EMG Analysis of Upper Limb Kinematics

Anthony De Leo, Muhil Bharathy

Mentors: Dr. Mohammad Rahman, Dr. Inga Wang

Objectives

The goal of this study is to map Upper Limb (UL) Kinematics (position, velocity and acceleration) and physiological (EMG) measurements correlated with a variety of upper extremity movements that perform ADL. The purpose is to measure and interpret EMG signals that occur while performing activities of daily life (ADL) in order to determine a baseline for human's range of motion correlated to each movement. The results will be used to provide engineers, physicians and occupational therapists with a better understanding of how EMG signals correspond with Upper Limb movements.

Methodology

EMG data collection from the various movements was captured via the Delsys EMGWorks Acquisition program. The procedure is outlined below:

1. After wiping the skin free of dead skin and bacteria with disinfecting alcohol wipes, Delsys Avanti sensors were placed on the muscles of subject.
2. Use the plot and store function in EMGWorks Acquisition to perform data collection.
3. Instruct subject to execute movement, resting for three seconds in between cycles to ensure an accurate capture of the start and end of each movement.
4. EMG data is analyzed using EMGworks Analysis, then exported into MATLAB. Here, the data is transformed into biomechanical measurements.

Figure 1 : EMGWorks Acquisition & Analysis
- Used to record and analyze EMG measurements from each movement.

Figure 2: Delsys Trigno Avanti Sensors
- Used to capture electromyographic signals from skin surface.

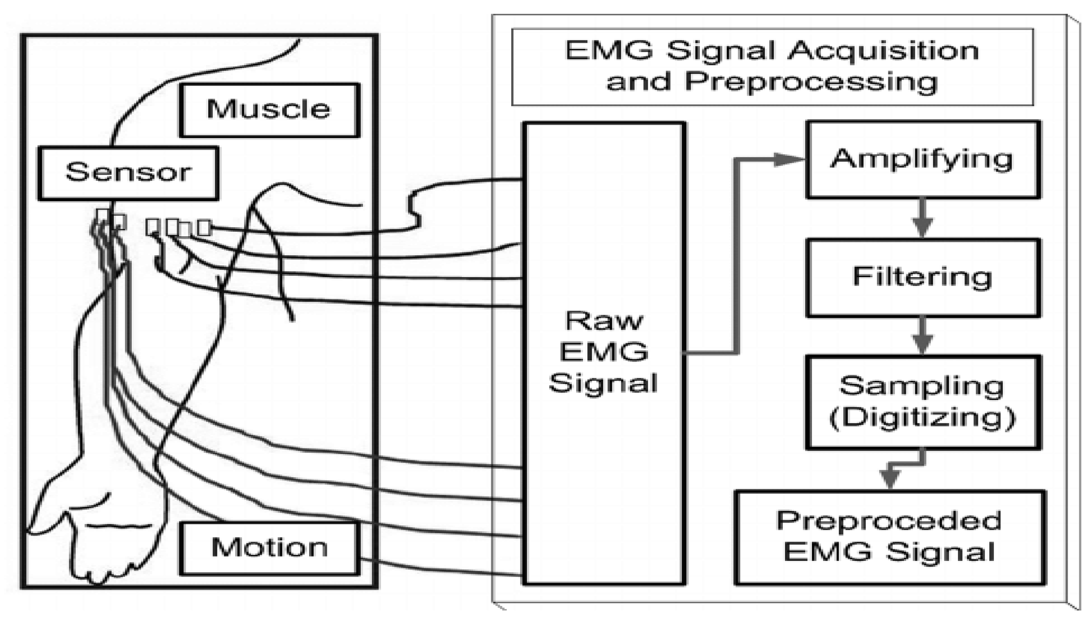

Figure 3: Schematic of EMG signal path.

A total of 8 movements were performed:
- Shoulder Vertical Flexion & Extension (SVF/SVE)
- Elbow Flexion & Extension (EF/EE)
- Wrist Ulnar & Radial Deviation (WUD/WRD)
- Shoulder Internal & External Rotation (SIR/SER)

Experimental Setup

Figure 4: Starting position.

Figure 5: Shoulder Vertical Flexion.

Figure 6: Resting position.

Figure 7: Shoulder Vertical Extension.

Experimental Results

The graphs below illustrate the successful mapping of EMG signals produced during Shoulder Vertical Flexion and Extension.

