Signal Processing for Neuroscience - Session 2

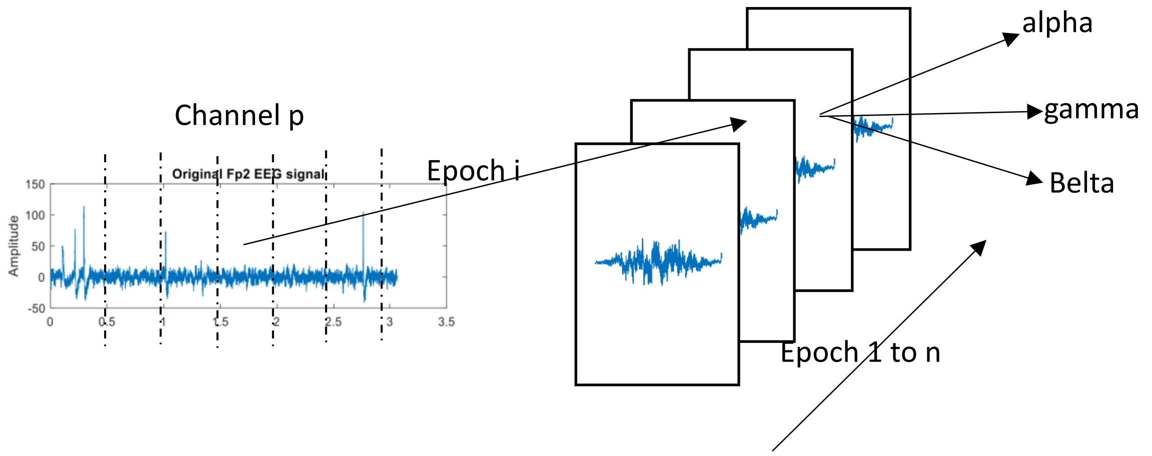
LIU Jianghao

SIGMA code : Sigma_bme_project.m

Interface : GUI_gui_aure_v1.m

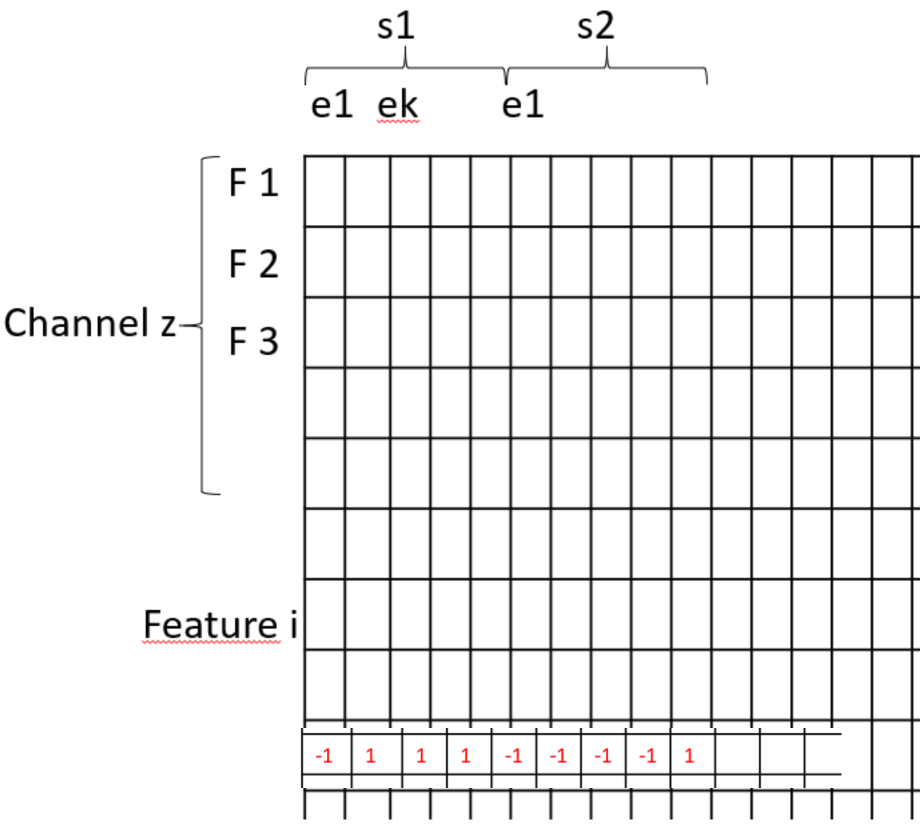
1 Features extraction

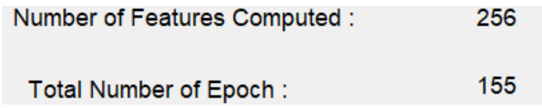
The EEG signal is collected from 16 electrode channels from subject' scalp. Firstly, the EEG signal will be divided into different epoch n where the original signal multiply the window function, hamming, hanning windows, etc.



Then we are going to extract the features from each epoch according to the methods selected. For every algorithm, we can extract numerous features depending on their parameters. For instance, with the Fourier power spectrum, we apply band-pass filters to extract the EEG data in these sub bands. Here, we use four frequency ranges, delta(3-4Hz), theta(4-8Hz), alpha(8-12Hz) and belta(12-25Hz).

