Intuitive Human-in-the-Loop Control for Medical Cyber-Physical Systems

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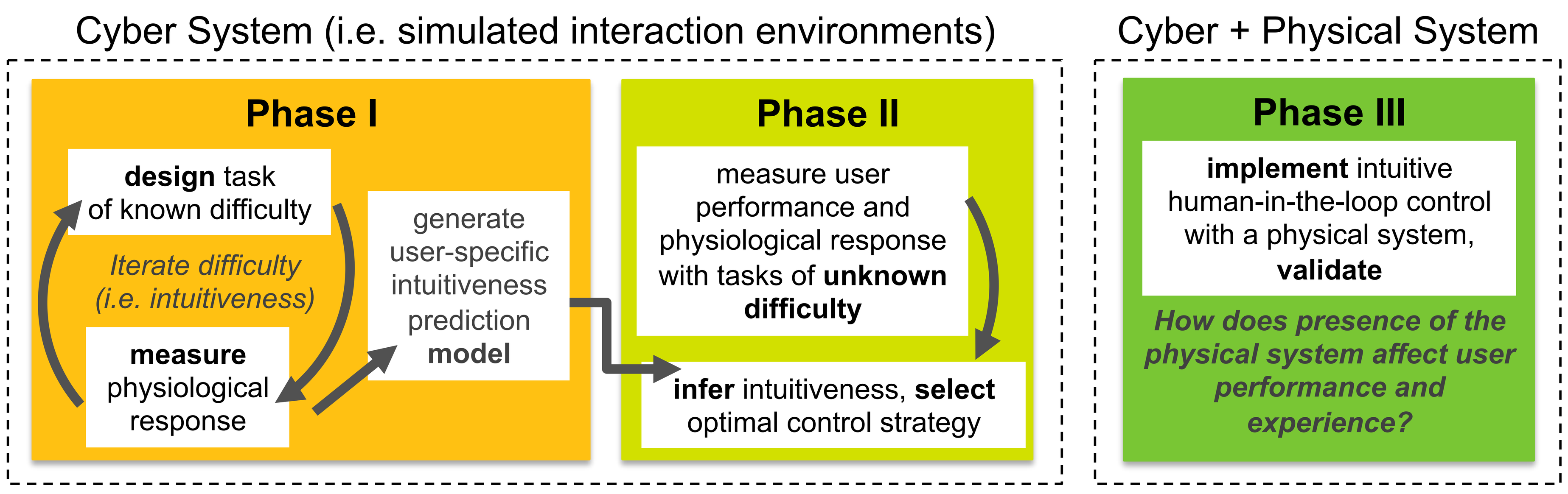
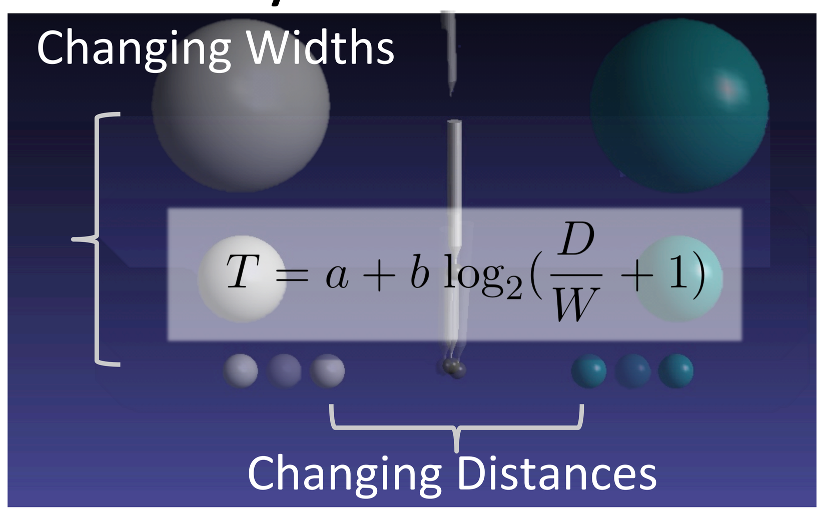
Overall Research Strategy



Designing a Task of Known Difficulty

Fitts' Law is a widely accepted psychomotor relationship between the time (T) to move between targets of distance (D) apart, and width (W). We will conduct a human user study *(UTD IRB #14-57)* to build models of intuitiveness using known difficulty and measured user response. *Student Lead: Ziheng Wang*

