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

Marcia K. O'Malley (PI) | omalleym@rice.edu
Dept. of Mechanical Engineering, Rice University

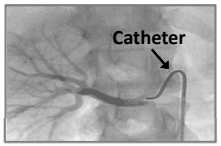
Michael D. Byrne (Co-PI) | byrne@rice.edu
Dept. of Psychological Sciences, Rice University

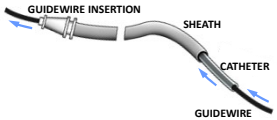
In partnership with **3D Systems, Auris Health, & Houston Methodist Research Institute**

OBJECTIVE: Improve effectiveness of endovascular surgical skill training by providing real-time, objective feedback via informative and intuitive haptic cues

BACKGROUND

- **Endovascular surgery:** a class of minimally invasive procedures involving manipulation of flexible guidewires and catheters various interventions.
- Current training is **subjective** and **qualitative**:
  - Requires expert examiners to evaluate trainees
  - Relies on structured surveys and rating scales
- **Quantitative** approaches are underutilized in manual and robotic endovascular procedures

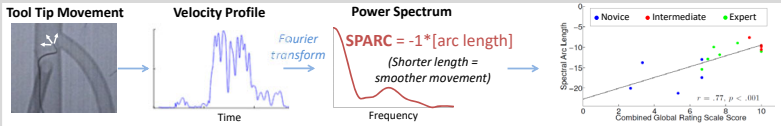




PRIOR WORK

- Smoothness of tool tip motion correlates with surgical experience

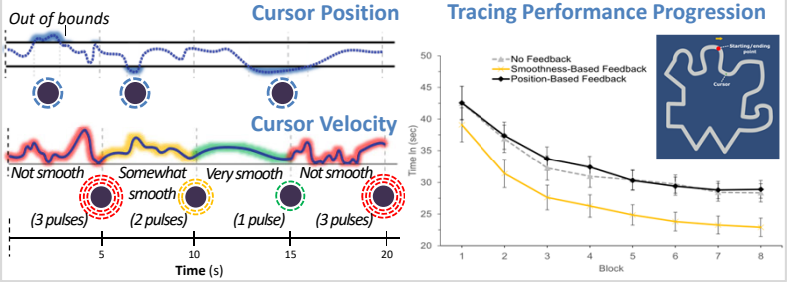
SPECTRAL ARC LENGTH CALCULATION



Tool tip smoothness measured with Spectral Arc Length (SPARC), a robust and sensitive frequency domain metric

- Feedback based on movement smoothness positively affects motion strategies compared to position feedback or no feedback

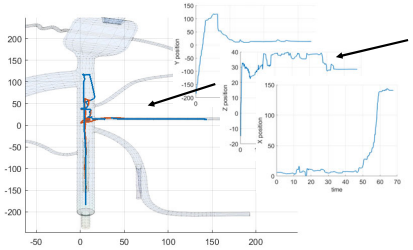
REAL TIME FEEDBACK USING MIRROR TRACING



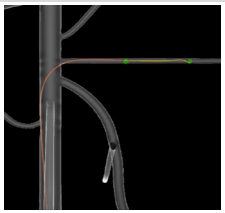
RECENT FINDINGS

DATA COLLECTION: FUNDAMENTALS OF VASCULAR AND ENDOVASCULAR SURGERY (FVES)

X, Y, Z, position and velocity data streamed from ANGIO Mentor



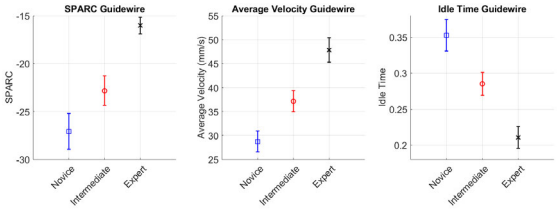
Guidewire and catheter tool trajectories



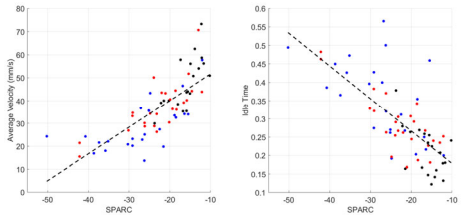
Target navigation task performed on ANGIO Mentor using practice guidewire and catheter

- Guidewire and catheter tool tip kinematics are streamed from ANGIO Mentor endovascular simulator running virtualized FVES training module
- Candidate metrics are derived from tool tip kinematics:
  - SPARC (movement smoothness)
  - Average tangential velocity
  - Total time of idle tool motion (idle time)

INTUITIVE METRICS FOR IMPROVED REAL-TIME FEEDBACK



- FVES task performance (measured by SPARC, average velocity, and idle time) shows significant differences across expertise groups



- Average velocity and idle time provide an indirect though more intuitive measure of movement smoothness than SPARC, making them more appropriate for real-time performance feedback

NEXT STEPS

- Implement real-time haptic performance feedback on simulator and robotic platforms using smoothness-based metrics (SPARC, average velocity, idle time)

Simbionix ANGIO Mentor

BROADER IMPACTS

- Recent work provides further validation of smoothness-based performance assessment
- Smoothness-based metrics will be incorporated in vascular surgery curriculum by APDVS governing body
- Educational outreach had reached middle and high school students, older adults, and provided mentoring opportunities for graduate students

FVES Fundamentals of Vascular & Endovascular Surgery

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