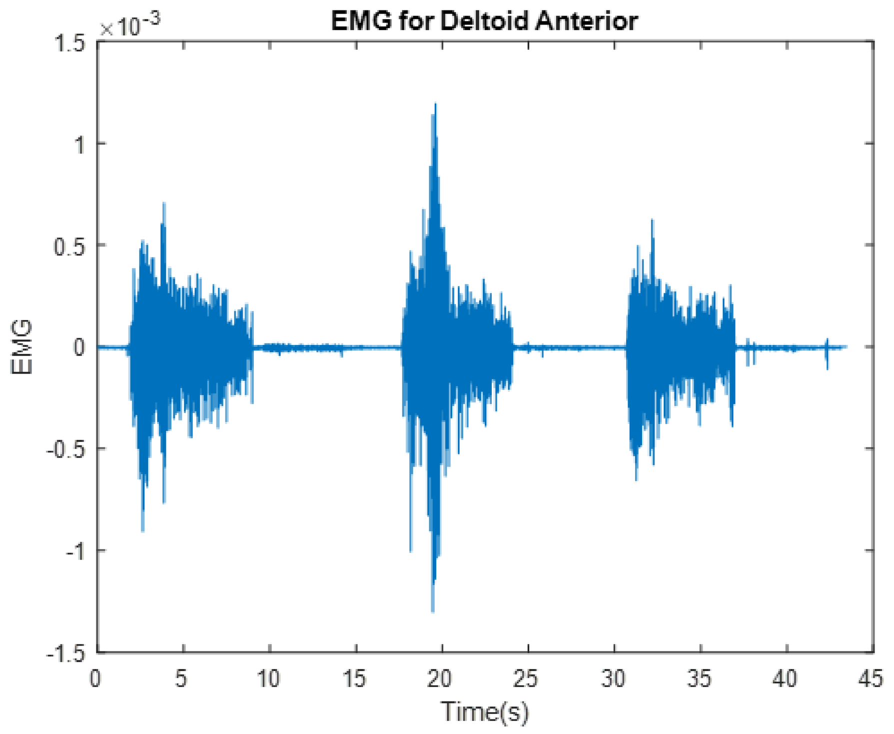

Figure 8: EMG data for Anterior Deltoid during SVF.

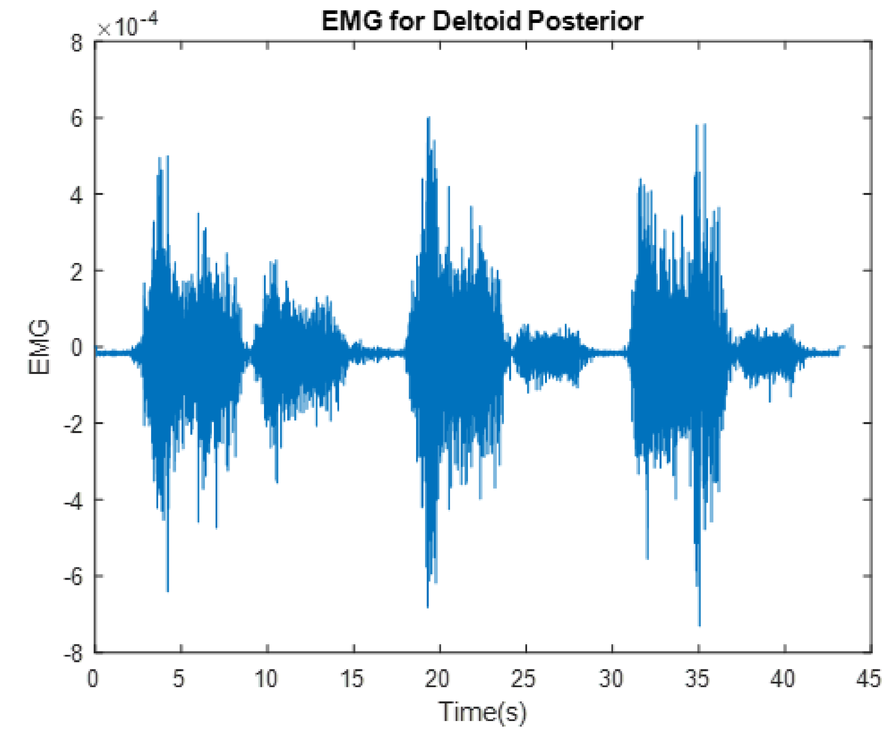

Figure 9: EMG data for Posterior Deltoid during SVE.

