



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

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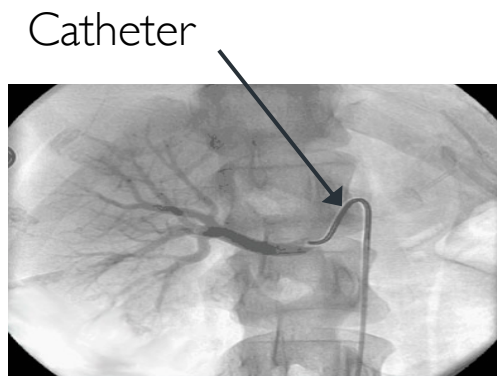
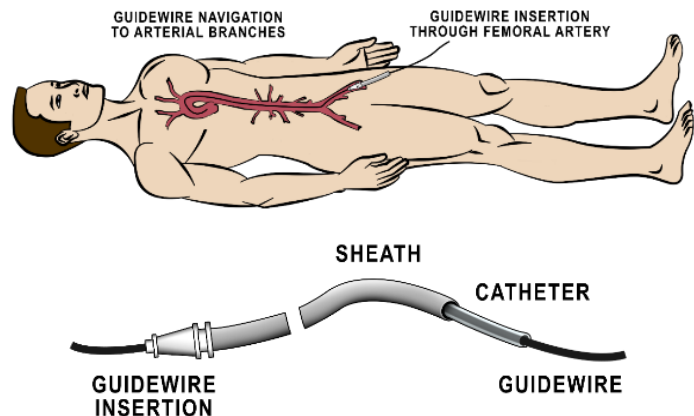
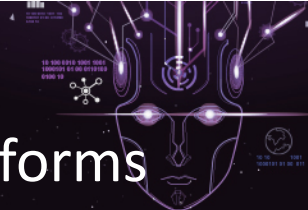
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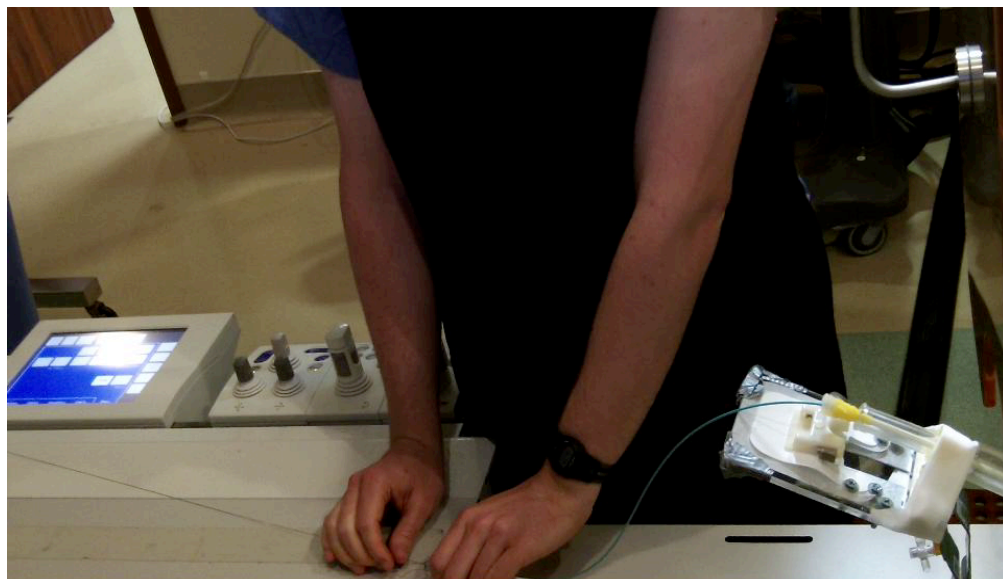


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Endovascular surgical training relies on practice by novices using inanimate models or virtual reality systems, coupled with subjective evaluation of skill by experts.





