Motor Unit Drive: A Neural Interface For Real-Time Upper Limb Prosthetic Control

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Motivation

The functional and mechanical capabilities of prosthetic limbs have significantly advanced in recent years. But prosthetic limbs used today rely on outdated neural interfaces whose performance prevents access to these advanced control capabilities. Consequently, 23-32% of people in the US with upper-limb-loss abandon regular use of their myoelectric prosthesis[1]. While implantable solution technologies have significantly advanced to solve this challenge[2-3], the higher-costs, health-risks and integration of surgery into the prosthetist directed health care model remain obstacles to commercial integration of these sensors.

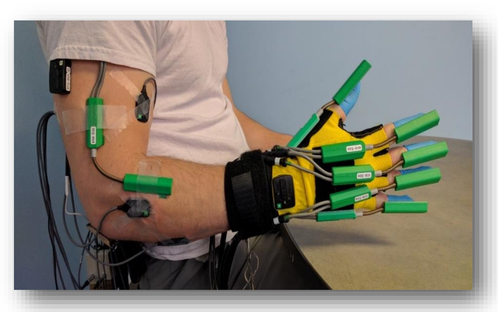
Objective

We have set out to develop technology that can access the same neural information as implanted systems but with a noninvasive solution, referred to as MU Drive, to provide a lower cost, lower health-risk, prosthetic control solution that is compatible with current prosthetic-care model and will result in increased health care access for amputees.

In this work our goal was to establish the proof-of-concept that MU Drive significantly improves control capabilities over existing myoelectric approaches.

Experiments & Testing

Subjects	Transradial Amputees	Intact Controls
Number	n = 13	n = 10
Age (y)	47 ± 15	37 ± 15
Male/Female	8/5	5/5

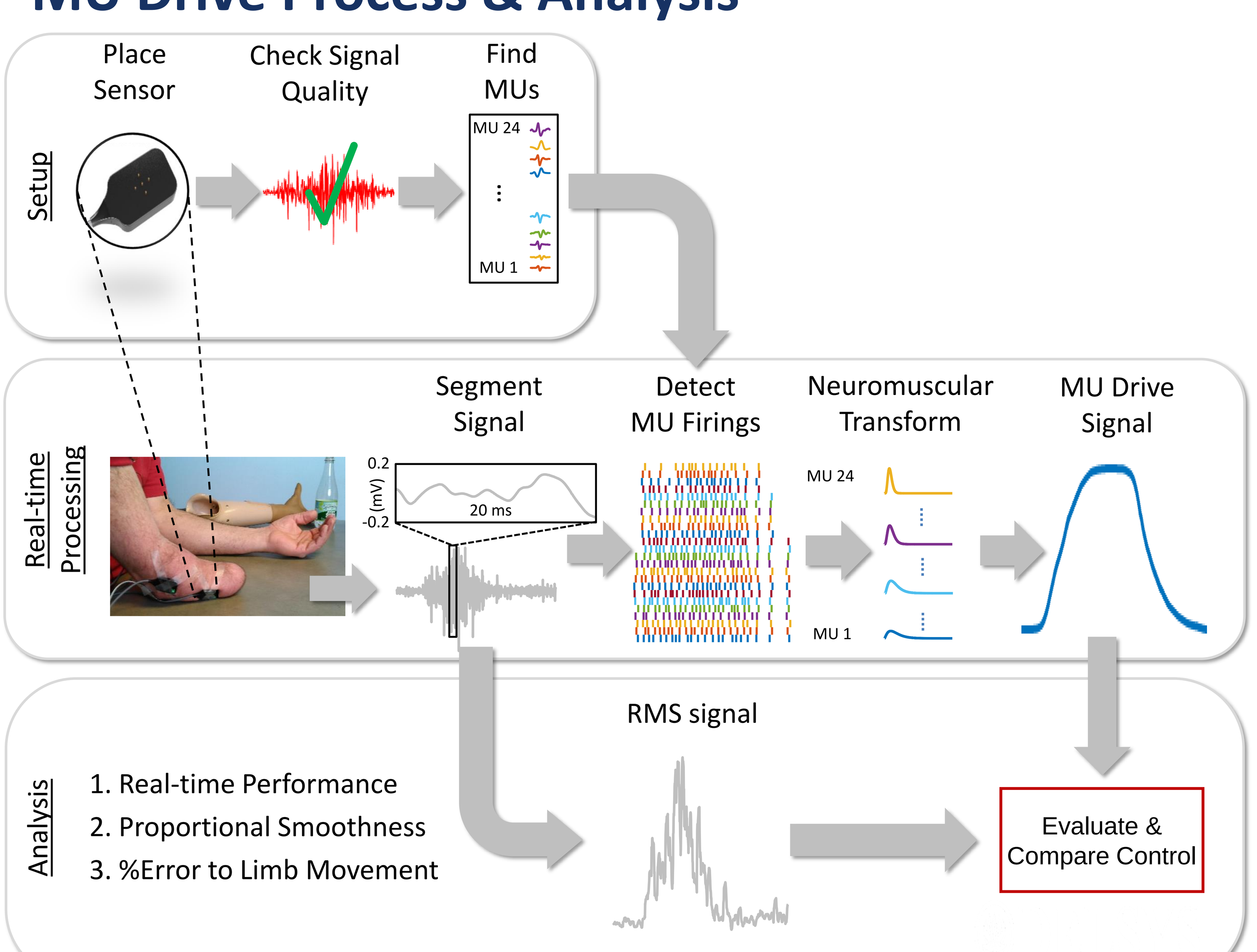


Muscles
- Extensor Digitorum
- Flexor Digitorum Profundus
- Pronator Teres
- Biceps Brachii

