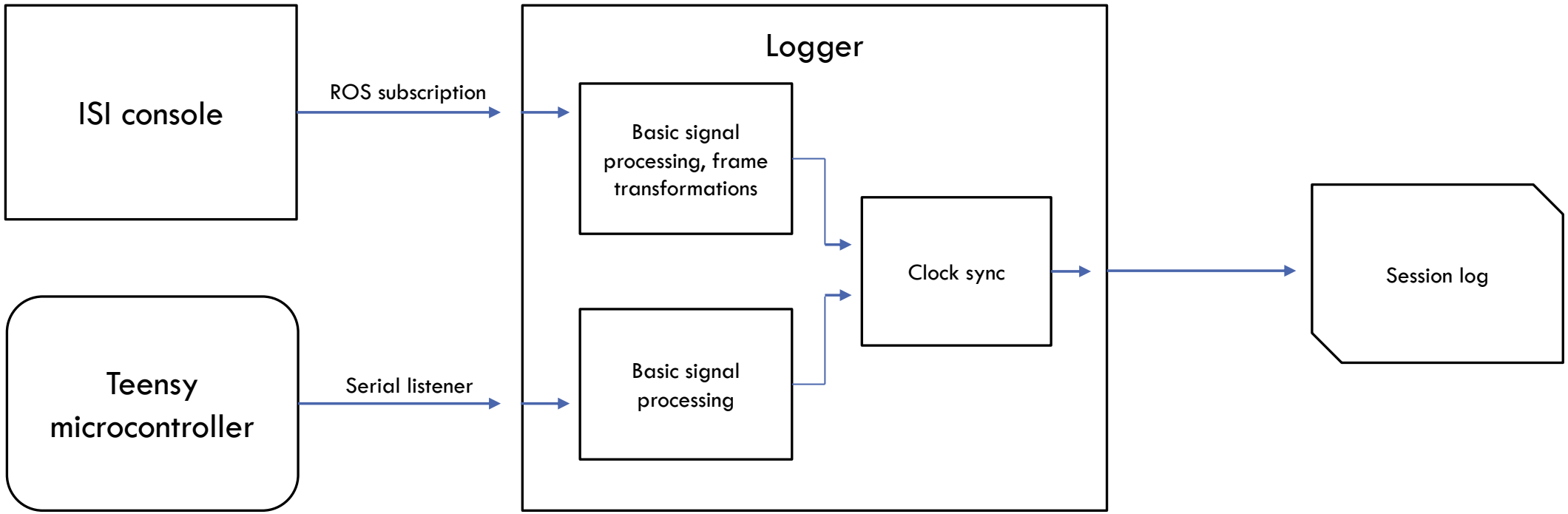


Logger

Data collection and processing, visualization, feature extraction

Statistical analyses, ML feature suggestions

LOGGER ARCHITECTURE (MINIMAL)

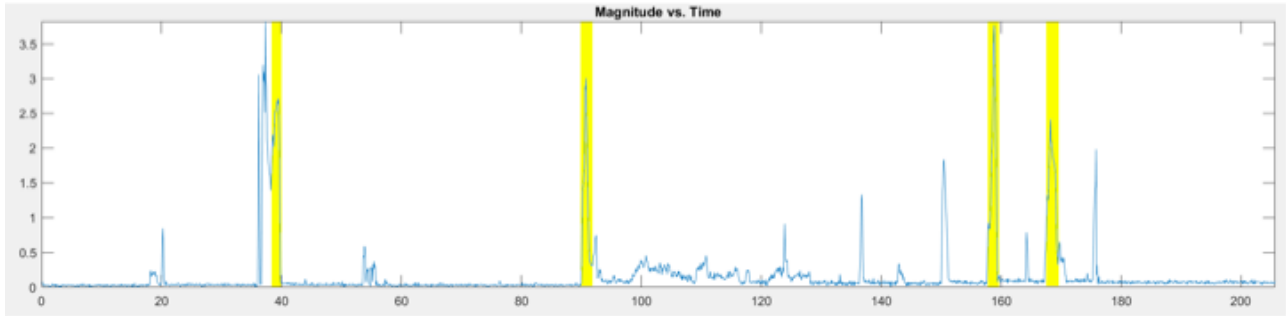


DATA COLLECTION (EXPECTED)

- Added to existing IRB proposal with no (current) need for amendments
  - Peg transfer and ring walk
  - Collection at MISTIC (4/13, 4/20)
- Concurrently development of user manual and documentation
- Multi-modal tracking:
  - Surgeon's manipulators
  - Tool tip/end effectors
  - Endoscope camera
- Collecting time-series data:
  - Position
  - Velocity
  - Acceleration
  - Interaction forces
- Calculating discrete features from signal data

FEATURE EXTRACTION (EXPECTED)

- Develop software tools (and documentation for) time-series data visualization, analysis
  - Continuing off previous work -> max, min, variance, etc.
  - Investigate new features based on pilot data trends



STATISTICAL ANALYSES (MAXIMAL)

- Data set analysis to test correlations of extracted features with proxy measures
  - Resident standing
  - Number of RAMIS procedures performed
- Sensitivity analyses
  - PCA
  - Clustering metrics
- Suggest features to be used in later ML approaches and more thorough testing on large-scale datasets

READING LIST

J. D. Brown, C. E. O'Brien, S. C. Leung, K. R. Dumon, D. I. Lee and K. J. Kuchenbecker, "Using Contact Forces and Robot Arm Accelerations to Automatically Rate Surgeon Skill at Peg Transfer," in *IEEE Transactions on Biomedical Engineering*, vol. 64, no. 9, pp. 2263-2275, Sept. 2017.

Curry M, Malpani A, Li R, et al.. "Objective Assessment in Residency Based Training for Transoral Robotic Surgery." *The Laryngoscope* 122.10 (2012): 2184–2192. *PMC*. Web. 12 Feb. 2018.

K. Bark et al., "Surgical instrument vibrations are a construct-valid measure of technical skill in robotic peg transfer and suturing tasks", *Proc. Hamlyn Symp. Med. Robot.*, pp. 50-51, 2012.

E. D. Gomez et al., "Objective assessment of robotic surgical skill using instrument contact vibrations", *Surgical Endoscopy Interventional Techn.*, vol. 30, pp. 1419-1431, 2015.