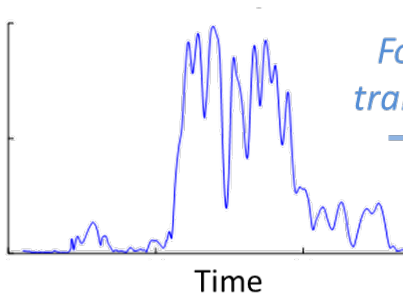
Prior work: Smoothness of endovascular tool tip motion correlates with surgical expertise

SPECTRAL ARC LENGTH CALCULATION

Tool Tip Movement

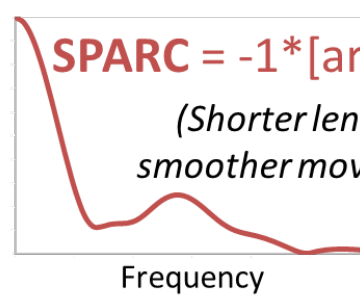


Velocity Profile

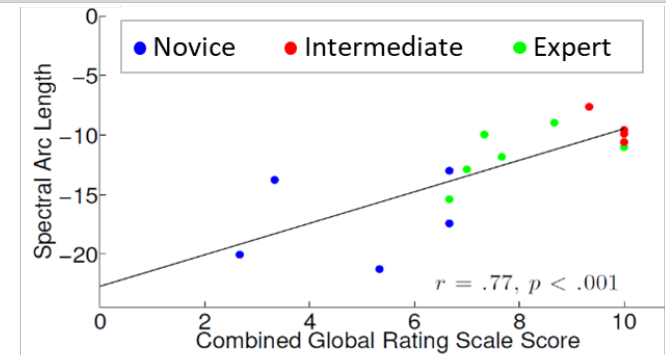


Fourier transform

Power Spectrum



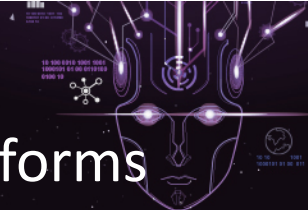
SPARC = -1*[arc length]
(Shorter length = smoother movement)



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

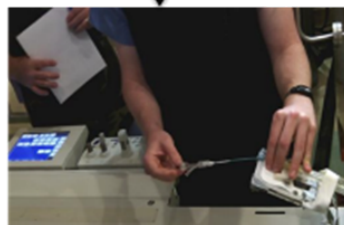
O'Malley et al., IEEE THMS 2019
Schwein et al., JVS 2018, JVS 2016

Estrada et al., IEEE THMS 2016
Duran et al., JVS 2015



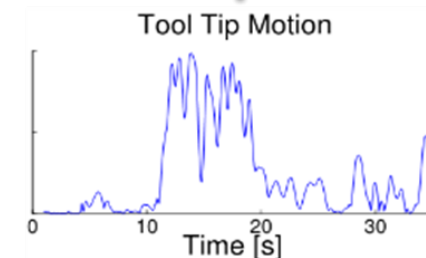
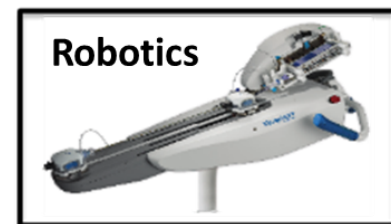
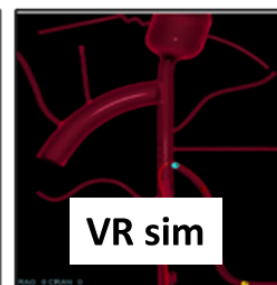
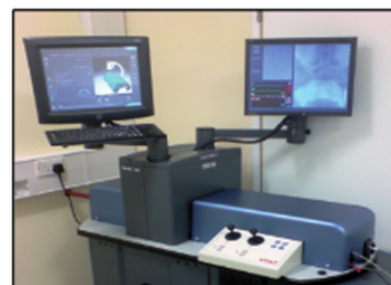
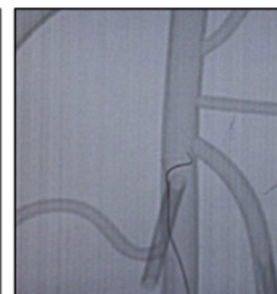
OBJECTIVE: Provide real-time performance feedback during endovascular surgical training

1. What is a task we can do in the lab without surgeons?
2. How are we going to encode “smoothness” for feedback?
3. Will this actually affect task performance strategies?



