Comparing EMG- and Goniometer-Driven NMI Control For A Virtual Target Acquisition Task

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Motivation

Many advanced algorithms have been developed to estimate a user's movement intent from electromyography (EMG) for controlling neural-machine interfaces (NMI), such as myoelectric prostheses [1] and virtual interfaces [2].

Inevitable discrepancies between the estimated and actual movement intent can limit the efficacy of NMI control, especially for the wearer of the prosthesis.

We previously developed a novel EMG-driven NMI controller based on a musculoskeletal model of the hand [3].

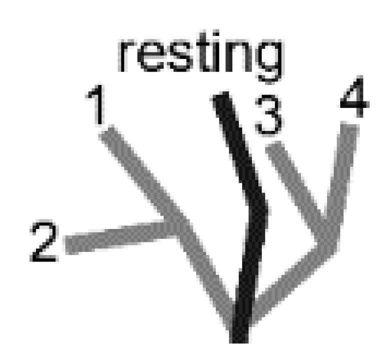
The objective of our study was to determine the effect of the model's movement estimation discrepancies on subject's performance of a real-time virtual target acquisition task.

Hypothesis: Task performance would be worse with the EMG-driven musculoskeletal model than when the users' hand kinematics were used directly to control the virtual hand's movement.

Experiment Design

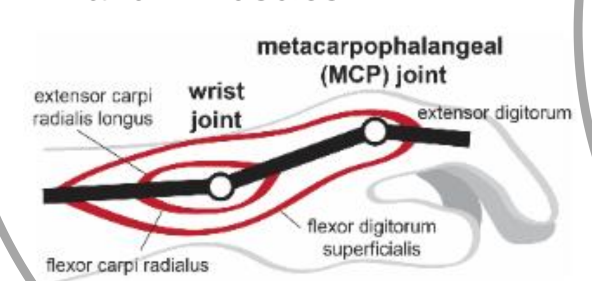
Real-Time Virtual Task

Four able-bodied subjects attempted to match four target postures (grey lines in figure at right) starting from a base posture (black lines) with a 2-DOF virtual hand, sequentially and in a randomized order.



EMG-driven

- Surface EMG from 4 muscles
- Musculoskeletal model implemented in MATLAB included 2 joint-segments and 4 muscles



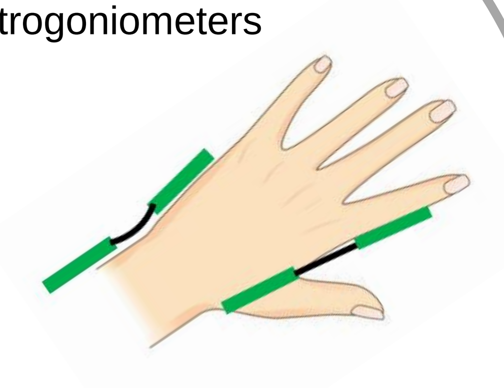
- EMG normalized by peak EMG during maximum voluntary contractions (MVC)

1 upper extremity posture:

1 forearm posture: **neutral**

Goniometer-driven

- Two (2) Biometrics Ltd Twin-Axis Electrogoniometers



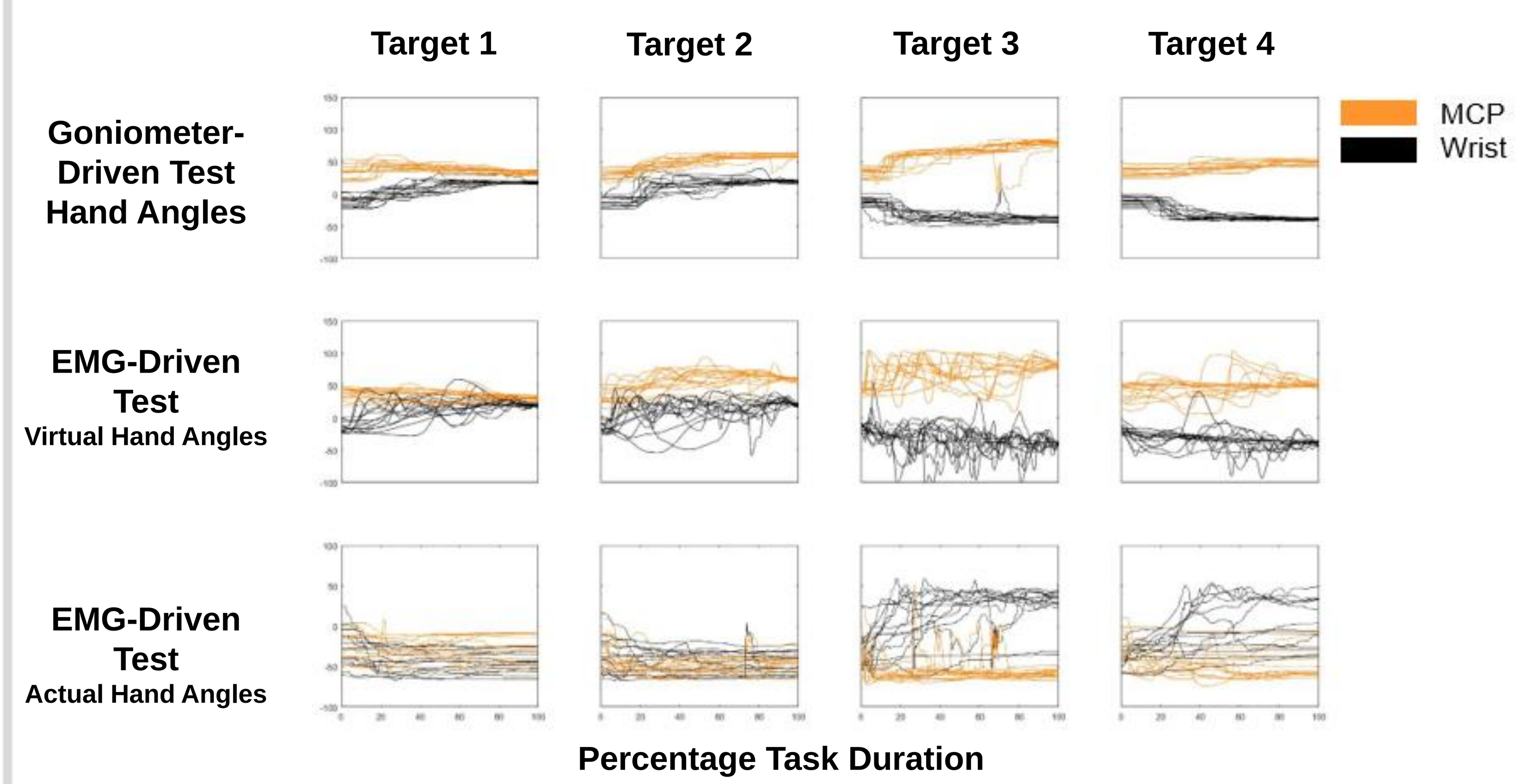
- Virtual hand postures produced using measured joint angles

