A Case Study on Classification of Foot Gestures via Surface Electromyography

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Motivation

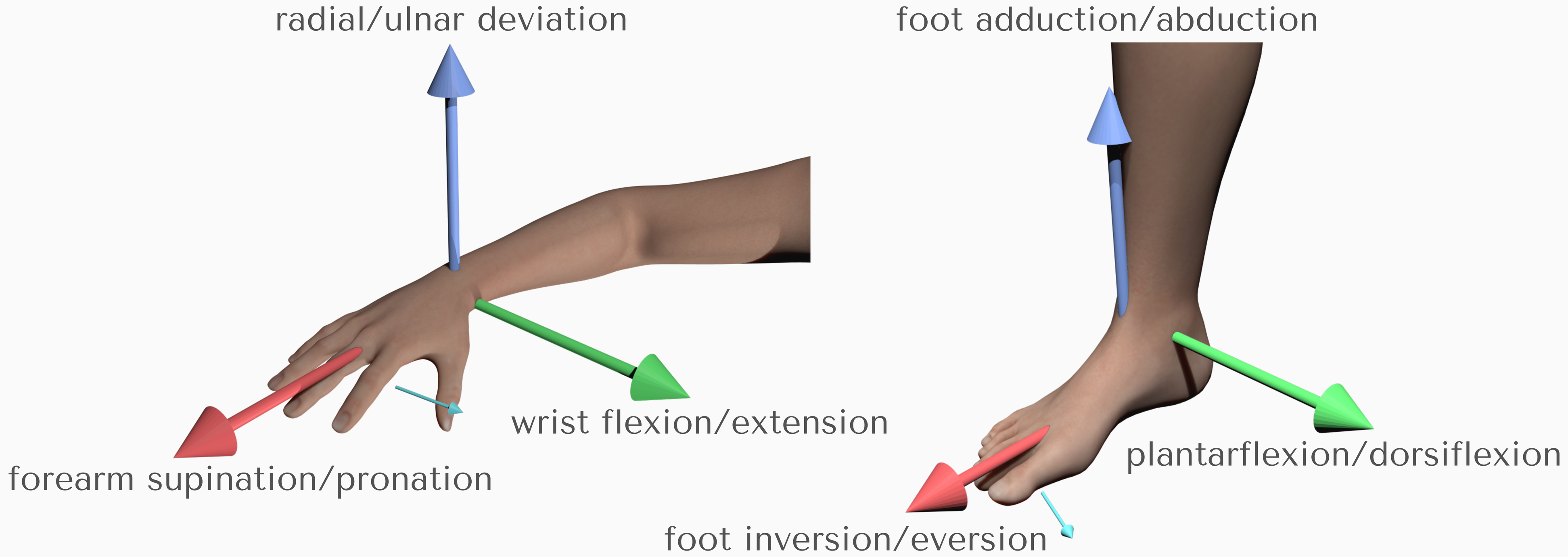
Individuals with high-level upper limb amputations stand to benefit the most from advanced prostheses, yet there are few methods available for prosthesis control when the amputation is proximal to the elbow.

Targeted muscle reinnervation (TMR) is a surgical technique offering intuitive powered prosthesis control to high-level amputees, but less invasive methods could be beneficial. We propose a non-invasive alternative, where the user controls a prosthesis by performing homologous movements of the lower leg and foot recognized using standard techniques in EMG-based gesture recognition.

This work represents a preliminary step toward this goal, where we determine the feasibility of recognizing lower leg and foot gestures via surface EMG.

Arm-Leg Mapping

The proposed control method is based on the alignment of the rotational axes of the wrist and the ankle, providing a natural mapping between arm and leg movements.

