Group 7404

THE EFFECT OF LIMB POSITION ON MYOELECTRIC PROSTHETIC CONTROL USING LINEAR REGRESSION

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Introduction

Electromyography (EMG) is widely used for controlling functional prosthetics. However, EMG signals for the same movements change with variations in limb position and lowers the accuracy in control schemes [1]. Most previous studies have utilized classification for pattern recognition when changing limb position, with a negative effect in performance. Linear regression is a newer method in control of myoelectric prosthetics, which has proven to yield robust simultaneous and proportional control [2]. Only the RMS feature was previously tested in variations of limb positions in regression-based control [3]. This study investigated the effect of limb position in a linear regression-based control scheme, when using the commonly used Mean Absolute Value (MAV) and Logarithmic Variance (LogVar) feature, where the latter has shown linear properties [2].

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. Filtering were done through a second-order Butterworth high-pass filter (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 (LogVar). MAV represent the amplitud of the signal. It is defined as the average of the absolute values of the sEMG signal:

$$MAV = \frac{1}{N}\sum_{i=1}^{N}|x_i| \tag{1}$$

where N is the length of the signal, and x_i is the signal of i samples. LogVar is a nonlinear transformation of the variance

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

where N is the length of the signal, x_i is the i^th sample of the signal and μ is the mean. The regressors are implemented through simple linear regression:

$$Y = \alpha + \beta X + \epsilon \tag{3}$$

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 performance (time per reached target) of the online test was compared between the different limb positions of the same feature and between all limb positions of the two features through statistical analysis.

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.

Offline Results

Results of the superimposition of the regressor outputs on the estimated data.

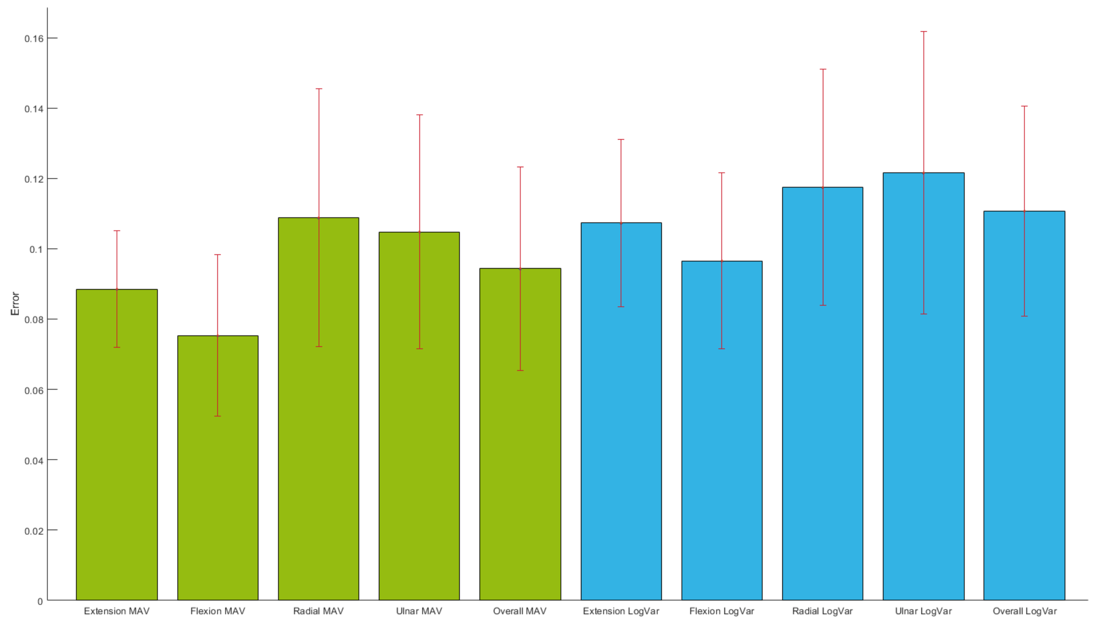

Figure 3: DATA

The results for the offline test of accuracy of the regressors of both test and training data. This test determines if the training of the regressors have over- or under-fitted to the training data.

Feature	Overall mean error	Highest mean error
MAV	0.0943 ±0.0290	0.1088 ±0.0366
Log-Var	0.1107 ±0.0298	0.1216 ±0.0402

Table 1: RMSE of training data

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Feature	Overall mean error	Highest mean error
MAV	??? ±???	??? ±???
Log-Var	??? ±???	??? ±???

Table 2: RMSE of test data

Online Results

Results for the online test of regressor accuracy and control. The test is performed in a modified Fitts' Law test of reaching targets. The score is calculated as the relation between time and number of targets reached.

