Context-based control with full wrist mobility surpasses current transradial myoelectric prostheses during reaching in virtual reality

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Background

Commercial transradial prostheses propose forearm pronation/supination (Fa-P/S) but not wrist flexion/extension (W-F/E) and wrist radial/ulnar deviation (W-R/U).

This lack of wrist mobility results in substantial increase in compensatory movements [1].

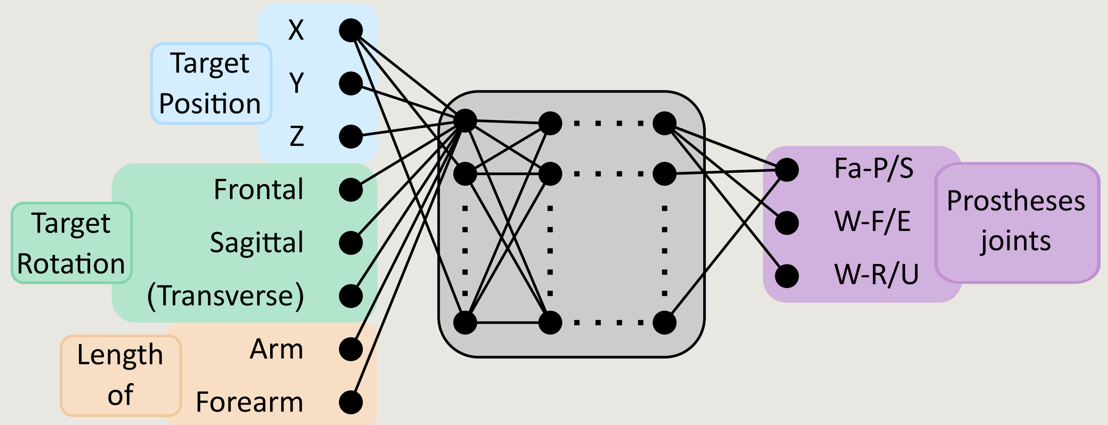
Despite the emergence of 3-degrees-of-freedom (DoFs) robotic wrists, myoelectric control does not provide easy and intuitive control over multiple DoFs.

Our Context-Based Prosthesis Control (CB-PC)

Following [2], our control system is based on an Artificial Neural Network (ANN) that predicts a prosthesis configuration from contextual target information.

As the ANN was trained on a database of natural arm movements [3], it encapsulates the natural coordination of arm movements, providing the user with consistent and intuitive motion.

Its predicted configuration is turned into a trajectory using shoulder velocity and distance to object [4].



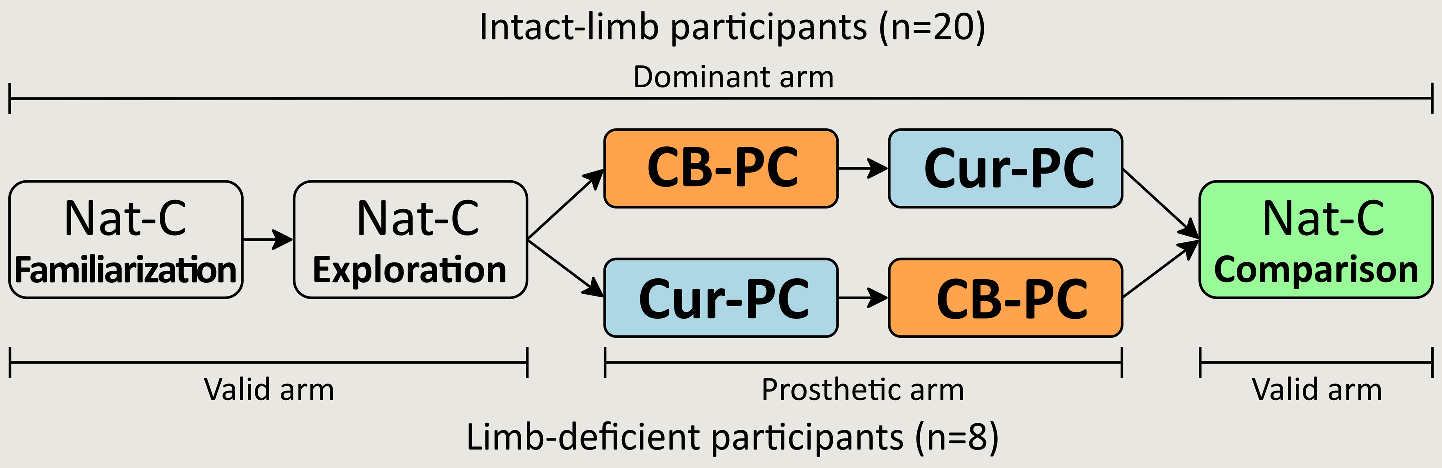
Experimental conditions

Supplementary videos

Natural **C**ontrol **(Nat-C)**: Dominant or intact arm without restrictions

Current **P**rosthesis **C**ontrol **(Cur-PC)**: Myoelectric prosthesis or wrist brace, control only over wrist pronation/supination

