

Experiment protocol for test subjects

Title of the project

Using confidence levels of movement recognition in user training to improve prosthesis control

Details on investigators

All investigators are 2nd semester biomedical engineering master students at Aalborg University.

Purpose

The purpose of this experiment is to train the subject in getting better at controlling a functional prosthesis. The subject will be training seven hand movements that is used in activating the prosthesis. In the experiment the prosthesis will be represented on a computer screen, where the subject will receive visual feedback on how the prosthesis interpret the hand movement performed by the subject. By receiving this visual feedback it is hypothesized that the user will get better at controlling the prosthesis over time.

Background

Electromyography (EMG), or muscle signals, is widely used for controlling functional lower arm prosthetics for transradial amputees. The ideal purpose of a functional prosthesis is to behave as functional as possible compared to a biological arm. Functional prosthetics that rely on pattern recognition-based control are becoming exceedingly good in performance in a clinical environment, due to highly optimized system control. However, still only one commercially available pattern recognition-based prosthesis exist. Users reject these functional prosthetics usually due to functionality issues when utilizing them in daily life tasks outside the clinical environment. Many improvements have been made in the area of system control, but another approach of improving the prosthetic control is by training the user. User training has only been explored scarcely in the research literature, thus, new techniques to improve the user's ability to control a prosthesis are yet untouched. This experiment will focus on training the user to improve prosthetic control on a fixed pattern recognition-based control system. The novel approach in this study is to provide the user with information on how well the system recognizes the performed movement during user training.

Research hypothesis

Exposing subjects to user training, in which confidence levels of movement recognition is used as feedback, will show statistically significant improvement in performance in a classification-based myoelectric prosthetic control scheme, when compared to subjects who have not had the same feedback during user training.

Session time

The experiment consist of three sessions, which are spread over three consecutive days; one session per day. Each session is estimated to have a total duration of 30-60 minutes.

Inclusion criteria

The subject needs to be:

- able bodied.
- above 18 years old.
- able to read, understand and speak Danish and/or English.
- assessed by the investigators to understand and perform the instructions given during the experiment.

Exclusion criteria

The subject must not have:

- diseases that might influence subject performance.

Experiment procedure

The experiment consists of three sessions containing different procedures as illustrated on figure 1. The concept and chronology of each procedure is described below the illustration. During the experiment it is important that the subject is placed sitting on a chair, with the arm wearing the Myo armband (MYB) hanging relaxed down by the side of the body, as shown in figure 6 on page 7 illustrating the experiment setup.

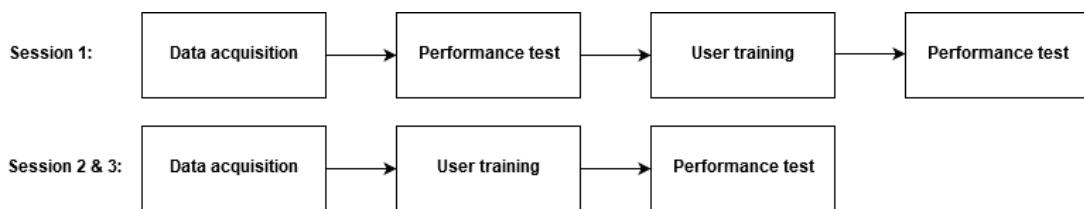


Figure 1: Pipeline for the three sessions in the experiment and what procedures each session contains.

Data acquisition

For the myoelectric control system to be able to identify a performed movement as the movement that is actually performed, it needs information about how the movement looks when represented as a EMG signal. Thus, EMG data needs to be acquired from the forearm of the subject while the subject performs the movements that is used in the experiment, see figure 5 on page 6. This data is fed to the control system to train the system to recognize each movement. In this experiment EMG data will be acquired from the subject with an EMG-electrode armband: MYB from Thalmic Labs. The chronology of this procedure is as follows:

1. Apply MYB on dominant forearm at the thickest part.
2. Synchronize MYB by performing wrist extension until three distinct vibrations are felt from the MYB.
3. Perform 15 seconds of maximum voluntary contraction (MVC) of instructed movement. The MVC is a contraction the subject is able to withhold in a constant intensity for the 15 seconds. Following the MVC the subject will be given a 30 seconds resting period to avoid muscle fatigue.
4. Perform three 15 seconds contraction trials of respectively 40%, 50% and 60% of MVC. During these contractions the subject will control a green marker representing the EMG signal and try to follow a trapezoidal trajectory as precise as possible. The trapezoidal trajectory consists of two 2.5 second transition phases and one 5 second plateau phase. Between each trial the subject will be given a 10 seconds resting period to avoid muscle fatigue.
5. Repeat step 3-4 until training data from all four wrist movements has been recorded.

An illustration of the interface used for data acquisition is shown in figure 2.

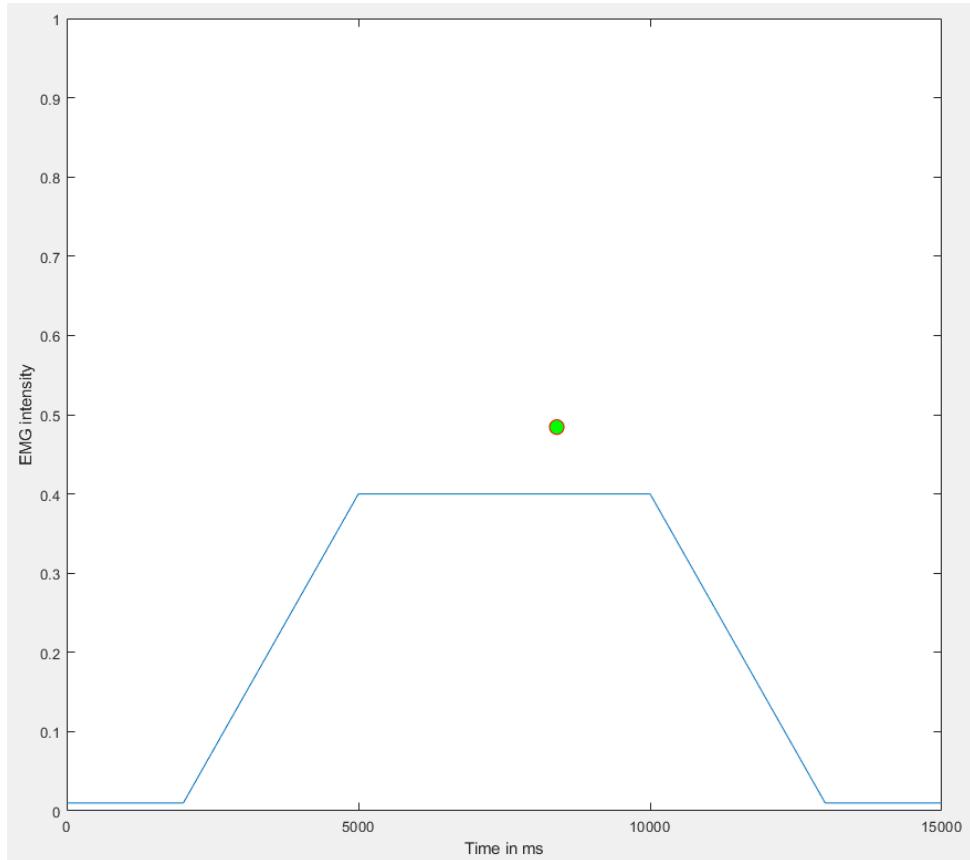


Figure 2: Illustration of the data acquisition interface showing the trapezoidal trajectory and the green marker representing the EMG signal.