- Residents
- Fellows
- Attendings

Haptic feedback cues to surgeon

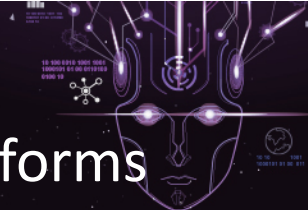


Motion-Based Metrics

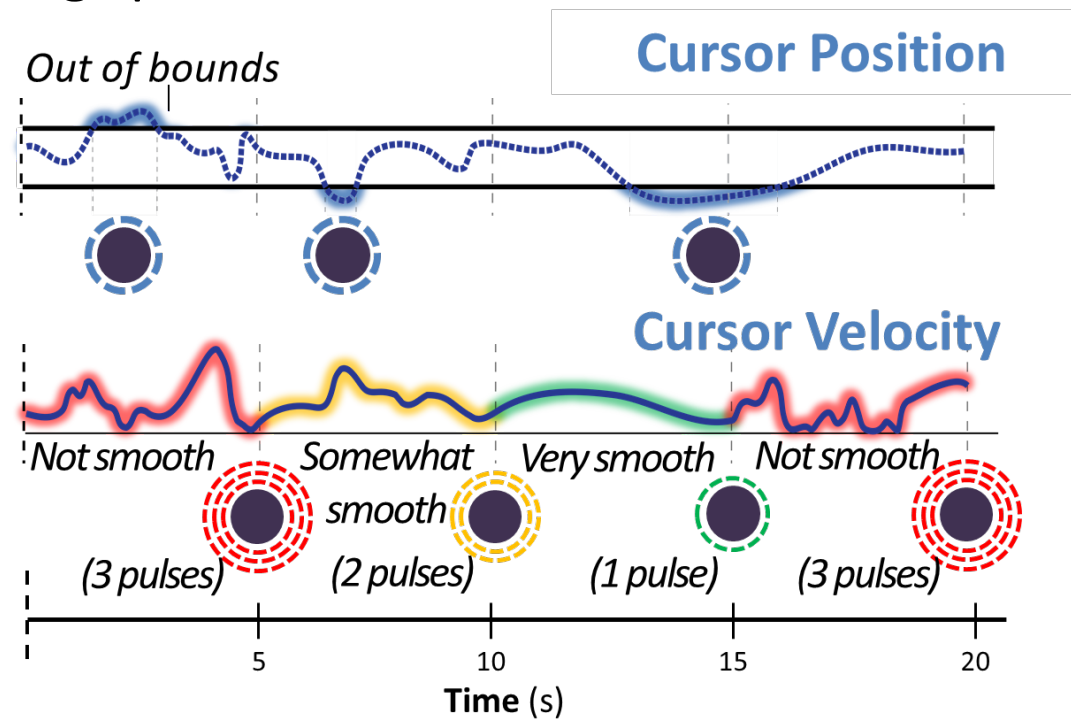
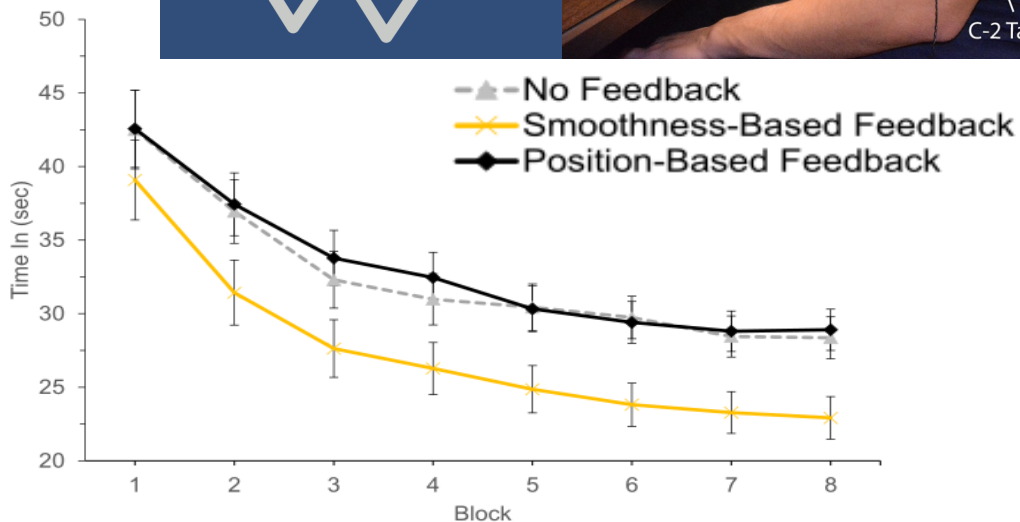
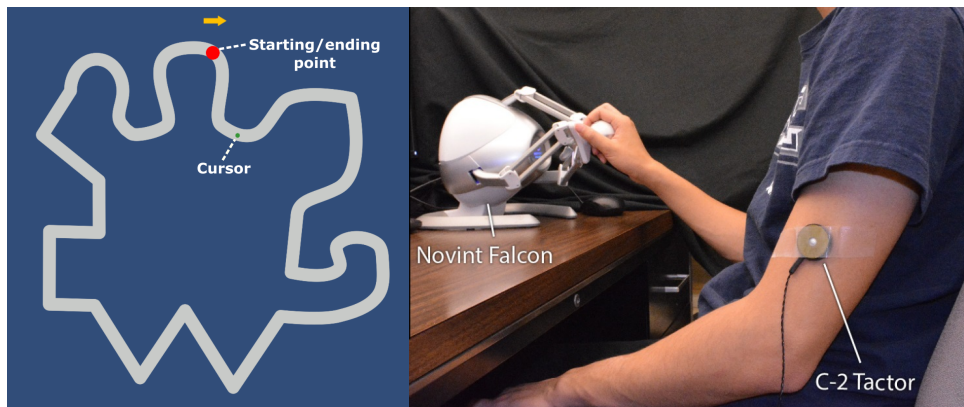


