Development of the Myoelectric Control Resolution Assessment: A Rapid and Device-Agnostic Outcome Measure for Upper-Limb Prostheses

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Background

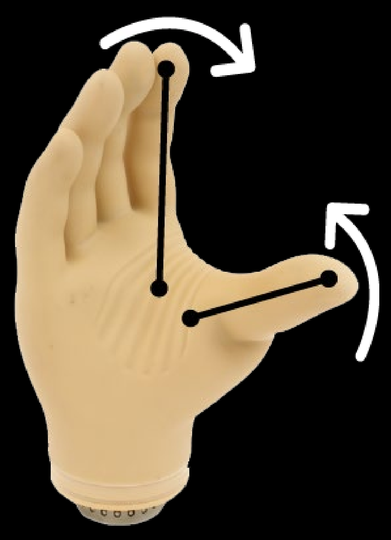
- Many outcome measures exist to assess performance with myoelectric prostheses, however most are time consuming and impractical for clinical settings
- This paper introduces the Myoelectric Control Resolution Assessment (MCRA), a rapid and device-agnostic outcome measuring requiring only a caliper

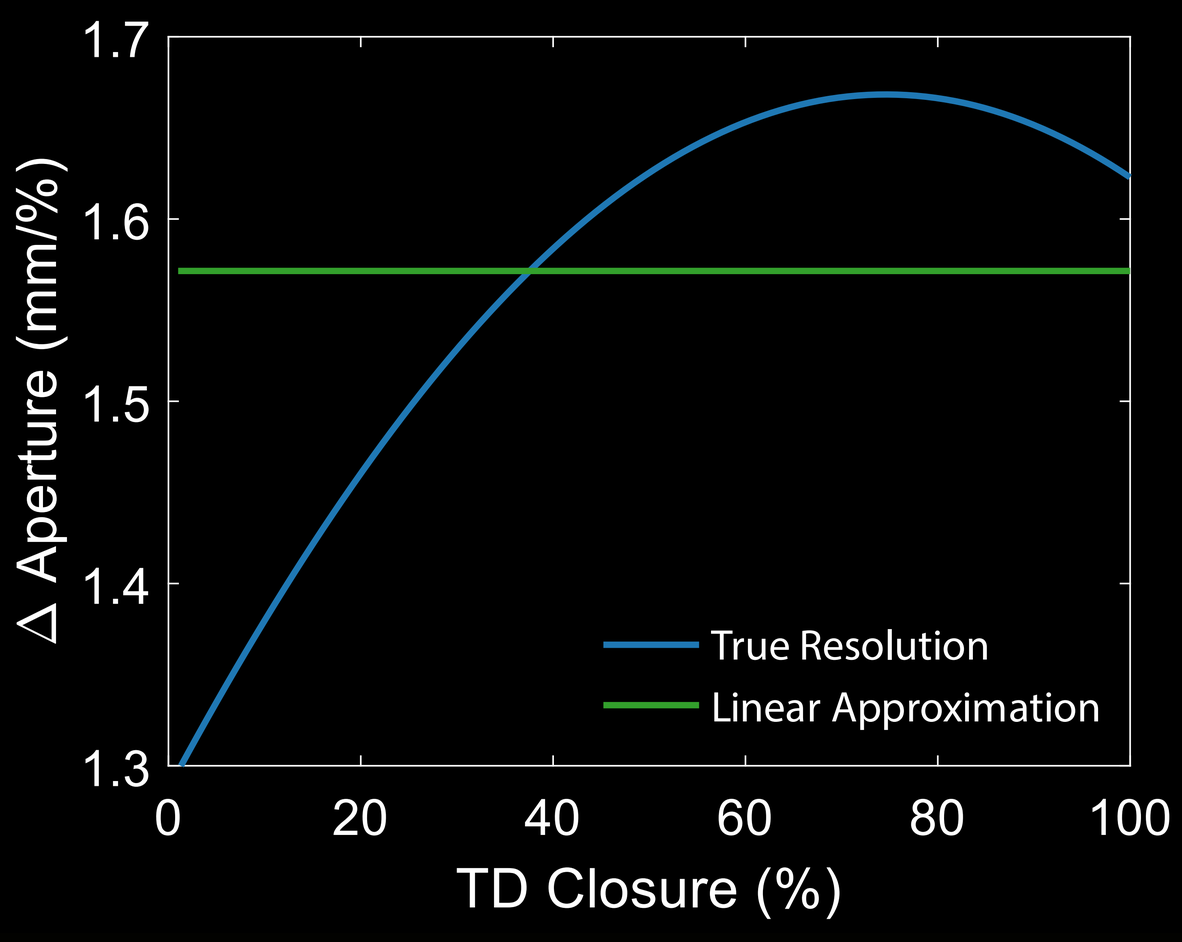
Take-aways

- The MCRA evaluates the smallest volitional movements made using a myoelectric prosthesis, normalizing measurements to account for mechanical differences in terminal device design
