Performance test of linear regressors using inertial information combined with sEMG to minimize the limb position effect in proportional and simultaneous control of lower arm prosthetics.

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Aim

The aim for this project are expressed in the following two hypotheses:

- Simultaneous and proportional control of two DOF's of the wrist in different limb positions, can be achieve trough the use of linear regression as control system.
- Combining ssurface EMG and IMU's can minimize the limb position effect when using regression as control system.

Materials & Methods

Surface EMG data was collected from four able-bodied subjects. Subjects were instructed to performed four different hand gestures. This study only focus on two DOF, which are, flexion and extension, radial and ulnar deviation of the wrist. sEMG signals were recorded with Myo armband, positioned on the right forearm of the subjects while standing.
The sEMG was recorded by eight channels in a frequency range 0-200Hz. IMU data was recorded using the buildt in accelerometer in the Myo armband. sEMG data were filtered through a second-order Butterworth high-pass filter, with cutoff frequency f_c=10Hz.
Features are extracted using a sliding-window of 40 samples with an overlapping of the 50%. Two time domain features are extracted; Mean absolute value (MAV) and logarithmic variance. MAV represent the amplitud of the signal. It is defined as the average of the absolute values of the sEMG signal:

$$MAV = \frac{1}{N}\sum_{i=1}^{N}|x_i| \qquad (1)$$

where N is the length of the signal, and x_i is the signal of i samples. The logarithmic variance is a nonlinear transformation of the variance applied to

$$log(\sigma^2) = log(\frac{\sum_{i=1}^{N}(x_i-\mu)^2}{N}) \qquad (2)$$

where N is the length of the signal, x_i is the i^th sample of the signal and μ is the mean. PCA is applied to qualitatively determine the separability of the feature data. Data is evaluated for differncies in feature data clusters and significant outliers. If the feature clusters are distinguishable from each other and have no significant outliers, the data is of high quality and will be used to train the regressors. Only the first three principal components identified through PCA will be used to train the regressors. The regressors are implemented through simple linear regression:

$$Y = \alpha + \beta X + \epsilon \qquad (3)$$

where Y is the dependent variable or response, X is the independent variable or the predictor, β is the regression coefficient or the slope, and α is the Y intercept (predicted value of Y at $X = 0$), ϵ is the error. The regressor accuracy of control is tested qualitatively through superimposition of the output of the regressors build for each feature onto the actual data for the intensities of the movements. The regressor accuracy is quantitatively tested through a target reaching task measuring time to reach 16 targets. The scores are compared through stastistical t-test, comparing scores between limb positions and between only using sEMG data and including IMU data.

All data processing is performed in Matlab (2017).

Introduction

The development of EMG controlled prosthetics have advanced greatly in recent years. More complex prosthetics are demanded and more advanced control mothods has been developed. Most control methods so far has utilized pattern recognition which only enables control of one degree of freedom at a time. Most studies have conducted tests in only one limb position, not considering the limb position effect on EMG signals. [1] This study aims to overcome the limb position effect by combining EMG with inertial information in the training sessions of the regressor to obtain simultaneous and proportional control of EMG prosthesis.

Results 2

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Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 1: Table caption

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Treatments	Response 1	Response 2
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Table 2: Table caption

