NRI: Guiding with touch: Haptic cueing of surgical techniques on virtual and robotic platforms

PI: Marcia K. O'Malley omalleym@rice.edu Co-PI: Michael Byrne byrne@rice.edu

Rice University

Partners: Houston Methodist Research Institute, 3D Systems, Auris

Motivation

- **Skill level** can affect **clinical outcomes** after surgery
- **Simulation** (inanimate models, virtual reality, and more) offers many venues for practice of procedures, including patient-specific anatomy
- Limited tools exist for **objective** and **quantitative assessment** of **surgical skill**
- Rapidly advancing **technology** offers the chance for motion capture and motion analysis
- **Motion capture**, which is enabled by new technologies like EM sensing and VR systems, offers a new opportunity to provide **objective performance feedback**

Current Skill Assessment Methods

Type	Definition	Examples
Outcome Based	Assessment based on student performance	• Completion time • Success/failure
Structured Grading	Assessment based on validated rating sheets	• Global rating scales (Likert) • Error score card analysis
Motion Analysis	Assessment based on metrics derived from motion data	• Kinematic-based measures • Force/torque-based measures

Objectives

- Explore the potential for a standardized, objective, and quantitative means of measuring technical competence based on analysis of the kinematics of endovascular tool tip motions
- Improve surgeon performance with real-time performance feedback of tool movement quality via haptic cues
- Increase efficiency of training for endovascular navigation

Does haptic delivery of movement features enhance surgical performance and training efficiency?

Methods

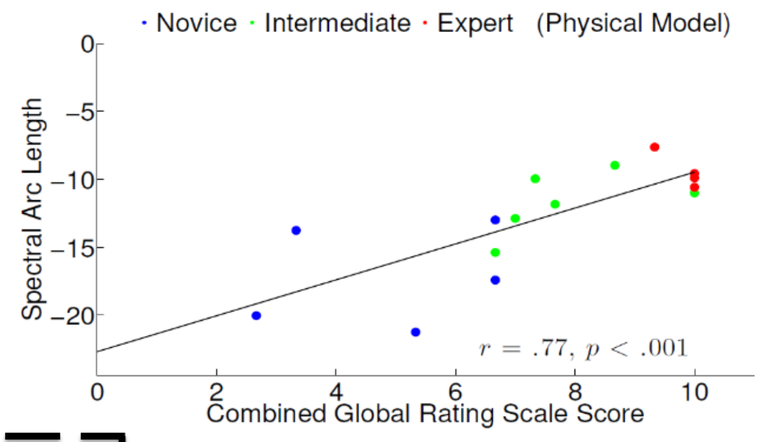
- Measure endovascular tool tip movement on two systems
  - Virtual reality (VR) training simulator
  - Telesurgical robotic system
- Translate movement features to haptic feedback cues to surgeon
- Assess impact of feedback on performance and training

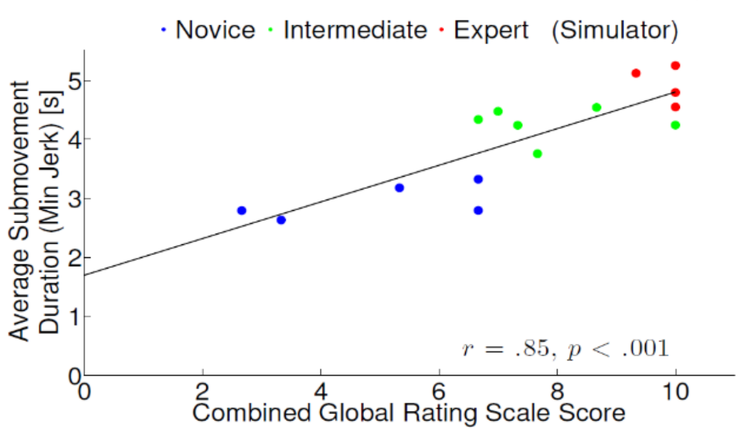
(a) (b) (c) (d)

(a) 3D Systems VR platform (b) Subject cannulating VR model of vasculature (c) Subject manipulating RCM and surgical tools from Hansen Magellan remote workstation, (d) robotic system experimental set-up with 1) face of Siemens C-arm (for fluoroscopic images), 2) physical model, 3) Plexi-glass casing, 4) Window Field Generator for electromagnetic motion tracking, 5) Velcro straps, 6) Remote Catheter Manipulation (RCM) device.