User Training

The purpose of user training is for the subject to train the movements used in the performance test. During the user training the subject will train one movement at a time at different contraction levels. When training a movement, visual feedback in form of which movement the control system recognizes, is shown in a bar plot. In addition, the level of contraction is shown in a horizontal bar above the other bar plot. When performing the instructed movement at the instructed level of contraction the horizontal bar plot will appear green; if it is outside the instructed level or the control system does not recognize the performed movement, it appears red. The aim for the subject is to reach and withhold the instructed contraction level for the instructed movement while the control system recognizes it. When the subject withdraws the contraction level inside the instructed contraction level for 1 seconds while the control system recognizes it the colour of the horizontal bar will appear blue. This indicates that the subject is performing well. After it has appeared blue, the subject must return to rest and perform the movement again and try to reach the instructed contraction level while the recognition of the control system matches the performed movement. An additional aim for the subject is to make the horizontal bar plot appear blue as many times as possible. The chronology of this procedure is as follows:

1. Perform instructed movement at 75-85 % contraction level for 30 seconds followed by 10 seconds rest.
2. Perform step 1 for the remaining movements.
3. Repeat step 1-2 at 55-65 % contraction level.

4. Repeat step 1-6 at 35-45 % contraction level.
5. Repeat step 1-6 at 15-25 % contraction level.

An illustration of the interface used for user training is shown in figure 3.

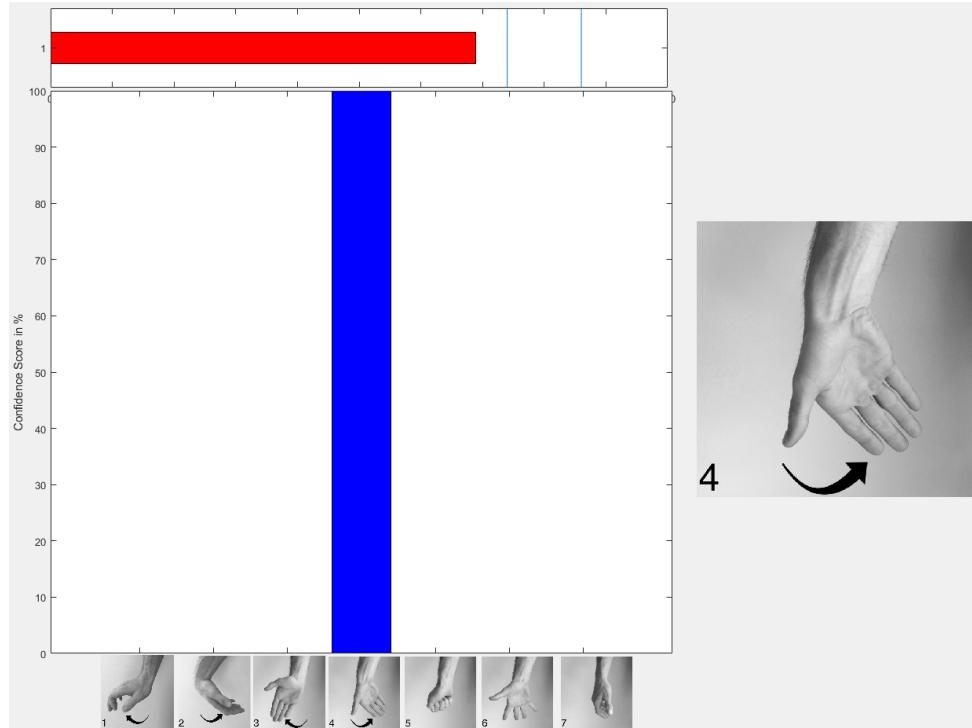


Figure 3: Illustration of the user training interface showing the bar plot indicating which movement is being recognized and the horizontal bar plot indicating contraction level. The picture on the right side of the bar plot indicates which movement needs to be performed.

Performance test

The purpose of the performance test is to assess the subject's ability to control a prosthesis. Instead of doing a test with a real prosthesis a virtual alternative has been developed for this experiment. The prosthesis is represented as a red circular cursor with a black dot inside in a Cartesian coordinate system, which the subject can move as well as expand and shrink in size by performing the trained movements. The following bullets describe which movement corresponds to which action in the coordinate system:

- Extension moves the cursor right.
- Flexion moves the cursor left.
- Radial deviation moves the cursor up.
- Ulnar deviation moves the cursor down.
- Closed hand shrinks the cursor.
- Opened hand expands the cursor.
- Rest keeps the cursor still.