Results 1

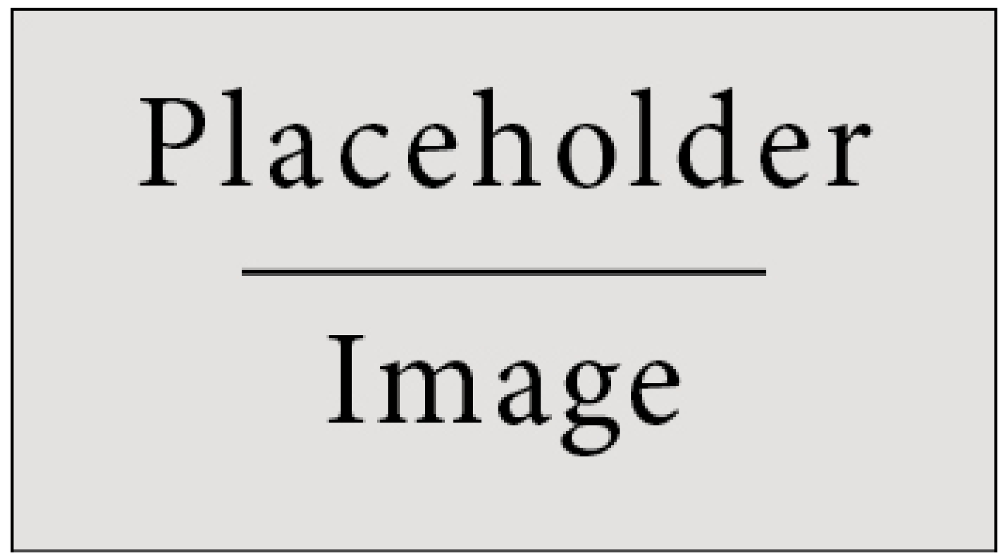

Figure 1: Figure caption

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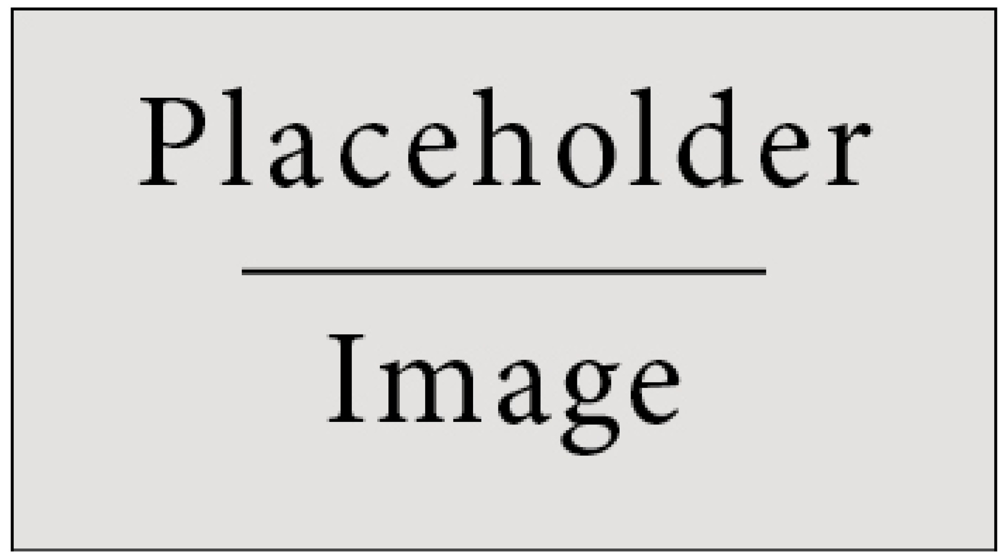
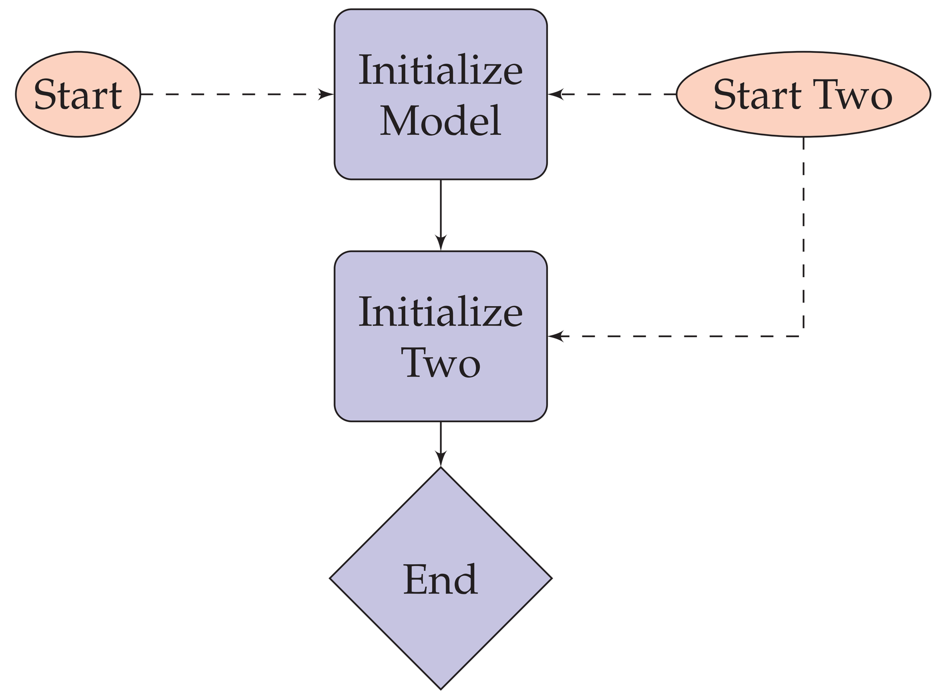


Figure 2: Figure caption

Conclusion



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References

[1] Anders Fougner, Erik Scheme, Adrian D.C. Chan, Kevin Englehart, and Øyvind Stavdahl. Resolving the limb position effect in myoelectric pattern recognition. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 19, 2011.

[2] J. M. Smith and A. B. Jones. *Book Title*. Publisher, 7th edition, 2012.

[3] A. B. Jones and J. M. Smith. Article Title. *Journal title*, 13(52):123–456, March 2013.

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