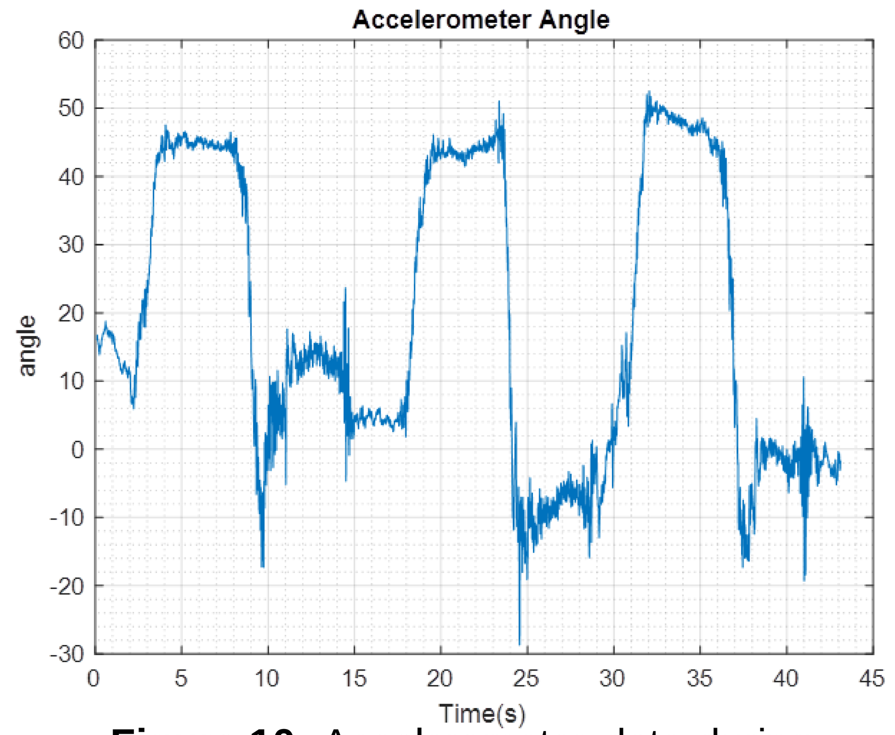

Figure 10: Accelerometer data during SVF/SVE.

Discussion

The goal of this research was to record EMG signals during various movements to determine the kinematics involved. To do so, agonist and antagonist muscles for each movement were used. Agonist and antagonist muscles are primarily responsible for the pulling motion needed to perform each movement. For Shoulder Vertical Flexion, the Anterior Deltoid acted as the agonist, moving the upper limb vertically above the head. The antagonist during Shoulder Vertical Extension is the Posterior Deltoid. During Shoulder Vertical Extension, the roles are switched: the Posterior Deltoid is the agonist and the Anterior Deltoid is the antagonist. Having this knowledge allows for the tracking of EMG data from each specific muscle. Initially, poor data was gathered as the previous procedure instructed subjects to complete 100% of the movement cycle (SVF/SVE in one motion). The data from the previous procedure did not illustrate the start and stop points of each cycle effectively. An adjustment was made, asking the subjects to pause for a brief three to five seconds before beginning the next movement. This insured proper and accurate recording of each movement, delineating the start and stop points.

Conclusions

An EMG documents the movement of muscles, which is contingent upon the burst of electrical activity generated as they contract. This electrical activity circulates between adjacent tissues and bones, prior to registering at each sensor. The EMG activity is linearly correlated to the amplitude of the muscle contraction. The kinematic data collected represents the muscle contractions of agonist and antagonist muscles involved in each movement.

Bibliography

Rahman, Mohammad, et al. "A Comprehensive Study on EMG Feature Extraction and Classifiers." *A Comprehensive Study on EMG Feature Extraction and Classifiers*, 2017.

Valevicius, Aida M, et al. "Characterization of Normative Angular Joint Kinematics during Two Functional Upper Limb Tasks." *Characterization of Normative Angular Joint Kinematics during Two Functional Upper Limb*, 2019.

Contact Information

Anthony De Leo: adeleo@uwm.edu
Muhil Bharathy: muhil@uwm.edu
Dr. Mohammad Rahman: rahmanmh@uwm.edu
Dr. Inga Wang: wang52@uwm.edu