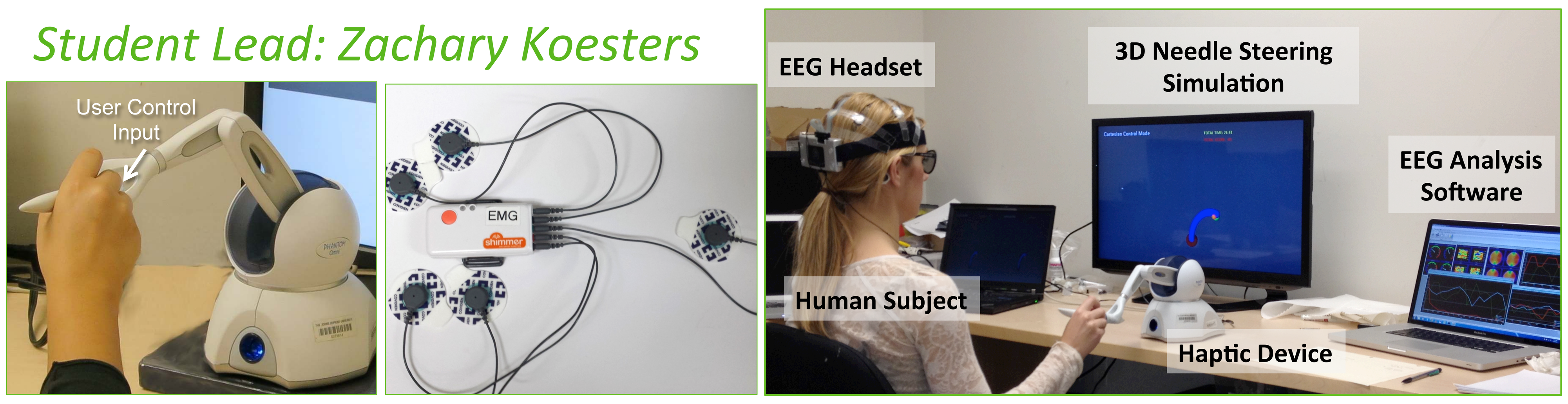


Phase I: Sources of Intuitiveness

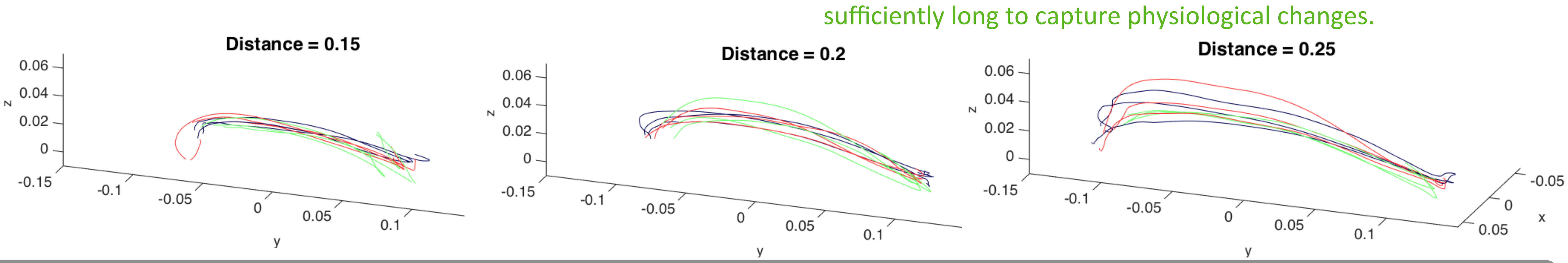
Sensor Integration to Measure Intuitiveness

To measure user performance and physiological response, we are integrating sensors such as IMUs with electromyography, skin galvanic response, and heart rate measurements (Shimmer Sensing) and an EEG headset (Biopac) with custom C++ code to control a haptic device, using the Robot Operating System (ROS).