PERFORMANCE MEASURES

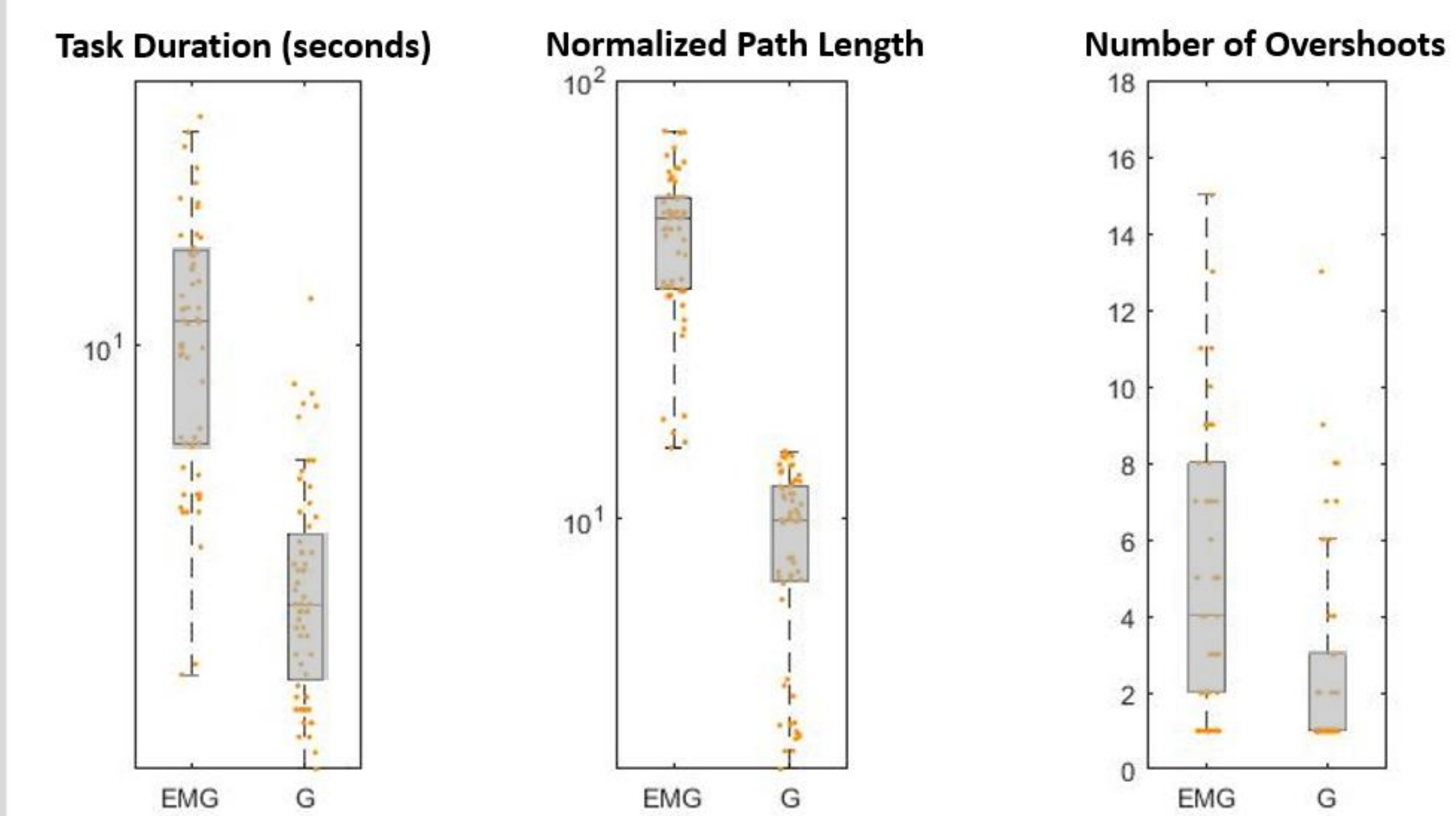
Task Duration	Time required to move within target posture for 1 consecutive second
Normalized Path Length	Trajectory length (in joint space) divided by minimum possible trajectory length
Number of Overshoots	Number of times virtual hand moved in then out of target posture

Results

It was easier for subjects to complete the goniometer-driven test than the EMG-driven test, as indicated by less oscillatory hand movement during the goniometer-driven test.