The performance test consists of a target reaching test, where the subject must reach 16 targets of different sizes and locations. A target consists of a circle with a smaller circle inside. Only one target will be visible at a time. For the subject to reach a target and make it appear, the subject must center the black dot of the cursor in the small circle of the target and expand/shrink the cursor to fit the size of the outer circle of the target. The cursor will appear green, when located at the correct position. The subject must dwell the cursor in a target for 1 seconds. When the cursor has dwelled for 1 second, it will appear blue for 1 second to indicate that the target has been reached. If a target is not reached within 15 seconds a new target will appear. When a new target appears the cursor will reset its position the origin. The aim for the subject is to reach as many target as possible as quickly as possible. The subject is only able to perform one movement at a time, as trained in the user training. Thus, no simultaneously performed movements will be recognized by the control system. The chronology of this procedure is as follows:

1. Use 2 minutes to get acquainted with the test.
2. Reach the visible target.

An illustration of the interface used for the performance test is shown in figure 4.

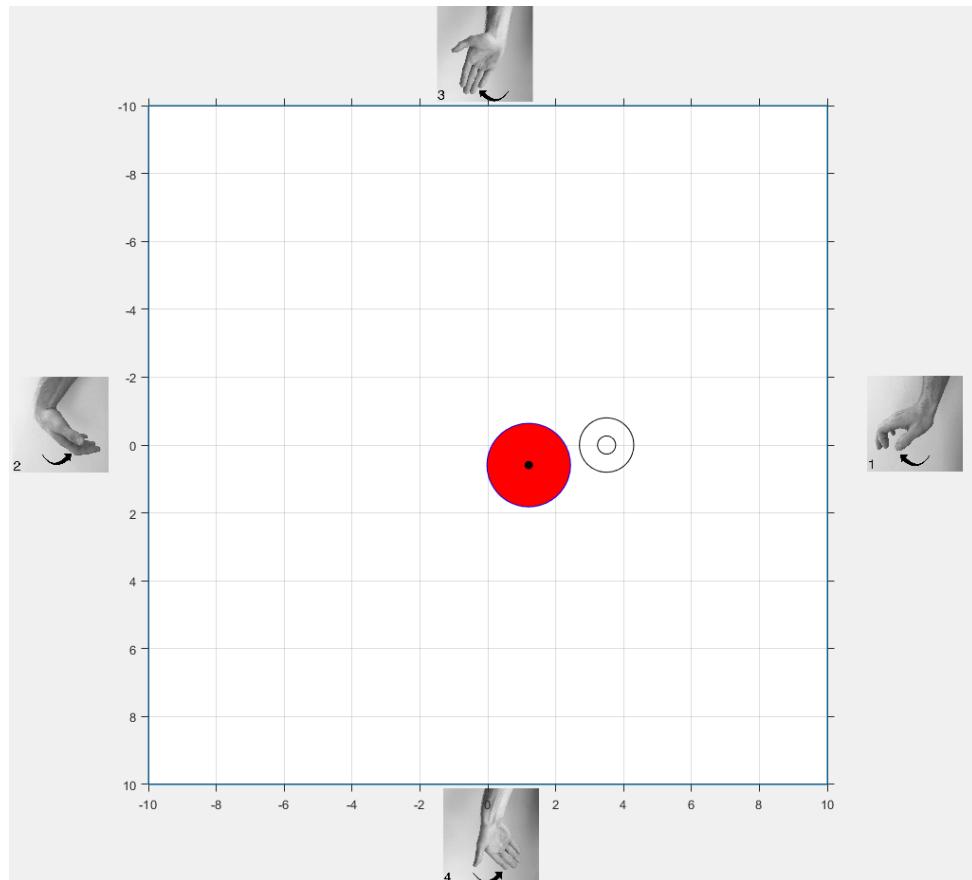


Figure 4: Illustration of the performance test interface showing a target and the cursor representing the prosthesis output. The pictures on the axes indicate which movement must be performed to move the cursor in a certain direction.