Student Lead: Zachary Koesters



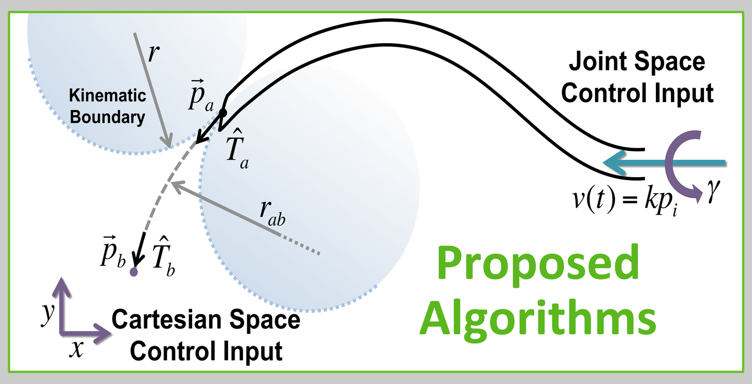
<u>Preliminary work</u> verifies that targets further apart lead to more trajectory error and longer completion time. Ongoing work is to ensure the experiment is sufficiently long to capture physiological changes.



Phase II: Classifying Intuitiveness for a Task of Unknown Difficulty

Steerable needles are able to reach targets while avoiding obstacles in tissue via curved paths. Needles steer due asymmetric tip forces during insertion and rotation.

Teleoperation of steerable needles allows the surgeon to stay in the needle control loop; however, an effective, intuitive teleoperation algorithm will be Important for clinical adoption.



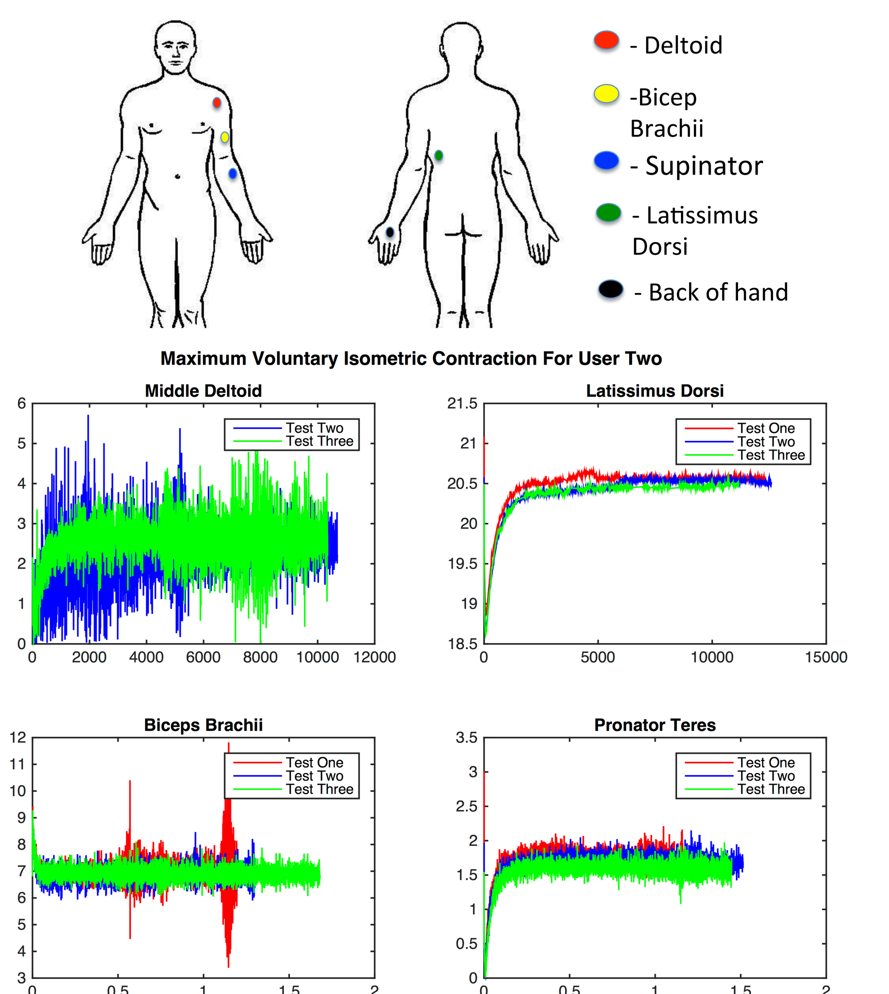
<u>**Long-Term Objective:**</u> Evaluate intuitiveness for steering needles in joint space (i.e., insertion and spin inputs) and Cartesian space (i.e., 3D needle tip control).