Context-**B**ased **P**rosthesis **C**ontrol **(CB-PC)**



Tasks

Pick-and-place: Picking up a virtual bottle from one platform and place it onto another

Refined Clothespin Relocation Test (RCRT): Moving three virtual clothespins either from a horizontal rod to a vertical rod or vice versa

Metrics

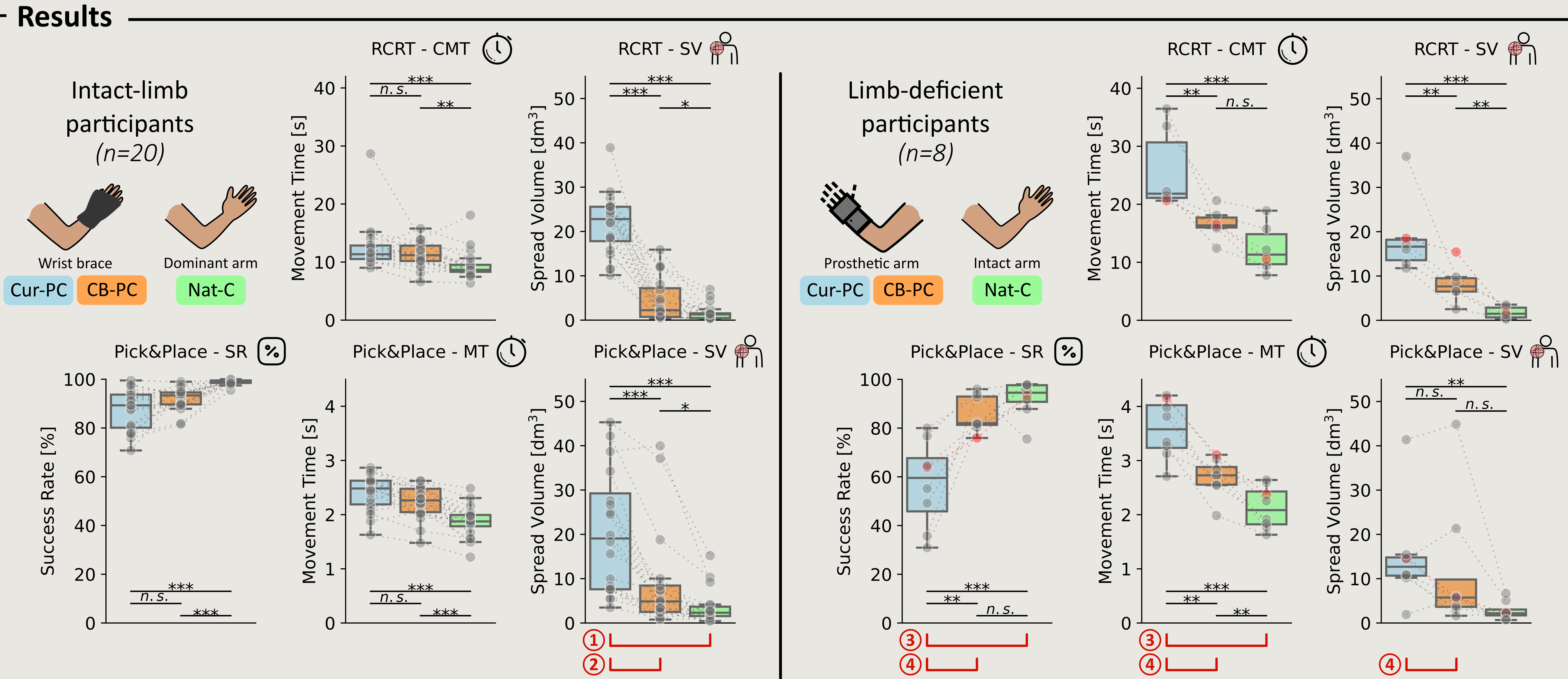
***Success Rate* (SR):** Percentage of trials validated (pick-and-place)

