Tuning a Virtual Prosthetic Limb to Improve Function

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Introduction

Background
- Prosthetics are becoming increasingly prevalent as technology continues to advance.
- Ease of use and training are major factors in prosthetic acceptance.²

A Problem
- Current prosthetics require significant practice before a user becomes proficient.
- This may be because the properties of most prosthetics are defined in an arbitrary way and are not customized to an individual’s unique physiology.³

Our Solution
- We hypothesize that tuning the properties of a virtual prosthetic arm to make it more like a user’s own arm will decrease training time and improve controllability.

Methods

Experimental Design
- Virtual model of a human arm created
- This virtual arm is moved by virtual muscles
- Virtual muscles are controlled in real-time by subjects using muscle activity measured from their biceps and triceps muscle

Conditions
1. Generic Arm
   Participants control a virtual arm with generic muscle properties by activating their biceps and triceps muscles isometrically.
2. Customized Arm
   Same as Generic Arm condition except the properties of the virtual muscles will be tuned to each individual.
3. Actual Arm
   Participants will move their own arm.

Task and Feedback
- Participants performed the same task under all three conditions
- Had to move actual/virtual arm and stop on a virtual target
- Participants instructed to move as fast and accurately as possible
- Actual/virtual arm and target positions shown on visual display to provide the same visual feedback under all conditions

Experimental Protocol
Day 1:
1. Subjects perform virtual task and adapt to Generic Arm (4 x 60 trials)
2. Subjects perform task with their Actual Arm (3 x 60 trials)

Interim:
1. Muscle activity measured during Actual Arm trials is used to simulate a virtual arm movement, which is compared to the movement produced in the Actual Arm trials.
2. Muscle strength, contractile dynamics, architectural features, and elasticity are altered, and an optimization algorithm is used to find the best fit for each individual.

Day 2:
- Perform task with Generic and Customized Virtual Arm
  - Alternating blocks of 60 trials (4 total)
  - These blocks are single-blinded. Subject unaware of virtual model type

Analysis
- Compared movement time and accuracy using the generic and customized virtual arms.

Preliminary Results
- Preliminary results from one subject demonstrated no difference in speed and accuracy between the Generic and Custom Arm conditions on the second practice day.

Figure showing how movement time and error changed as a function of practice and model type (generic or custom).

Conclusions
- These preliminary results do not support the hypothesis that tuning of virtual arm properties facilitates learning or improves controllability.
- This may suggest that there is no need to extensively customize prosthetic arm properties, i.e. generic properties will suffice.
- However, more data are needed before firm conclusions can be drawn.
- Further work is needed to refine the optimization algorithm to better match the experimental data.

References