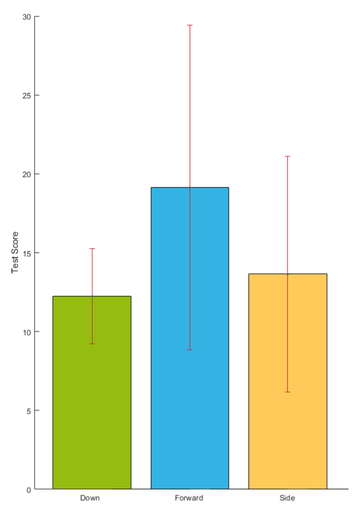

Figure 1: The mean test score among four subjects when using regressors trained with Log-Var excluding IMU information

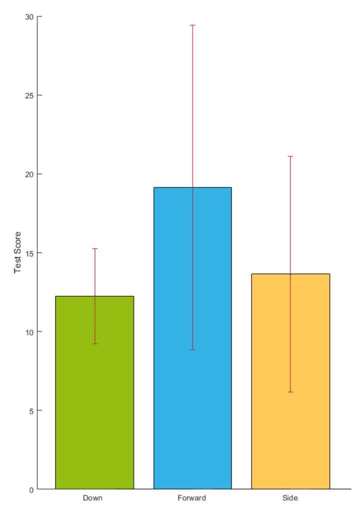

Figure 2: The mean test score among four subjects when using regressors trained with Log-Var excluding IMU information

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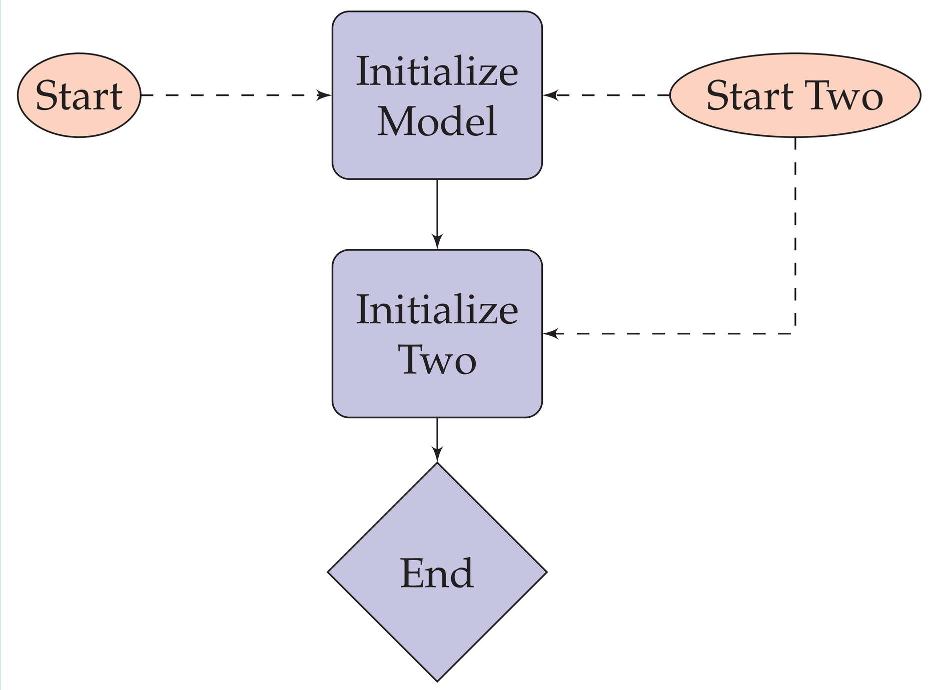
Conclusion



- Pellentesque eget orci eros. Fusce ultricies, tellus et pellentesque fringilla, ante massa luctus libero, quis tristique purus urna nec nibh. Phasellus fermentum rutrum elementum. Nam quis justo lectus.
- Vestibulum sem ante, hendrerit a gravida ac, blandit quis magna.
- Donec sem metus, facilisis at condimentum eget, vehicula ut massa. Morbi consequat, diam sed convallis tincidunt, arcu nunc.
- Nunc at convallis urna. isus ante. Pellentesque condimentum dui. Etiam sagittis purus non tellus tempor volutpat. Donec et dui non massa tristique adipiscing.

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. Hahne, F. Biebmann, Ning Jiang, Hubertus Rehbaum, Dario Farina, F. C. Meinecke, K.-R Muller, and L. C. Parra. Linear and Nonlinear Regression Techniques for Simultaneous and Proportional Myoelectric Control. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 22(2), 2014.

[3] Han Jeong Hwang, Janne Mathias Hahne, and Klaus Robert Müller. Real-time robustness evaluation of regression based myoelectric control against arm position change and donning/doffing. *PLoS ONE*, 12(11):1–22, 2017.

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