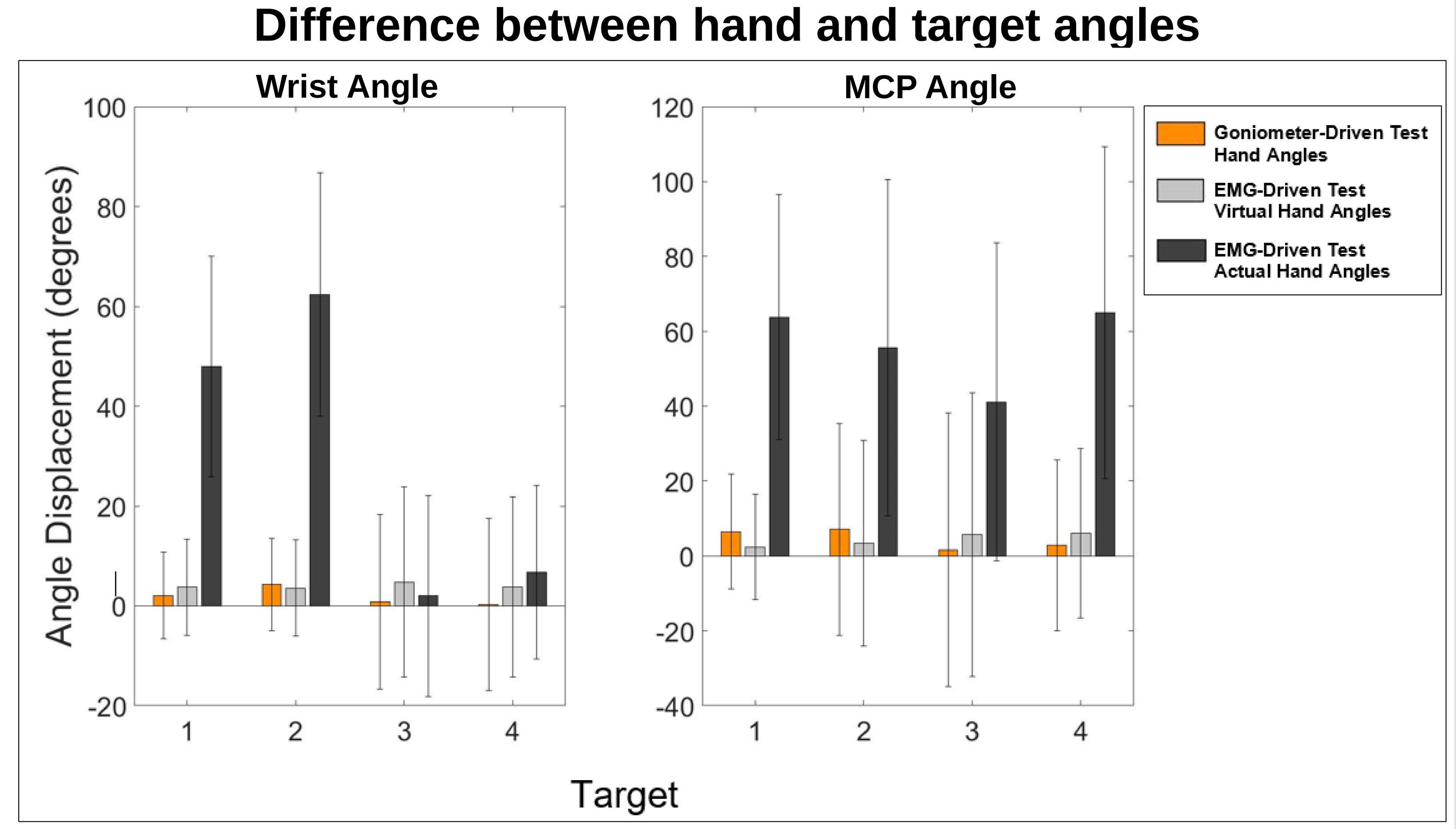


There was a trend of better overall task performance for the goniometer-driven test (G) than for the EMG-driven test (EMG).



For the EMG-driven test, there was an average angle discrepancy of 40-60 degrees between the measured and target hand angles at both joints.

Difference between hand and target angles



Conclusion and Future Work

As expected, our results suggest that the accuracy of movement estimates influences real-time task performance for EMG-based NMI control.

Errors could potentially be reduced by improving controller calibration procedures.

This study was limited by the low number of subjects tested and high inter-subject variation.

In the future we will potentially evaluate more muscles, incorporate more degrees of freedom, and evaluate the effects of other error sources (e.g. estimation delays) on task performance.

Acknowledgments

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References

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