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Compared to feedback based on position, smoothness-based feedback during a mirror tracing task resulted in improved accuracy without sacrificing speed.



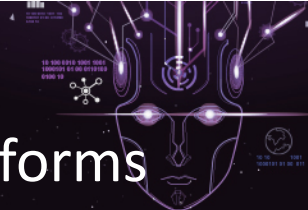
Pandey et al., HFES 2017

Jantscher et al., IEEE Haptics Symp 2018



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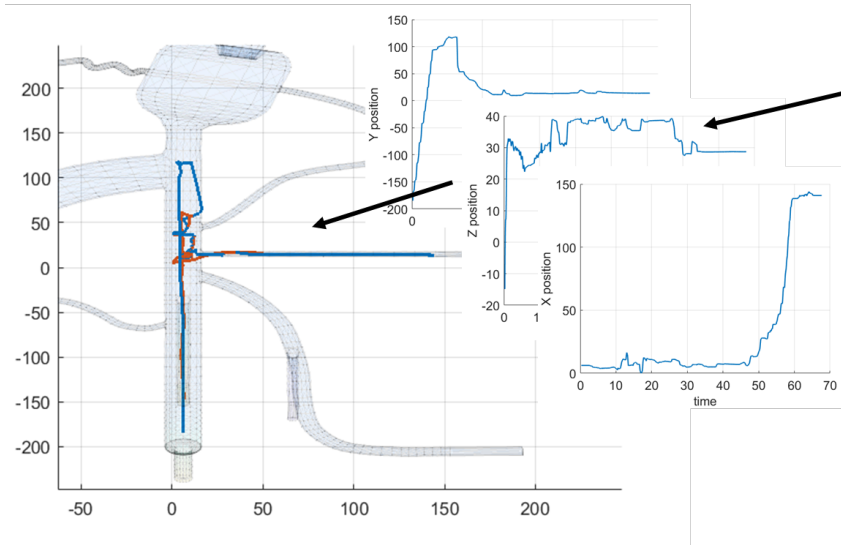
Recent findings: Validating automated data collection in the surgical domain

Guidewire and catheter tool tip kinematics are streamed from ANGIO Mentor endovascular simulator running virtualized FEVS training module

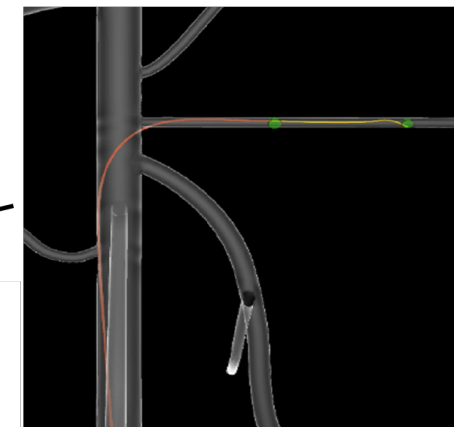


Murali et al., ISMR 2020
Belvroy et al., JVS 2020

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



Guidewire and catheter tool trajectories



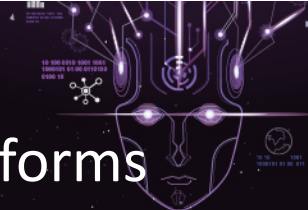
Target navigation task performed on ANGIO Mentor using practice guidewire and catheter