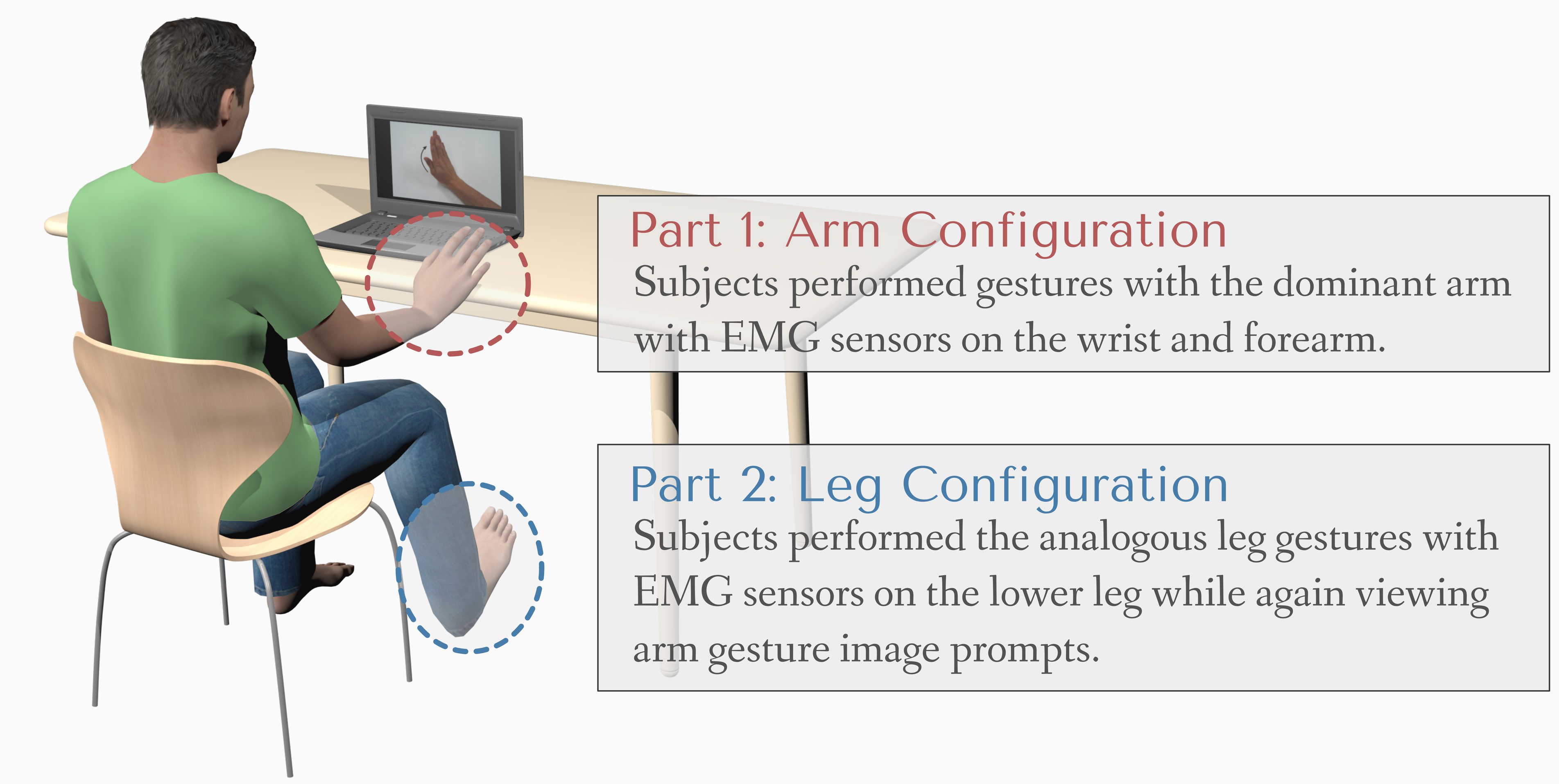


There are also sets of muscles with analogous functions in their corresponding limb. This aspect of the mapping serves to more directly compare the accuracy of upper and lower limb EMG-based gesture recognition.

	Arm		Leg	
	Muscle	Primary Action	Muscle	Primary Action
A	extensor carpi radialis longus	wrist extension	tibialis anterior	dorsiflexion
B	pronator teres	forearm pronation	peroneus longus	foot eversion
C	flexor carpi radialis	wrist flexion	gastrocnemius lateralis	plantarflexion
D	extensor pollicis longus	thumb extension	extensor hallucis longus	hallux extension
E	extensor digitorum	finger extension	extensor digitorum longus	lesser toe extension
F	flexor digitorum superficialis	finger flexion	flexor digitorum longus	lesser toe flexion

Experiment

Subjects viewed seven different gesture image prompts and performed each gesture several times while six channels of surface EMG were recorded.



