Review of methods for objective surgical skill evaluation

Group 4

Vishwa Parekh
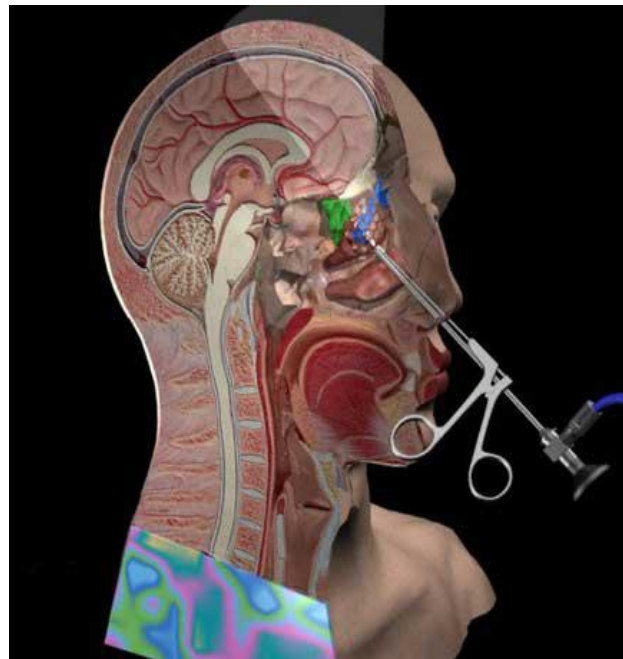
Mentors: *Dr. Gregory Hager, Daniel Mirota, Narges Ahmidi*

Project Background

Goal: Develop a mathematical model for surgical skill evaluation in endoscopic sinus surgery.

Input: Series of Surgical movements

Output: Surgical Skill Level

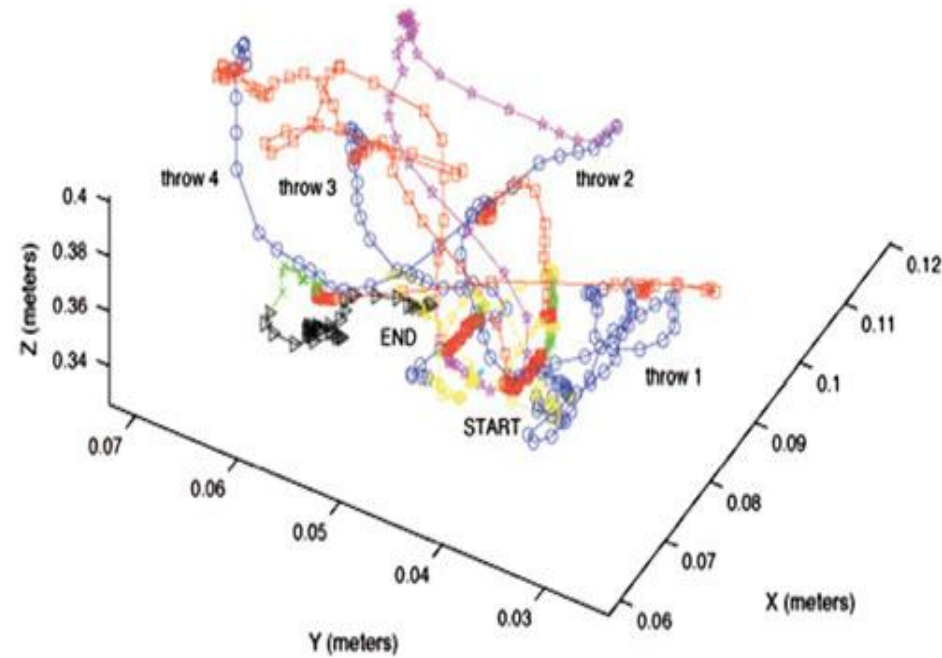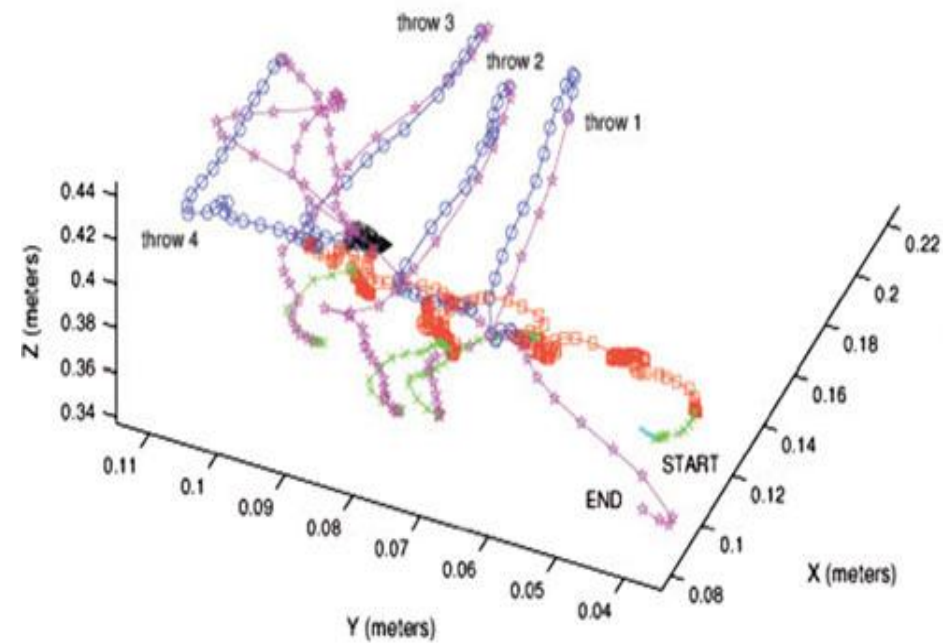*CIS1 Lecture slides on registration*

