Grasp-and-Lift EEG Detection

By Shallow Learning
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Introduction and Goal of the Project

Background:

Our group was mainly interested in different classifiers accuracy in predicting events on already collected data. We wanted to see how well different algorithms worked in achieving the same results.

Goal:

Classify grasp and lift trials based on EEG data containing six predefined events using different methods to see which is the most accurate.

Speaker: Shae

Motivation

- Give insight on which signals are most useful for detecting control on manipulation tasks

- Being able to analyze grasp and lift detection accurately can help improve prosthetic limbs

Matthew D Luciw, Ewa Jarocka & Benoni B Edin Paper Link

Speaker: Shae

Related Work

Bradberry, T. J., Gentili, R. J. & Contreras-Vidal, J. L. Reconstructing three-dimensional hand movements from noninvasive electroencephalographic signals. J. Neurosci. 30, 3432–3437 (2010).

Antelis, J. M., Montesano, L., Ramos-Murguialday, A., Birbaumer, N. & Minguez, J. On the usage of linear regression models to reconstruct limb kinematics from low frequency EEG signals. PLoS ONE 8, e61976 (2013).

Speaker: Shae

Our Data

Our dataset comes from Kaggle.

It was used in a competition 5 years ago.

https://www.kaggle.com/c/grasp-and-lift-eeg-detection/data

Grasp-and-Lift EEG Detection

Identify hand motions from EEG recordings

$10,000 · 379 teams · 5 years ago

Speaker: Shae

More on Our Data

- The data contains EEG recordings of subjects performing grasp-and-lift (GAL) trials.
- There are 12 subjects in total, 10 series of trials for each subject, and approximately 30 trials within each series.
- Subjects have a *_data.csv file which contains raw 32 channel EEG data sampled at 500Hz and an *_events.csv which contains either 0 or 1 for if that event has occurred at that time

A detailed account of the data can be found in

`Luciw MD, Jarocka E, Edin BB (2014) Multi-channel EEG recordings during 3,936 grasp and lift trials with varying weight and friction.` *Scientific Data* `1:140047. www.nature.com/articles/sdata201447`

Speaker: Shae

Collection of Data

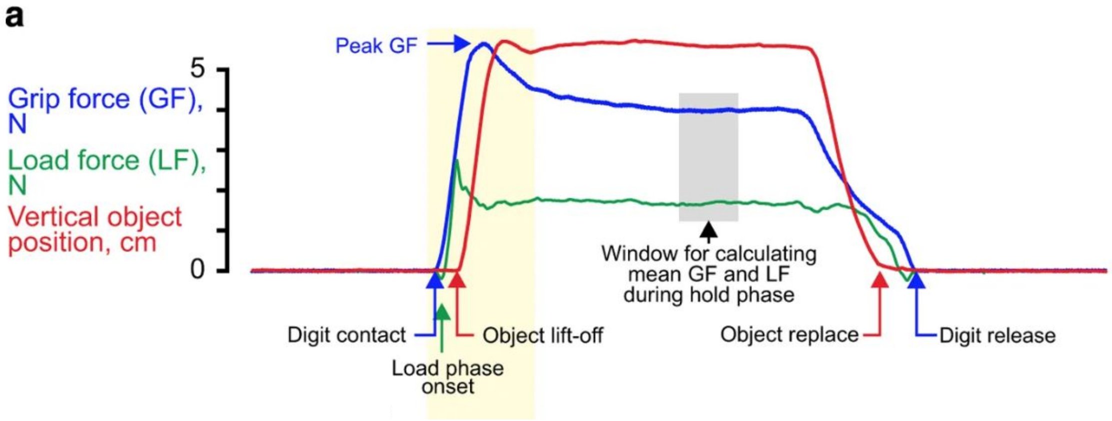
From “Multi-channel EEG recordings during 3,936 grasp and lift trials with varying weight and friction” Paper:

- Subjects lifted objects with the weight and surface friction being changed randomly each trial to encourage different force coordination in the fingertips
- Each subject had to: 1) reach for the object, 2) make contact with object 3) grab it with their thumb and index finger, 4) lift it, 5) replace back on the surface, 6) release it
- Recorded: 32 EEG channels, EMG (five arm and hand muscles), 3D position of hand and object, force/torque at contact plates
- Each trial has 16 event times (like ‘lift-off’) and 18 measures to characterise the behaviour (like ‘peak grip force’)

Speaker: Shae

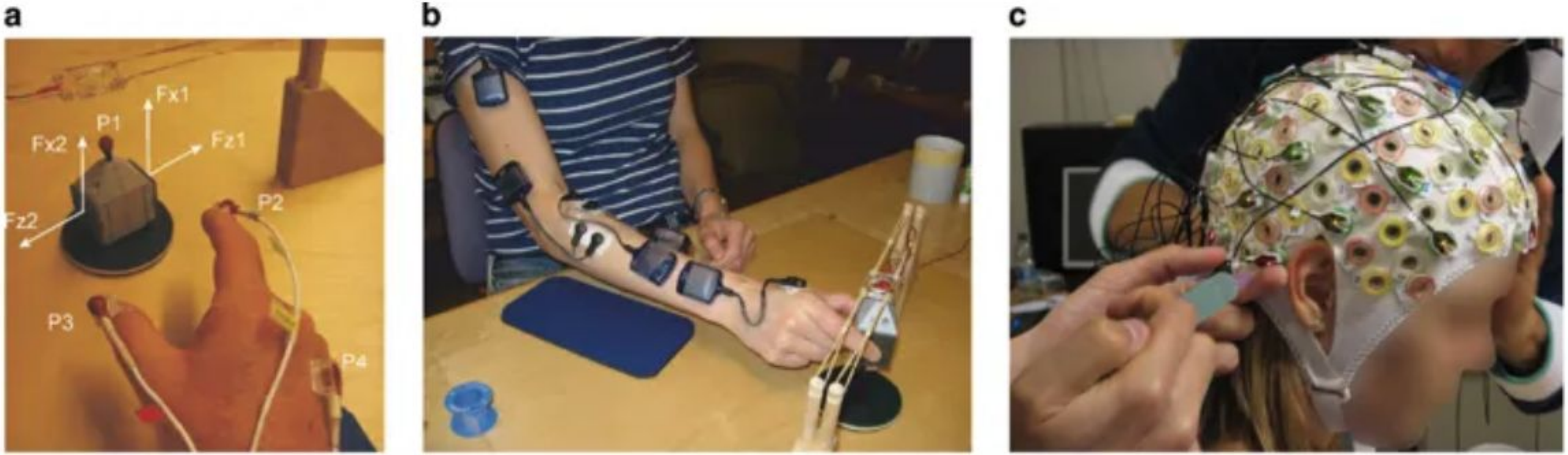
We will be detecting 6 different events

1. HandStart
2. FirstDigitTouch
3. BothStartLoadPhase
4. LiftOff
5. Replace
6. BothReleased



Speaker: Shae

Figure 1: *Methods.*



Speaker: Shae

Data Processing

The following was done to the data by the data collectors:

- Raw data from SC/ZOOM and BCI2000 was imported to MATLAB
- Removed unneeded or extra samples at the beginning and end of each series
- The only pre-processing done to the data was to remove the mean from the EMG signals
- No artifact rejection (blinking, eye movements, etc) was applied to the EEG signals

We split the data into train and test groups. Our train groups were series 1-6 for each of the 12 subjects. Our test data was the 7th and 8th series.