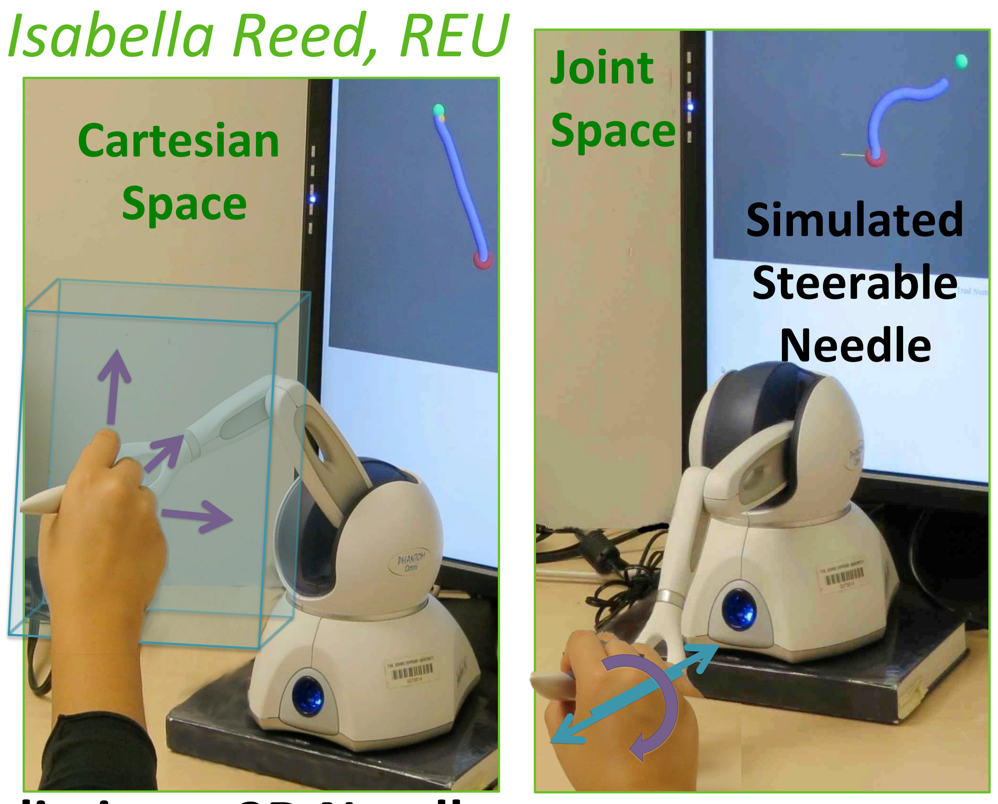
<u>**Short-Term Objective:**</u> Determine best-practices for obtaining physiological parameters during needle steering tasks.