Paper

C. Reiley, H. Lin, D. Yuh, and G. Hager, "Review of methods for objective surgical skill evaluation," Surgical Endoscopy, pp. 1-11, 2010.
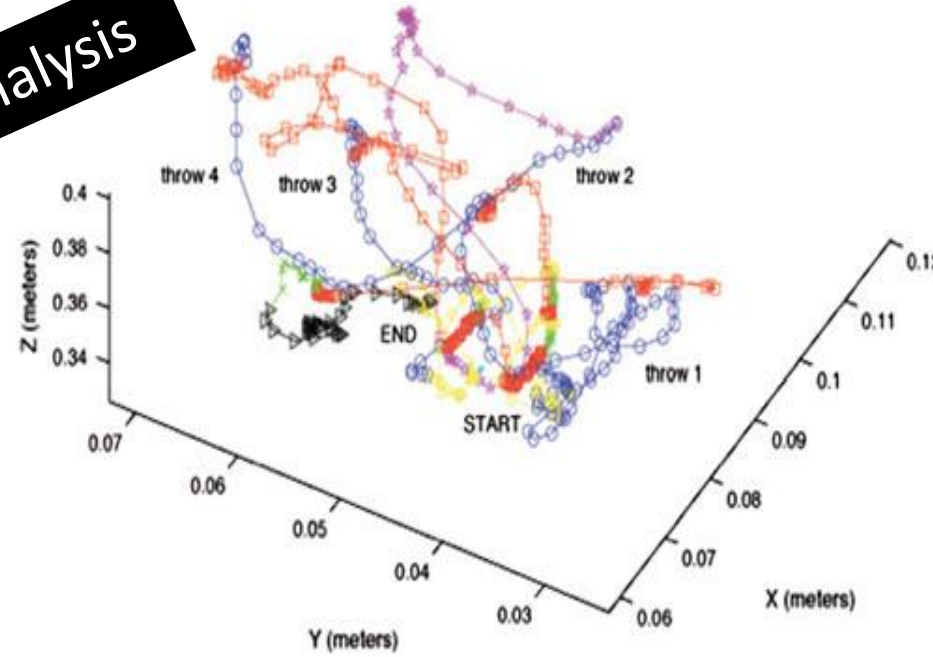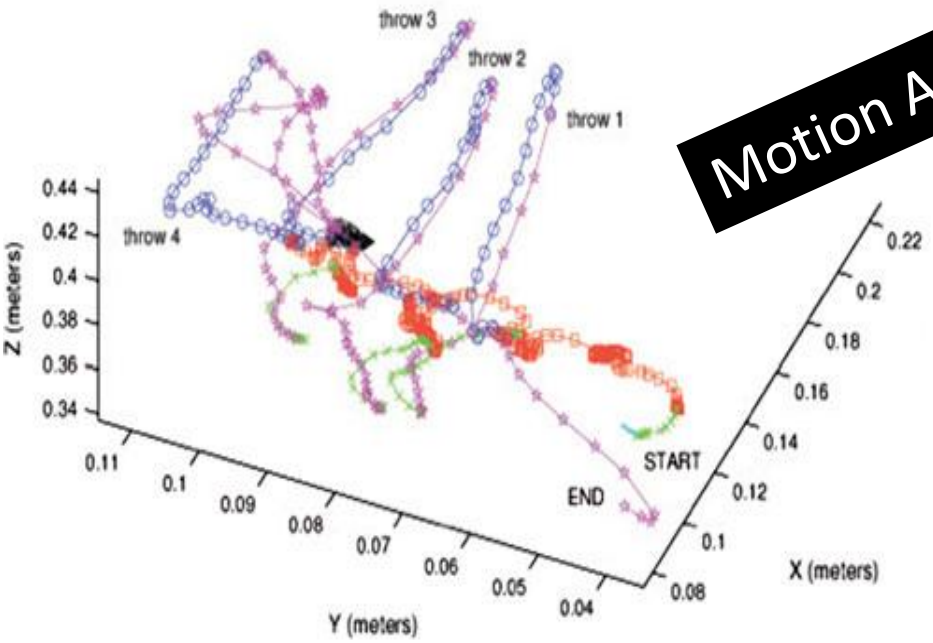
Why this paper?