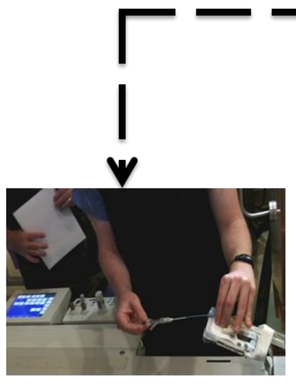
Preliminary Results

Strong and significant correlations between motion-based metrics of endovascular surgical skill and performance evaluated with a structured grading tool for manual catheterization on an inanimate model (left) and on a virtual reality simulator (right)

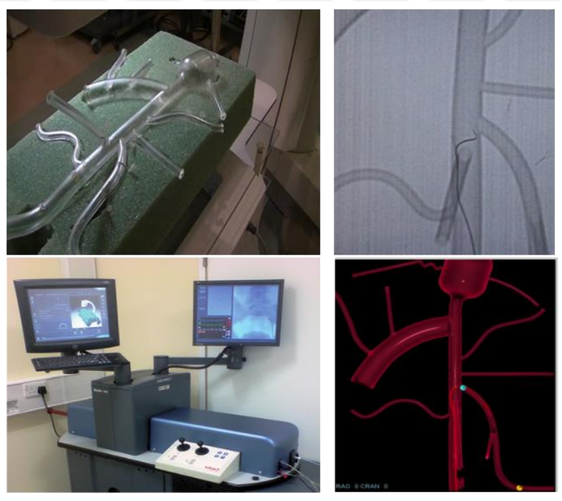


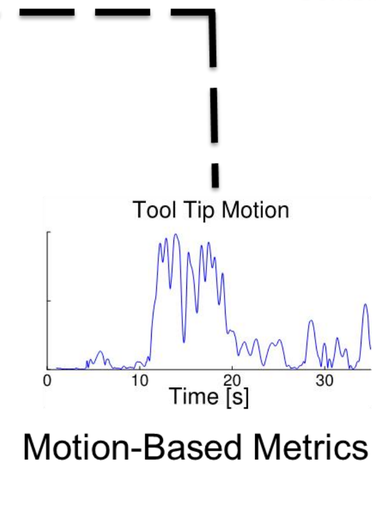


Correlations/Comparisons

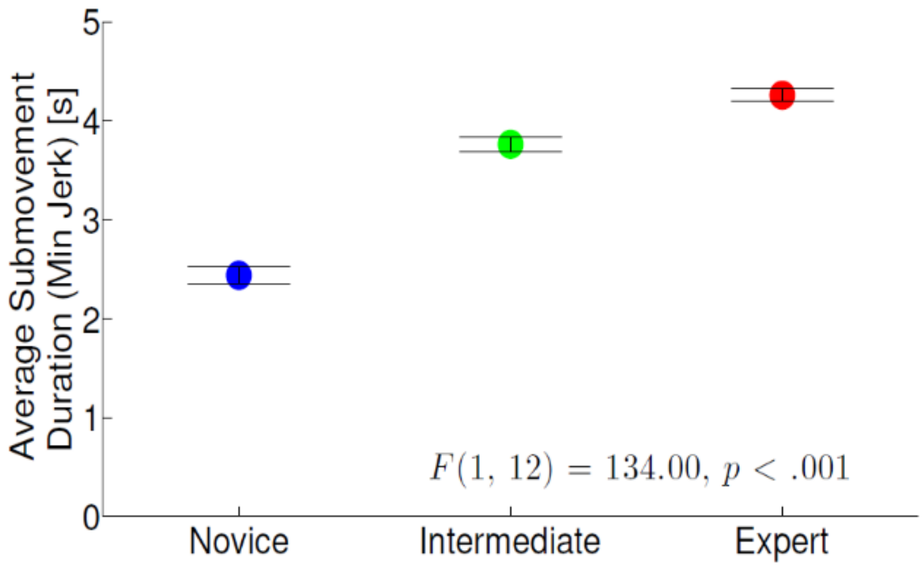


- Residents
- Fellows
- Attendings





Motion-Based Metrics



ANOVA shows significant differences in tool tip movement smoothness (measured by submovement duration) between expertise groups performing endovascular tasks on an inanimate model and VR simulator

Conclusions

- Motion-based metrics, particularly those that are based on the principles of motor control and capture movement quality characteristics such as smoothness, are strongly correlated to structured grading assessments of skill *(Estrada et al., IEEE THMS 2016)*
- Skill evaluation based on dexterity and motion economy while performing endovascular surgical procedures has potential for assessment and to provide as feedback during training

Acknowledgement

The authors gratefully acknowledge the support of the National Science Foundation Grant **IIS-1638073**