Speaker: Mina

Steps

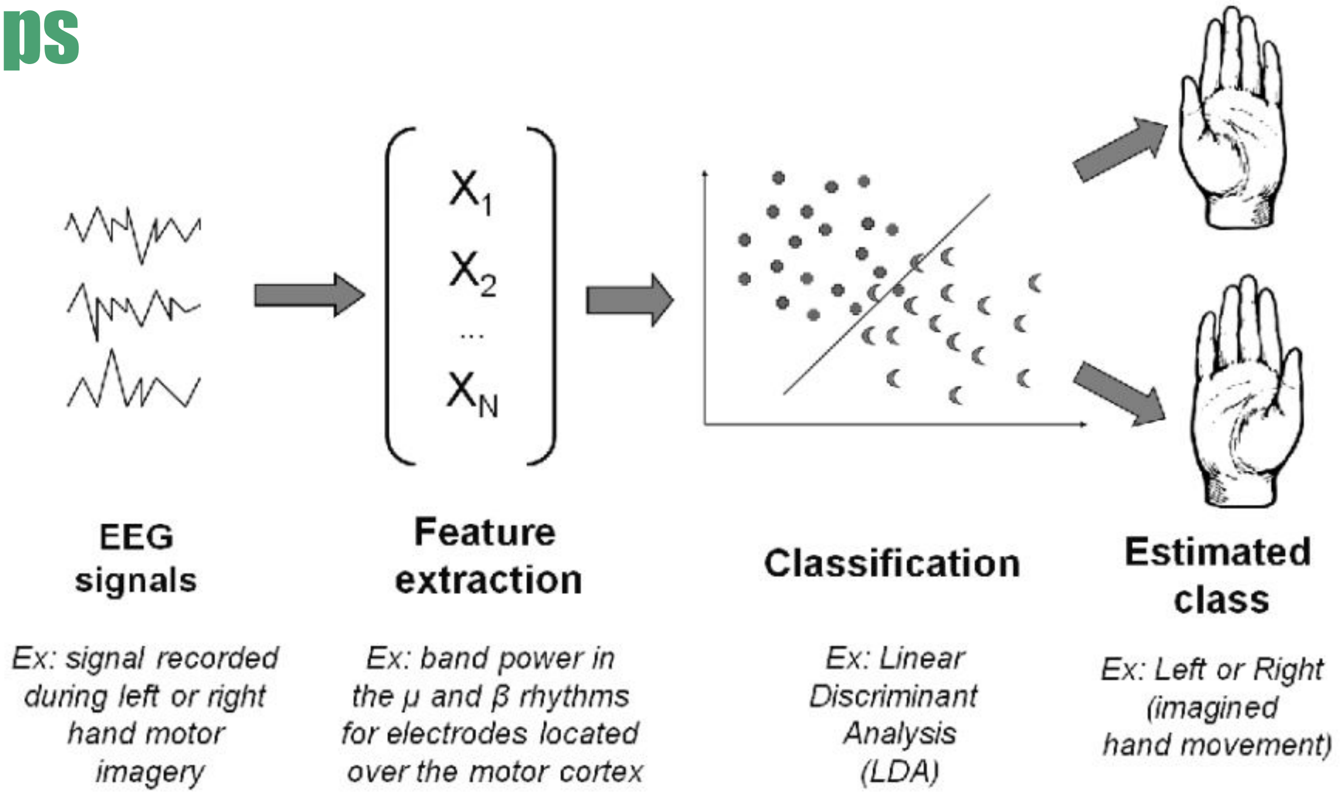


Image from EEG Signal Processing for BCI Paper

Speaker: Mina

Classifiers

1. **Logistic Regression**
2. **Linear SVM**
3. **K-nearest neighbors**
4. **AdaBoost**
5. **Linear discriminant analysis**
6. **Decision Tree**

To test the performance of our classifier we used ROC AUC (Area Under the Receiver Operating Characteristic Curve) from prediction scores.

Speaker: Mina

Task

Predict the probability of one of these events occurring over the time samples

We use the average area under ROC curve over each of the events

AUC-ROC curve: (Area Under Curve, Receiver Operating Characteristics)