- Survey on all the background work and state of the art.
- Serves as a good starting point to dive into the topic of surgical skill evaluation.

A four throw suturing task

[C. Reiley, H. Lin, D. Yuh, and G. Hager, "Review of methods for objective surgical skill evaluation," Surgical Endoscopy, pp. 1-11, 2010.]

Motion Analysis

[C. Reiley, H. Lin, D. Yuh, and G. Hager, "Review of methods for objective surgical skill evaluation," Surgical Endoscopy, pp. 1-11, 2010.]

Data Collection

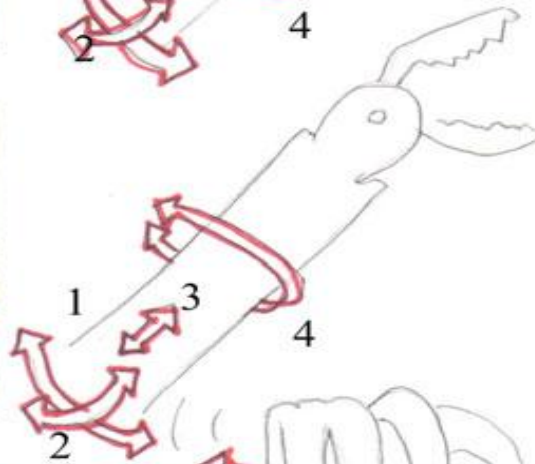- In order to evaluate motion, we need good data collection methods.

- The skills required for an open surgery are different that those required for minimally invasive surgery.

- Different surgical procedures will require different methods of data collection
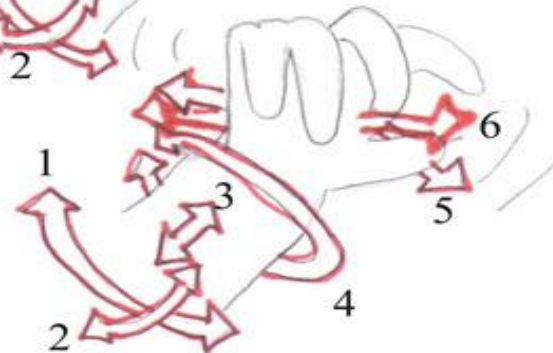
Data Collection

