Cognitive Algorithms Assignment 4

Electromyographic Decoding of Hand-Position

Due on Wednesday, December 11, 2013 ,10 am via ISIS

In the lecture, you learned about linear regression. In this assignment you will implement a linear regression and predict two dimensional hand positions from electromyographic (EMG) recordings obtained with high-density electrode arrays on the lower arm.
Download the python template `assignment4.py`, and the data set `myo_data.mat` from the ISIS web site.

1. (**18 points**) Implement ordinary least squares regression (OLS) by completing the function stubs `ols_train` and `ols_apply`. In `ols_train`, you estimate a linear mapping W,

$$W = (X_{\text{train}} X_{\text{train}}^\top)^{-1} X_{\text{train}} Y_{\text{train}}^\top$$

that optimally predicts the training labels from the training data. The function `ols_apply` than uses the weight vector to predict the (unknown) hand positions of new test data X_{test}

$$Y_{\text{test}} = W^\top X_{\text{test}}.$$

The function `test_assignment4` helps you to debug your code.

2. (**3 points**) Suppose we have N_{tr} training data points, N_{te} test data points, and each data points has D_X dimensions. The goal is to predict D_Y labels for each data point. That is, the dimensionality of the data matrices is given by

$$X_{\text{train}} \in \mathbb{R}^{D_X \times N_{tr}}, Y_{\text{train}} \in \mathbb{R}^{D_Y \times N_{tr}}, X_{\text{test}} \in \mathbb{R}^{D_X \times N_{te}}.$$

What is the dimensionality of $(X_{\text{train}} X_{\text{train}}^\top)$? What is the dimensionality of W? What is the dimensionality of Y_{test}?

3. (**3 points**) The data set `myo_data.mat` consists of preprocessed EMG data X and 2-dimensional stimulus labels Y. Labels are x/y positions of the hand during different hand movements. The function `load_myo_data` loads the data and splits it into train and test data. Familiarize yourself with the data by answering the following questions:
How many time points N_{tr} does the train set contain? How many time points N_{te} does the test set contain? At each time point, at how many electrodes D_X was the EMG collected?

4. (**2 points**) Predict two dimensional hand positions by calling the function `predict_handpositions`. It plots, for the train and the test data, the true hand position versus the estimated hand position, as in Figure 1. Do you notice a performance difference between train and test data set?

5. (**2 points**) In question 4, we have used the logarithmized muscle activiations to predict the hand positions. Uncomment the line where we logarithmize the EMG features in the function `load_myo_data` and call `predict_handpositions` again. Do you notice a performance difference compared to the logarithmized version?

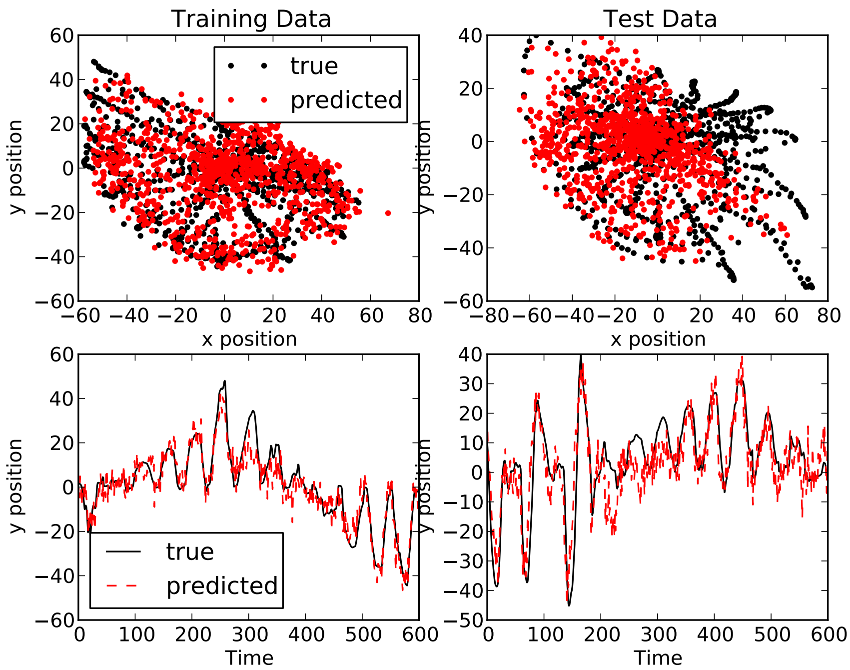

Figure 1: True versus predicted hand positions. *Upper Row*: Predicted hand position as x/y coordinates for the training and the test data set. *Lower row*: Time series of y-coordinates for the training and the test data set.

6. **(2 points)** If we cannot predict the labels Y perfectly by a linear regression on X, does this imply that the relationship between X and Y is non-linear?

Please hand in your completed `assignment4.py` via ISIS. Please write your name and your Matrikel Number as the first line of the code. Also hand in a pdf file that contains your name, the answers to the questions and the plot generated in Question 4 and 5, as well as your code of the functions `ols_train` and `ols_apply`.