Movements used in the experiment

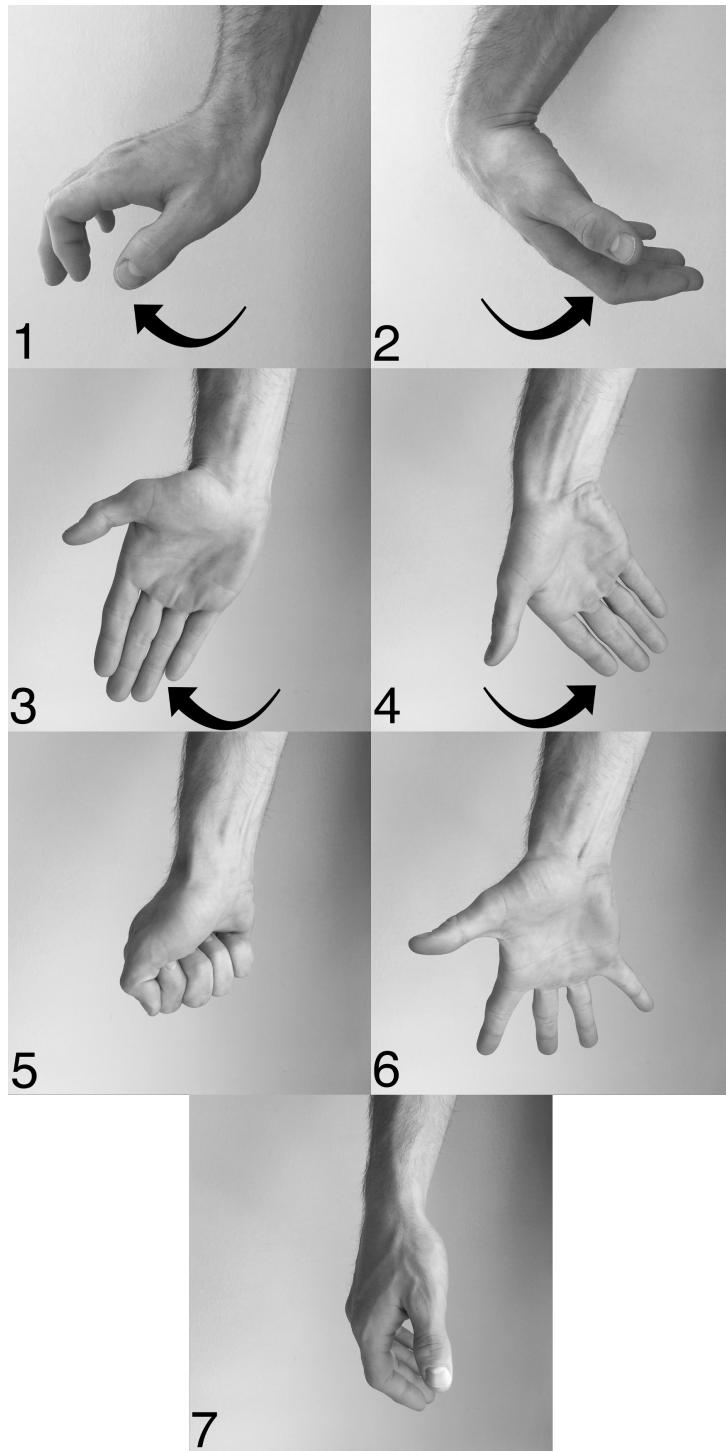


Figure 5: Illustration of the movements used in the experiment. 1: extension, 2: flexion, 3: radial deviation, 4: ulnar deviation, 5: closed hand, 6: opened hand and 7: rest.

