Methodology

This data was collected under University of Michigan IRB HUM00124839, ClinicalTrials.gov Identifier: NCT03260400. Two persons with transradial amputations (P1 and P2) had eight pairs of bipolar recording electrodes implanted into regenerative peripheral nerve interfaces (RPNIs) and residual muscles. We recorded electromyography (EMG) calibration data for pattern recognition algorithms. During this process, each participant followed a cue hand and mimicked individual finger or grasp postures with their phantom hand. The posture of the cue hand is time synced with the raw EMG recordings in the attached data files. The implanted electrodes were manufactured by Synapse Biomedical and the neural signal processor that recorded electromyography was a Cerebus system from Blackrock Microsystems. P2 also has one dataset where surface EMG was recorded with gelled Biopac electrodes simultaneously with the implanted electrodes.

Description

The data was used to calibrate and simulate pattern recognition algorithms for the following publication: Surgically Implanted Electrodes Enable Real-Time Finger and Grasp Pattern Recognition for Prosthetic Hands (medRxiv 2020, IEEE TRO in review). Each data file is named as follows Px_PostureSet.csv. Where Px is the patient number. The 1 of 10 posture set contains individual finger and intrinsic thumb movements, the grasps posture set contains a fewer number of combined finger movements. P1's calibration data for individual fingers is labelled 1 of 12 because it also includes two grasps, which were removed for analysis in the publication. The first column of each .csv file is the experiment time in seconds. The second column is the posture of the cue hand at that timestamp. The rest of the columns are the raw EMG data in microvolts sampled at 30KSps.

Cue Legend

The second column of each .csv file is the posture of the displayed cue hand. P1 and P2 followed the cue hand with their phantom hand while EMG was recorded from their implanted and/or surface electrodes.

1. Rest
2. Thumb flexion (IP joint)
3. Index finger flexion
4. Middle finger flexion
5. Ring finger flexion
6. Small finger flexion
7. Fist
8. Pinch
9. Point
10. Finger Extension
11. Wrist Flexion
13. Hand Abduction (splay fingers open)
14. Hand Adduction (squeeze fingers together)
18. Thumb opposition (MCP joint)

Datasets

P1_1of12.csv

Column 1: time (s)

Column 2: cue hand (postures 1,2,3,4,5,6,7,8,11,13,14,18)

Columns 3-10: intramuscular channels (µV) – flexor digitorum profundus index finger section, flexor carpi radialis, RPNI Ulnar nerve, RPNI Median nerve, extensor digitorum communis, extensor pollicis longus, flexor digitorum profundus small finger section, flexor pollicis longus

P1_Grasps.csv

Column 1: time (s)

Column 2: cue hand (postures 1,6,7,8,10,11)

Columns 3-10: intramuscular channels (µV) – flexor digitorum profundus index finger section, flexor carpi radialis, RPNI Ulnar nerve, RPNI Median nerve, extensor digitorum communis, extensor pollicis longus, flexor digitorum profundus small finger section, flexor pollicis longus

P2_1of10.csv

Column 1: time (s)

Column 2: cue hand (postures 1,2,3,4,5,6,11,13,14,18)

Columns 3-10: intramuscular channels (µV) – extensor pollicis longus, extensor digitorum communis, flexor pollicis longus, flexor digitorum profundus index finger section, RPNI Median nerve, RPNI Ulnar nerve 1, RPNI Ulnar nerve 2, flexor carpi radialis

P2_Grasps.csv

Column 1: time (s)

Column 2: cue hand (postures 1,7,8,9,13)

Columns 3-10: intramuscular channels (µV) – extensor pollicis longus, extensor digitorum communis, flexor pollicis longus, flexor digitorum profundus index finger section, RPNI Median nerve, RPNI Ulnar nerve 1, RPNI Ulnar nerve 2, flexor carpi radialis

P2_1of10_SimultaneousSurface.csv

Column 1: time (s)

Column 2: cue hand (postures 1,2,3,4,5,6,11,13,14,18)

Columns 3-10: intramuscular channels (µV) – extensor pollicis longus, extensor digitorum communis, flexor pollicis longus, flexor digitorum profundus index finger section, RPNI Median nerve, RPNI Ulnar nerve 1, RPNI Ulnar nerve 2, flexor carpi radialis

Columns 11-18: surface channels (approximate muscles, see notes) - extensor pollicis longus, extensor digitorum communis, flexor pollicis longus, flexor digitorum profundus index finger section, distal forearm 1, distal forearm 2, flexor digitorum profundus small finger section, flexor carpi radialis.

Notes: placed surface channels by feeling contractions on P2's forearm with movements corresponding to the primary function of residual muscles listed above (picture of surface electrodes on next page). Distal forearm channel 1 did not record a strong signal.


BIOPAC

Recommended Signal Processing

See example Matlab scripts *process_100to500Hz.m* and *process_5to400Hz_wnotch.m*

For intramuscular channels: downsample from 30KSps to 1KSps. Notch filters for 60Hz line noise could be implemented but are not necessary. A bandpass filter can then be applied to isolate EMG activity for feature extraction. We recommend a 100-500Hz bandpass. Sample Matlab code (2021a):

```
emg = downsample(emg,30);
[b, a] = butter(2, 2*[100, 499]/1e3, 'bandpass');
emg = filter(b,a,emg);
```

For surface channels: Downsample from 30KSps to 1KSps. Implementing notch filters eliminates 60Hz line noise and its harmonics. A bandpass filter can then be applied to isolate EMG activity for feature extraction. The 100-500Hz bandpass can be applied, although a 5-400Hz bandpass is also common for surface EMG. Sample Matlab code (2021a):

```
emg = downsample(emg,30);
for k = 1:floor(500/60)
    wo = 2*k*60/1e3;  bw = wo/35;
    [b,a] = iirnotch(wo,bw);
    emg = filtfilt(b,a,emg);
end
[b, a] = butter(2, 2*[5, 400]/1e3, 'bandpass');
emg = filter(b,a,emg);
```