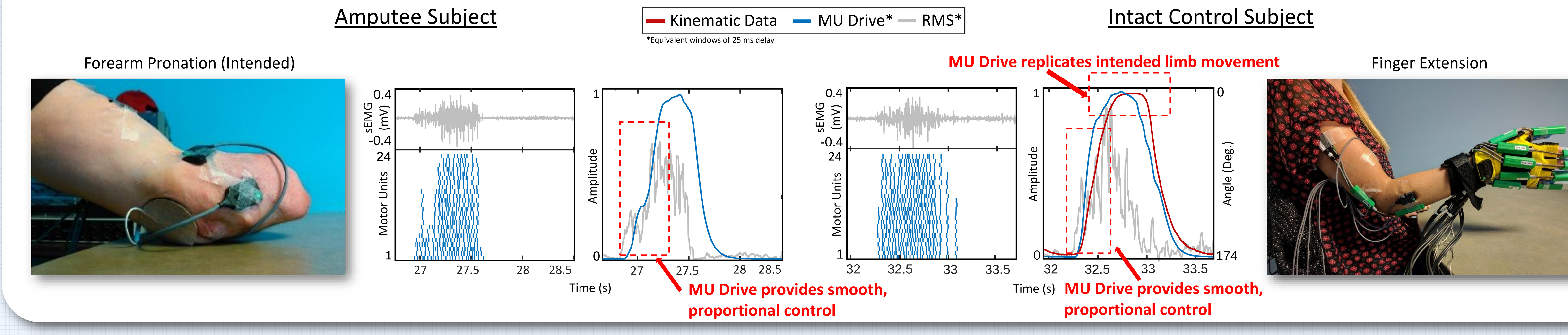
Activities
- Finger flexion
- Finger extension
- Forearm pronation
- Forearm supination

Recordings
- sEMG signals (dEMG, Delsys Inc.)
- Joint angles (SG75, Biometrics Ltd.)
- Forearm orientation (Trigno™ IM, Delsys Inc.)