***Movement Time* (MT):** Time from the start to the validation of a trial (pick-and-place)

***Cycle Movement Time* (CMT):** Time to complete one cycle (RCRT)

***Shoulder position spread Volume* (SV):** Volume of the ellipsoid containing shoulder positions (both tasks)

Results



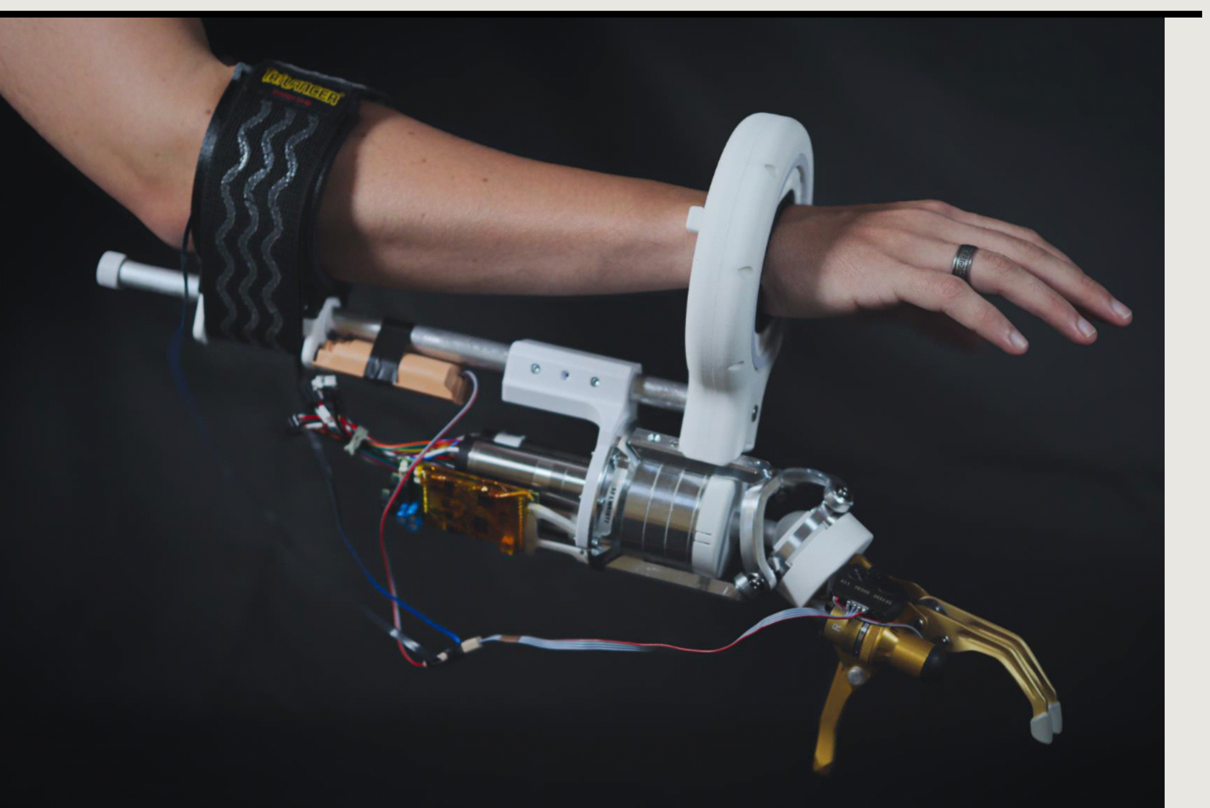
Significant increase in shoulder spread volume due to the mechanical constraint highlights the extensive compensatory movements required to maintain the same reachable space. ①

Although CB-PC did not completely match Nat-C in performance, it notably reduced compensatory movements, lessening the need for unnatural postures. ②

While the mechanical constraint of prostheses impacted compensatory movements, myoelectric control further deteriorated performance resulting in lower success rates and longer movements times. ③

CB-PC addresses these key issues, improving all metrics despite participants' lack of prior experience. ④

Discussion



CB-PC is a promising alternative to current prosthetic control systems, offering full wrist mobility while being more intuitive and faster to use than myoelectric control, with minimal learning required.

Next phase will involve real-world testing with actual object detection via computer vision and an operational 3-DoFs wrist (Orbita) integrated into bypass sockets for intact-limb participants and transradial sockets for limb-deficient participants.

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References

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