Data Collection

(A) RMIS
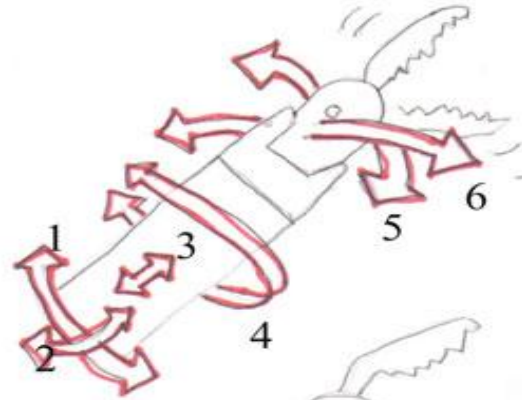
(B) Traditional MIS

(C) Open Surgery

From the RMIS system

From the tracker

Special Wireless Data gloves

Data Modeling

```
           ┌──────────────┐
           │     Data     │
           │   Modeling   │
           └───────┬──────┘
        ┌──────────┴──────────┐
┌───────────────┐     ┌───────────────┐
│  Descriptive  │     │   Language    │
│  Statistics   │     │    Models     │
└───────────────┘     └───────────────┘
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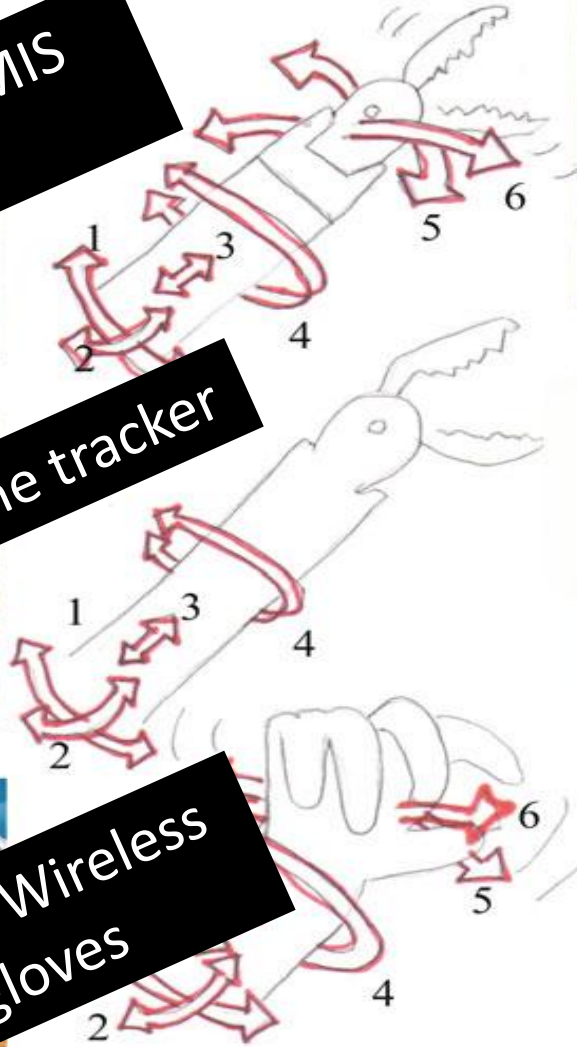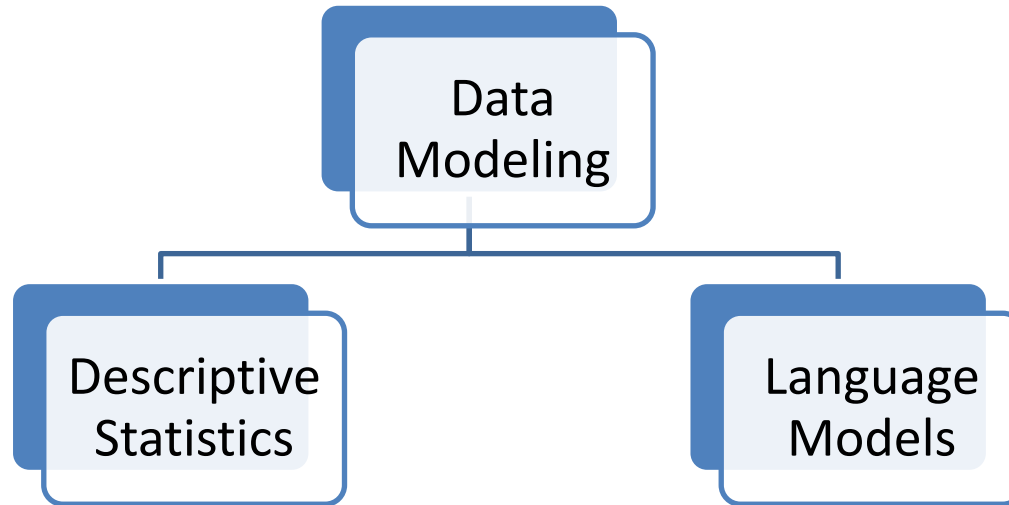
Position, Velocity and often Force, Torque

Not good enough to differentiate an expert from a novice.

Different surgical movements analogous to different words in a dictionary. Difference in pronunciations

⇕

Difference in Skill Level

Language Models

- The Language models can be formed at three different levels:
  - Procedure Level: This includes the complete surgical intervention. This model would be able to provide effectiveness of the surgical procedure but will not be able to comment on the surgeon's skill level.
  - Task Level: This includes different tasks in a surgical procedure like Suturing or Dissection.
  - Surgeme Level: This includes subtasks like needle insertion, position needle, reach for the needle, etc.

Segmentation of surgical procedure into tasks/subtasks before modeling

- Manual Segmentation
- Automatic Segmentation
  - Feature Processing
  - Linear Discriminant Analysis
  - Bayes Classification

Hidden Markov Modeling

- 3 Models – Expert/ Intermediate/ Novice
  - Transition states are various tasks/subtasks
  - Emissions: feature vectors
- Each of these models are trained using forward backward algorithm using training data from different skill levels.
- Now when given a sequence of unknown skill level, the sequence is fed into each of the models and the models with highest log likelihood wins.

Sequence Matching

- A sequence of gestures is encoded for an expert surgeon

- When given a new sequence of gestures, sequence alignment score is calculated to indicate the skill level of the surgeon.

Conclusions

- Interesting Review.

- Provides a great background and an overview of abundance of approaches to surgical skill evaluation.

- Will be implementing Hidden Markov Modeling for my Project.

Thank you

- Questions?