- ROC → probability curve
- AUC → degree of separability between classes

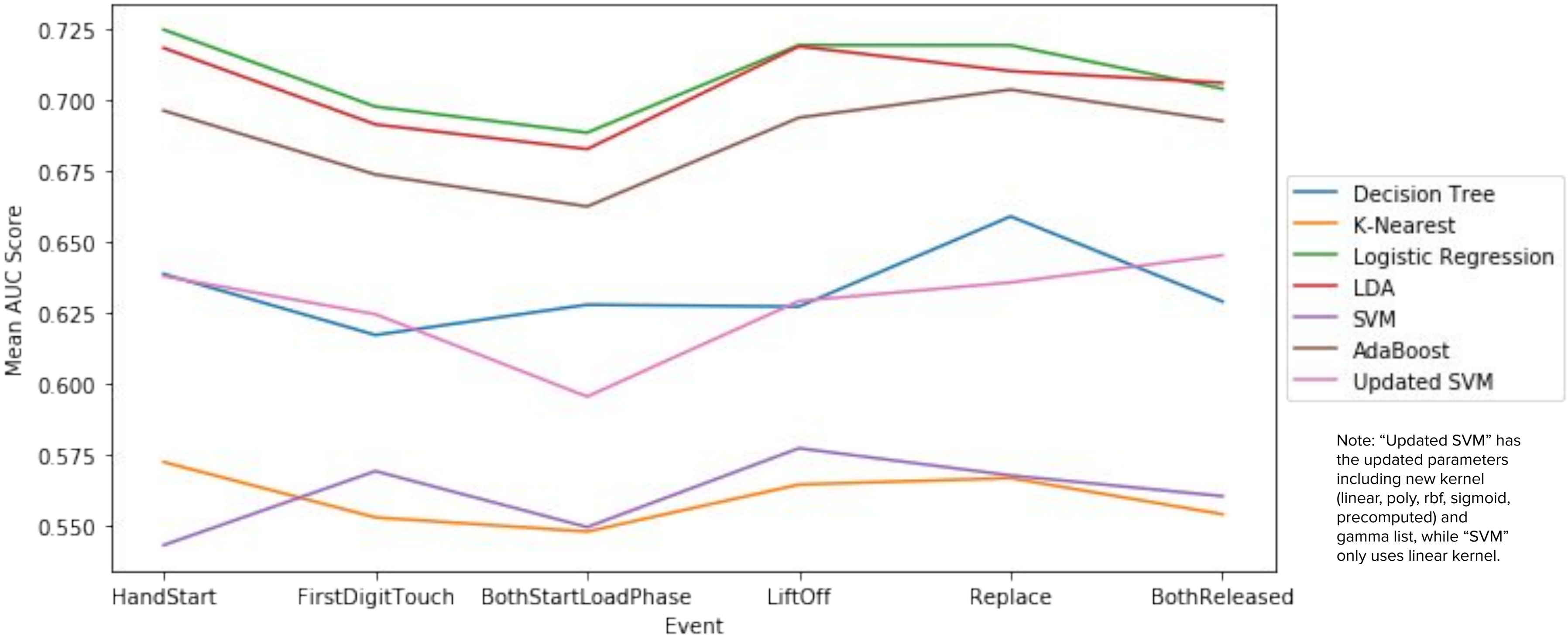
Speaker: Mina

Our Code/Method

1. Loop through all the subjects and read in the data and events files for each series for the test and train data
2. Loop through all the models (logistic regression, SVM, KNN, AdaBoost, LDA, decision tree)
3. Run GridSearch for each model, then fit using train data
4. Call predict_proba function on GridSearch estimator to get probability
5. Get the roc_auc_scores

Speaker: Mina

Results: Mean AUC scores per event across all subjects



Note: “Updated SVM” has the updated parameters including new kernel (linear, poly, rbf, sigmoid, precomputed) and gamma list, while “SVM” only uses linear kernel.

Speaker: Prabesh

Discussion:

We emphasize a lot in the class that simpler linear classifier works the best to classify the EEG data. Our results were consistent with what we learned in the class.

Some of the classifiers like SVM took very long time to train. (>8 hrs)

We were limited by computing power and time for training classifiers on large amounts of data. (8 core CPU, 16GB RAM)

Speaker: Prabesh

Future Work:

- Explore Deep Learning methods but still bound to linear classifier
- More aggressive filtering on the data
- Explore collecting data ourselves
- Get access to stronger computing power
    - Add more hyperparameters
    - Increase K to 10 for cross validation which will improve the ROC AUC score

Speaker: Prabesh

References & Links

[Data Set]

[Paper on Data Set]

[GitHub]

[Project Summary]