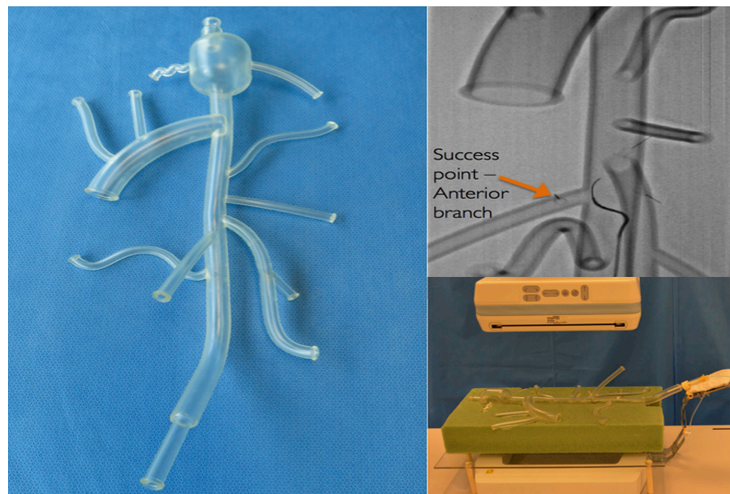
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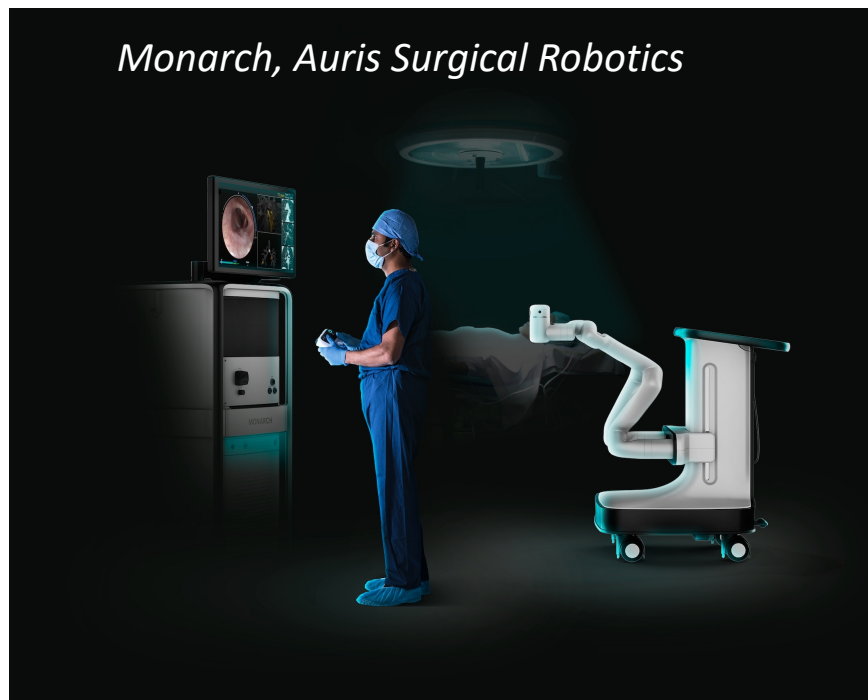
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Recent findings: Moving to real-time performance feedback in the surgical domain



Fundamentals of Endovascular Skill (FEVS)
Duran et al., JVS 2015



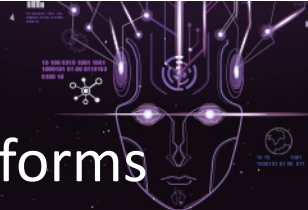
AngioMentor, 3D Systems



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Findings to date:

- Mirror tracing serves as a validated proxy task for prototyping haptic feedback methods
- Simple vibrotactile cues give performance feedback at timed intervals
- Smoothness feedback positively impacts mirror tracing performance
- **Final year:** translate our methods to the surgical domain