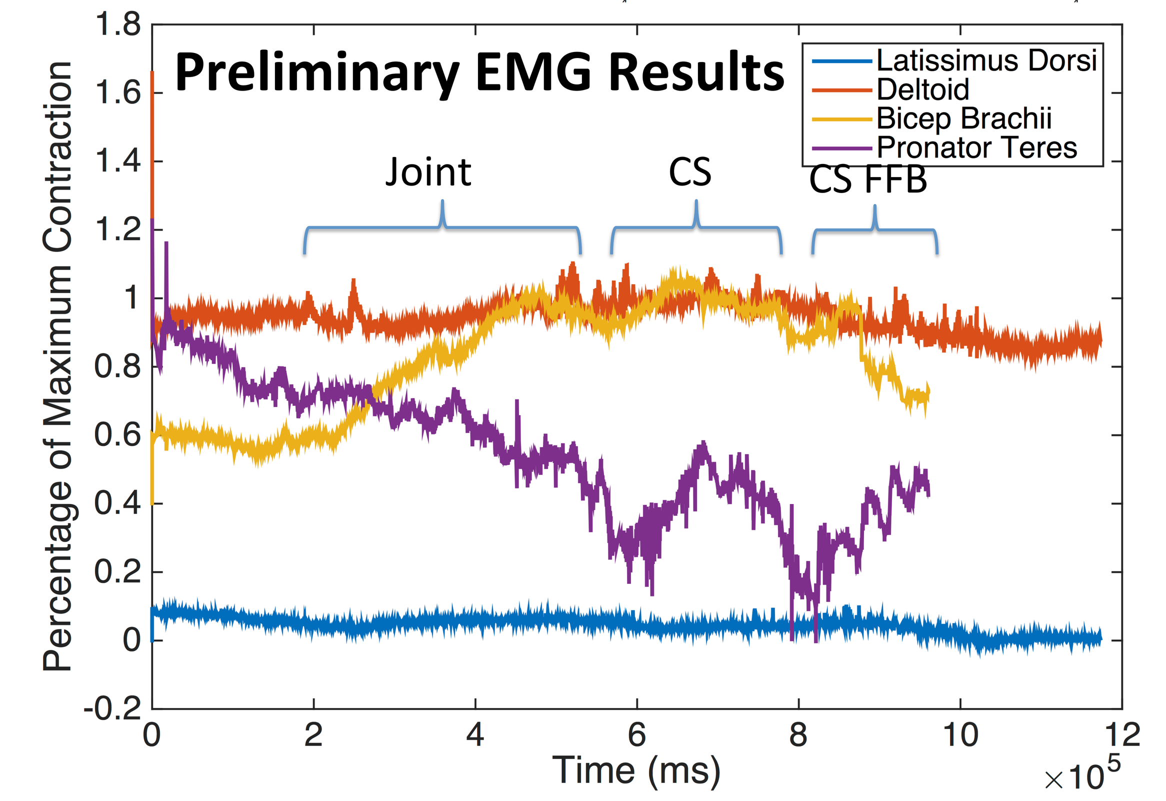
Obtaining Metrics from EMG Data

We identified the four most relevant muscles for teleoperated needle steering: deltoid, bicep brachii, latissimus dorsi, and pronator teres. Data is normalized with maximum voluntary contractions. We are currently analyzing data from a preliminary experiment with six subjects performing 3D teleoperated needle steering with EMG, galvanic skin response (GSR), and EEG data collection. *Student Lead: Isabella Reed, REU*

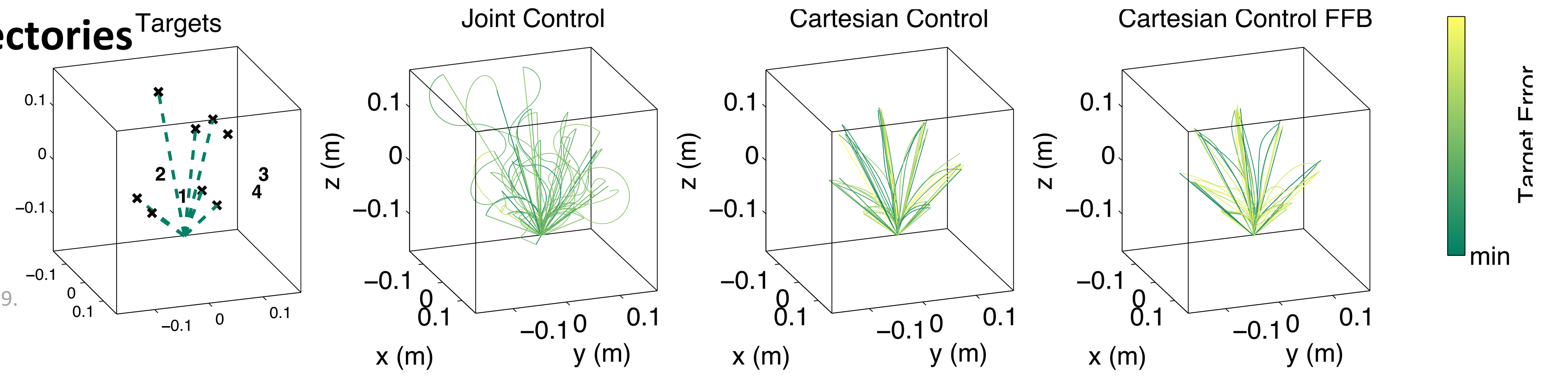
Muscle Selection and Calibration







Preliminary 3D Needle Trajectories



RELEVANT WORKS
[1] **A. Majewicz** and A. M. Okamura, "Cartesian and joint space teleoperation for nonholonomic steerable needles," in IEEE World Haptics Conf, Apr. 2013, pp. 395–400.
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[4] J. Romano, *et al.*,"Teleoperation of steerable needles," in *IEEE International Conference on Robotics and Automation*. IEEE, 2007, pp. 934–939.
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