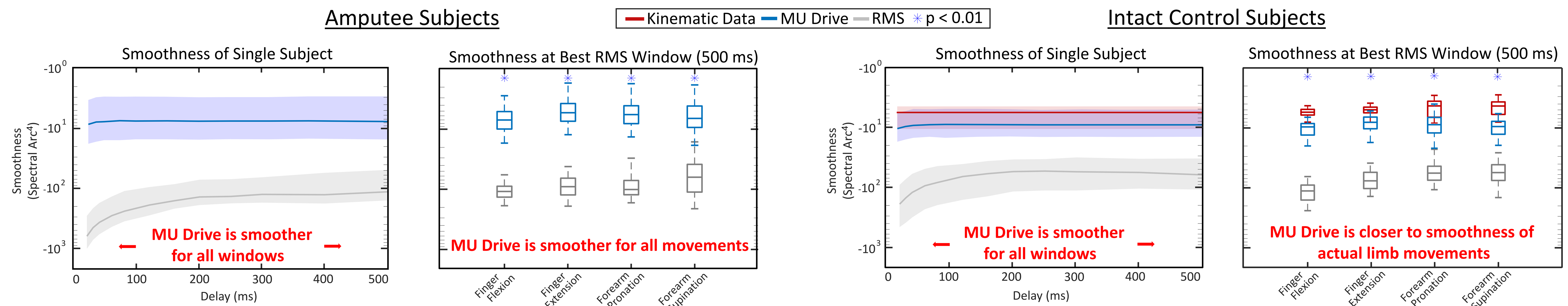
MU Drive Process & Analysis



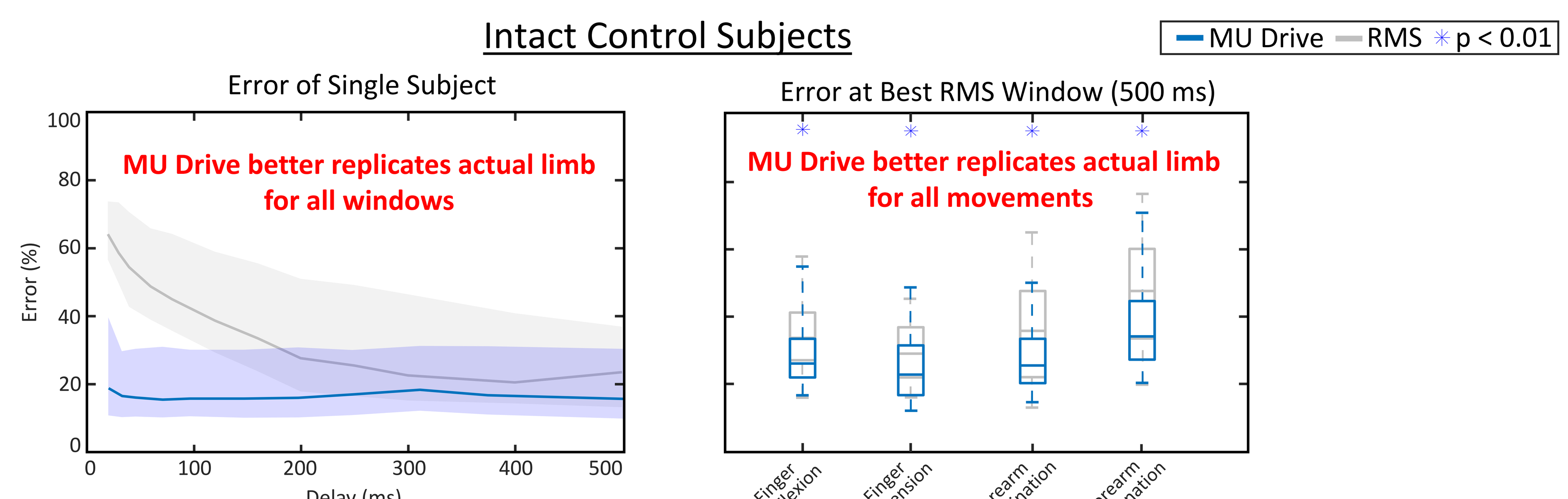
Result 1 MU Drive Control Characteristics



Result 2 MU Drive has Smoother, Proportional Control



Result 3 MU Drive Better Replicates Actual Limb Movement in Real Time



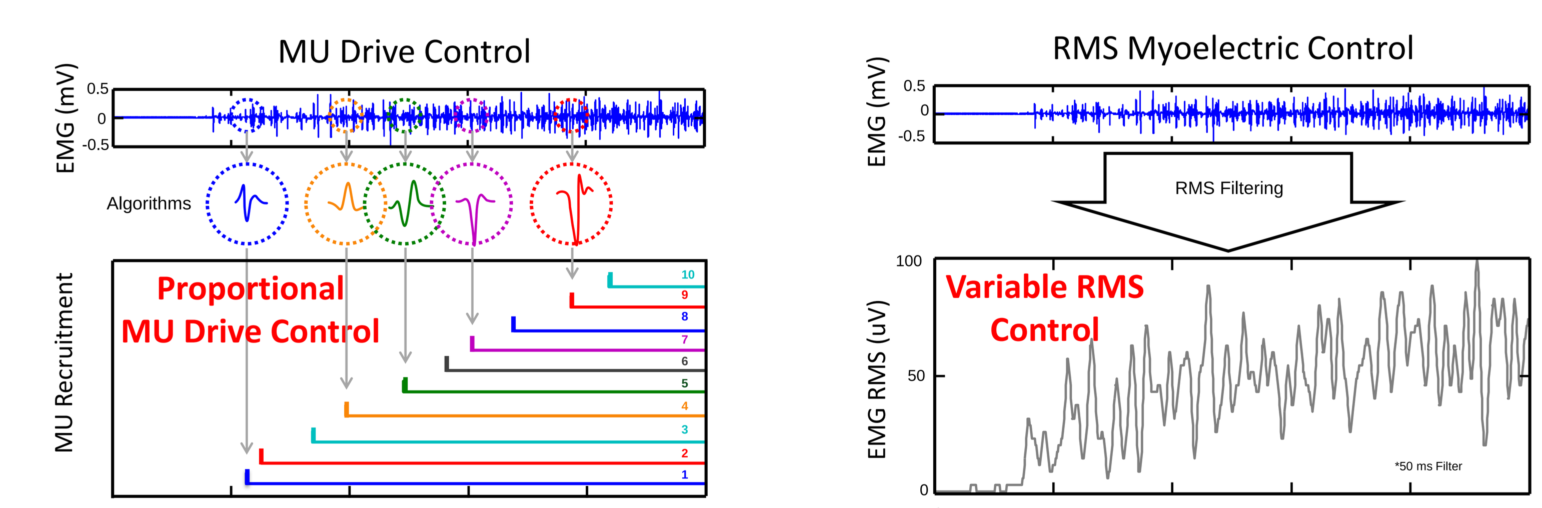
MU Drive Processing

MU Drive provides responsive real-time control

- 2.7 ± 1.3 ms of processing time (95% CI = 0.7, 4.7) for each 20 ms segment.
- Real-time ratio less than 0.25:1 and total delay less than 25 ms for each 20 ms segment.

Why MU Drive Improves Control

- Separates discrete control increments from variable signal.
- Uses natural mechanisms of muscle control in intact limbs, to create mechanically-informed neuromuscular control.
- Provides responsive, real-time control that maintains smoothness, and better replication of intended movement.



Future Directions

This first time proof-of-concept forms the basis for prototype development and testing of MU Drive in a transradial prosthesis for increased function.

Acknowledgements

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