Experiment setup

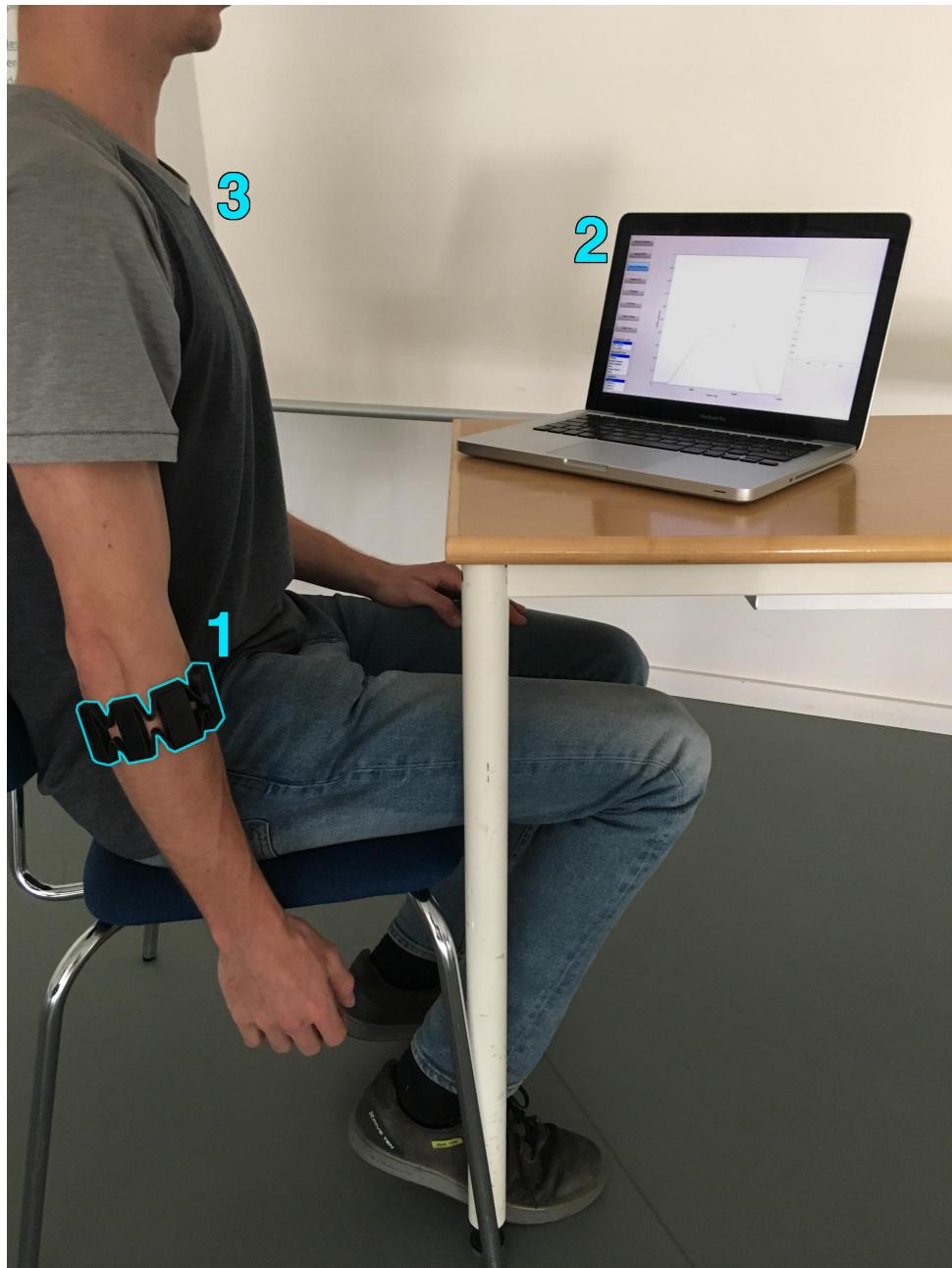


Figure 6: Illustration of the experimental setup; 1: MYB, 2: computer with interface and 3: subject. The subject is seated facing the computer screen with the arm wearing the MYB hanging relaxed down the side of the torso.