- The MCRA provides consistent and unbiased control resolution estimates in as few as five measurements

Methods

- Because of the geometry of the terminal device (TD), the rate of aperture change between the fingertips is not uniform throughout the range of motion
- For the hand shown here, a given control signal will yield smaller changes in aperture when the hand is open, and larger changes when the hand is closed





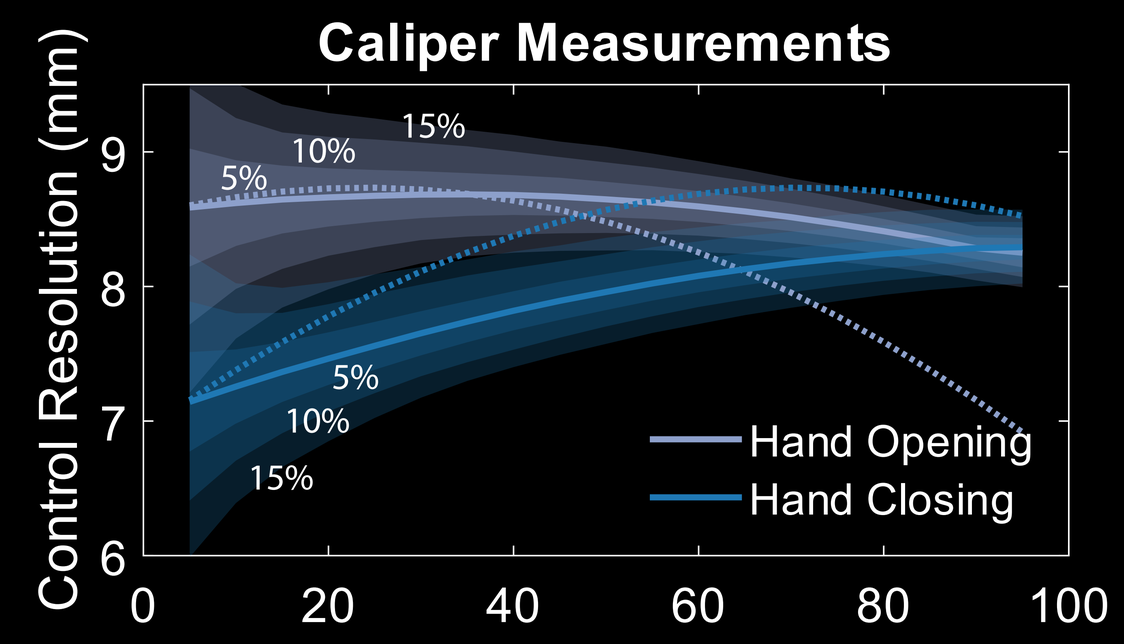
- The MCRA involves taking repeated measurements of the TD aperture using calipers while the user closes or opens the prosthesis in the smallest possible increments
- The MCRA accounts for non-uniformity in the prosthesis' rate of aperture change by employing an inverse closing function B^{-1} and actuation time T to calculate Myoelectric Control Resolution MCR using measured aperture α:

$$MCR(i) = T \cdot \left(B^{-1}(\alpha(i)) - B^{-1}(\alpha(i-1))\right)$$

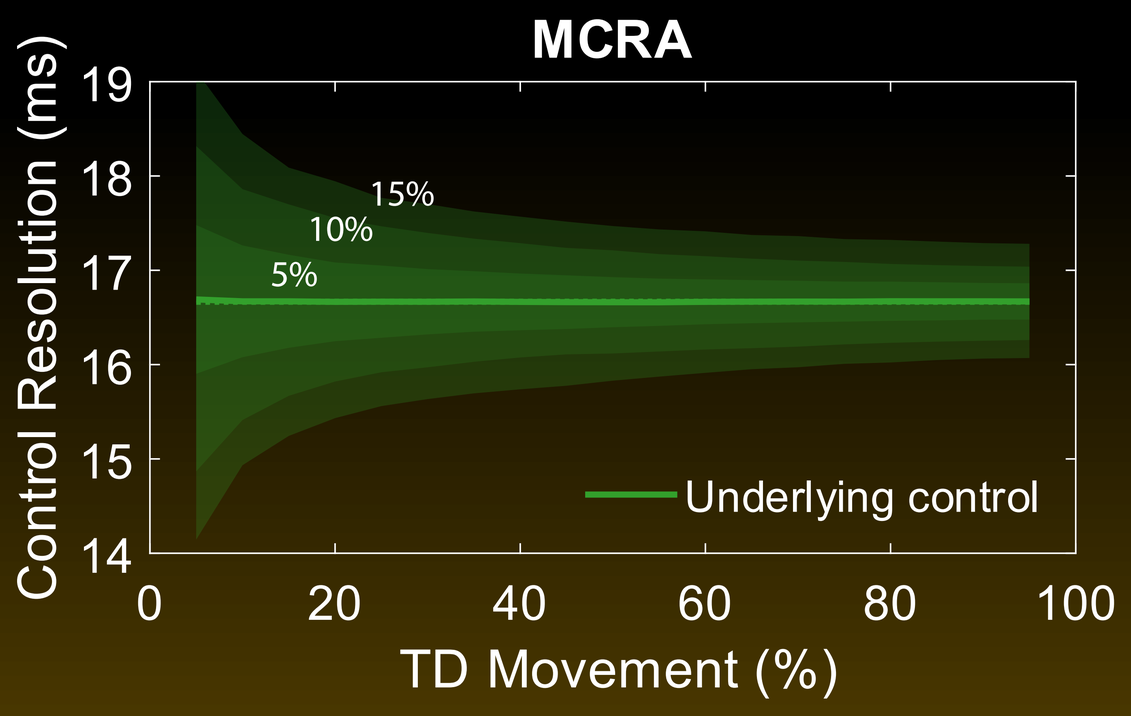
- The protocol for performing the MCRA is as follows:
  1. Measure the aperture α of the prosthesis using calipers
  2. The user operates the prosthesis by the smallest amount possible
  3. Remeasure the aperture α of the prosthesis
  4. Normalize the change in aperture using the TD's inverse closing function B^{-1} and actuation time T
  5. Repeat steps 1-4 and average across measurements

Results

- To characterize the performance of the MCRA, the mechanical closing and opening of a prosthetic hand was simulated with 5%, 10%, and 15% variability in motor commands
- Control resolution (caliper measurements and MCRA) was calculated as a cumulative average of the current and all previous measurements



- Cumulative averaging results in bias between the estimated (solid) and true (dashed) resolutions
- Directly estimating control resolution using caliper measurements yields inconsistent outcomes depending on whether the hand is opening or closing



- When using the MCRA, measurements are corrected by the inverse closing function B^{-1} to translate directly to the underlying myoelectric control
- Expected error of the MCRA drops to half of the control variability in as few as 5 trials