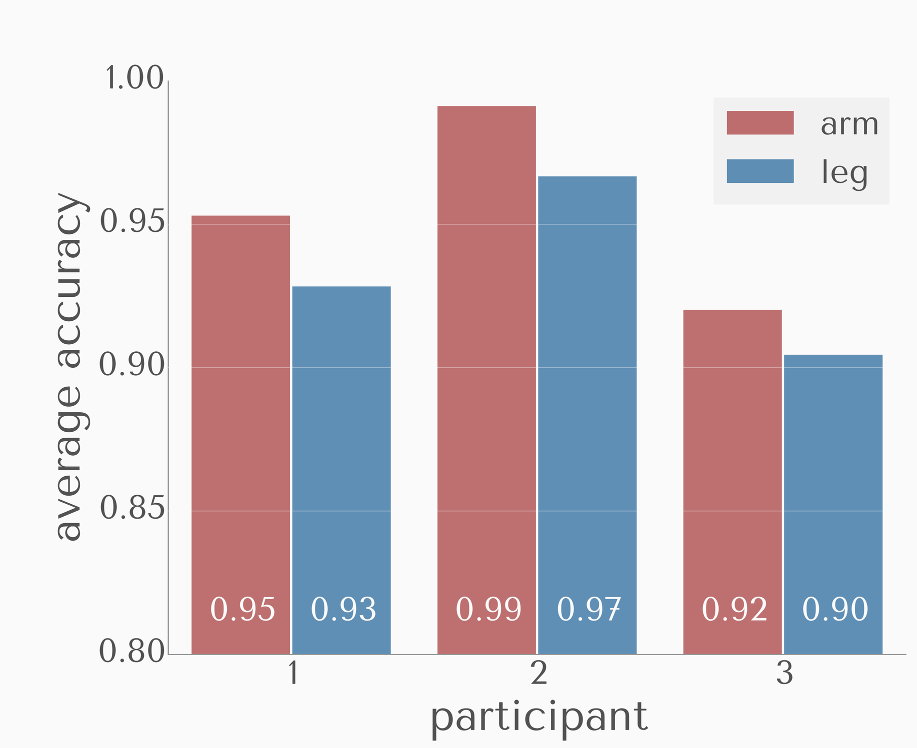
Part 1: Arm Configuration
Subjects performed gestures with the dominant arm with EMG sensors on the wrist and forearm.

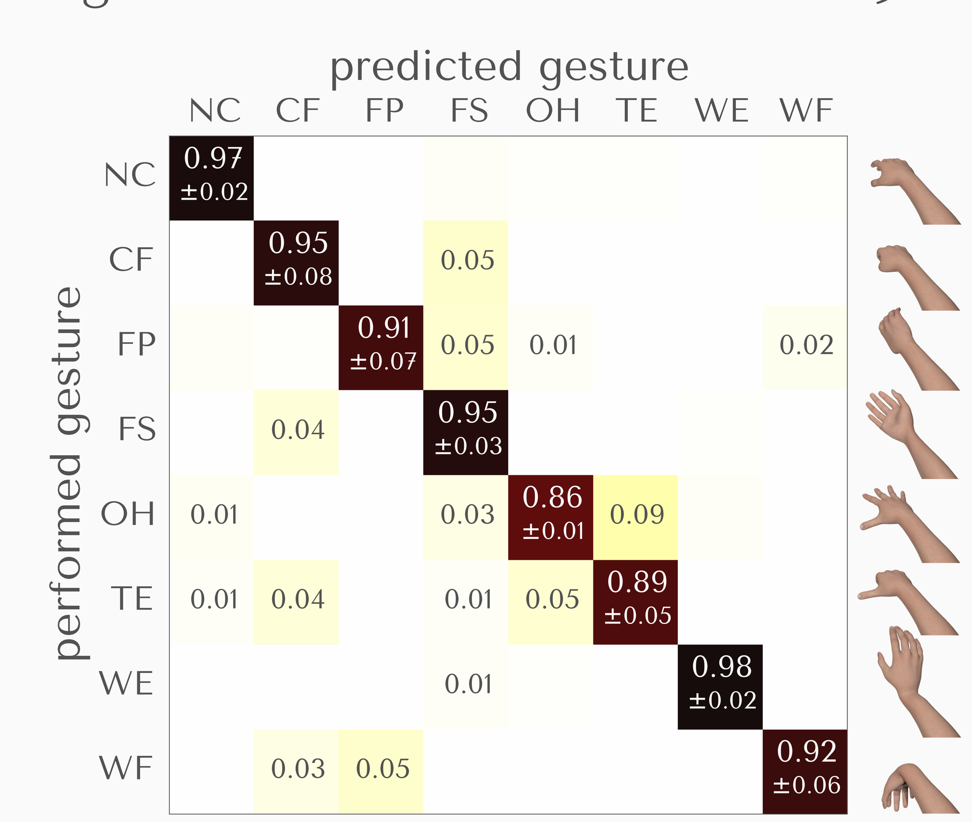
Part 2: Leg Configuration
Subjects performed the analogous leg gestures with EMG sensors on the lower leg while again viewing arm gesture image prompts.

Sensors were placed over six specific muscle sites according to the arm-leg mapping.

Results

The EMG recordings were processed offline using time domain features and linear discriminant analysis classification. While the results in the leg configuration are lower than in the configuration, all average classification accuracies exceed 90%.





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