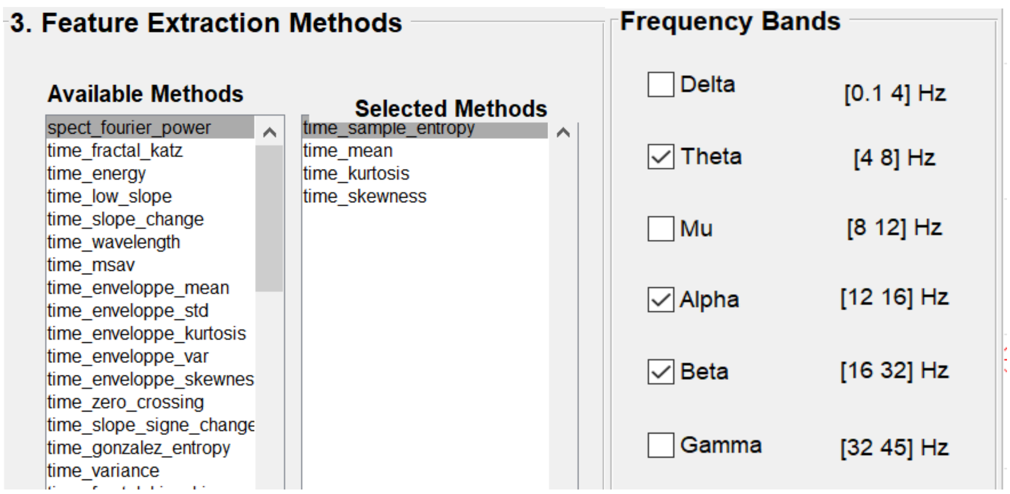
2 Features assembling





In this feature matrix, the column presents the number of epochs and the row is different feature.

Feature i=Channel z* Frequency band k* Method j.



Each epoch has one of the two class labels, +1 represent that the subject is concentrated during this time while the -1represent that he isn't concentrated.

To avoid overfit, the number of feature should be less than a half of example number.

3 Features ranking with the OFR

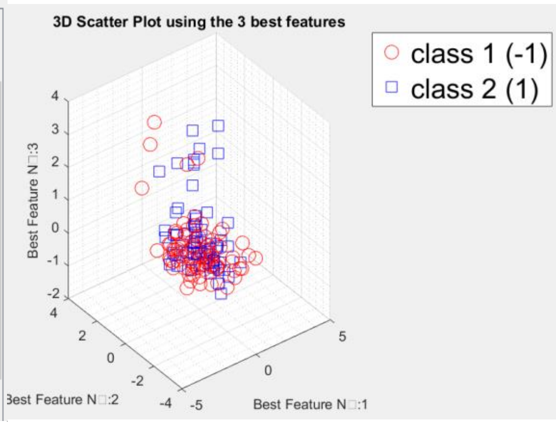
Once we have extracted feature matrix, it is necessary to look for the best features in the set. The idea is to rank the variables according to their correlation with the expected output (1 or -1), by applying a "supervised feature selection". The orthogonal forward regression (OFR) algorithm can be used for feature selection. This ranking procedure is to remove the intercorrelation of the feature vectors, therefore removing useless redundancies and estimate the best possible combination of features for a classification.

The more features put into the classification test, the slower the calculation is because it will generate a lot of data. On the Online stage, it's necessary to provide the classification result as quickly as possible. So, we need choose some most crucial features.

*Offline: use the collected data to train the model and to select the best features.

*Online: classify the real-time data with those optimal features extracted from Offline step.

	Method	Channel	Band
1	time_sample_entropy	6	5
2	time_mean	9	5
3	time_kurtosis	8	4
4	time_sample_entropy	13	4
5	time_mean	5	4
6	time_mean	8	4
7	time_kurtosis	12	8
8	time_skewness	3	5
9	time_skewness	4	4
10	time_sample_entropy	15	2



4 Machine Learning and classification

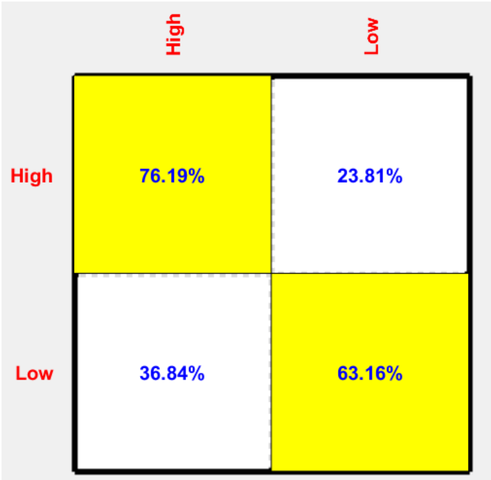
Once the best features are extracted, we can classify the feature sets and estimate the error of the classifier.

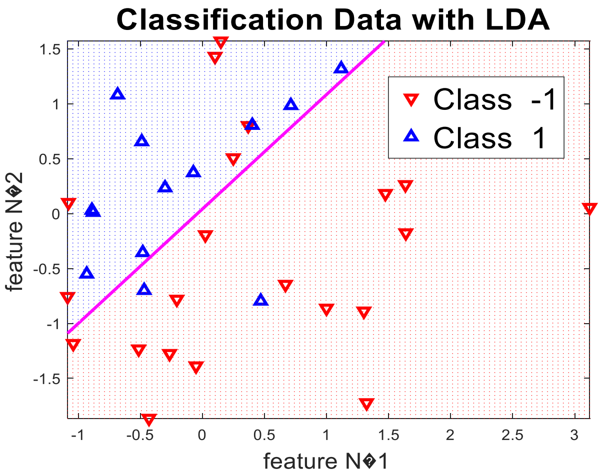
*LOEO: leave-one-epoch-out, we pick out one epoch and use the rest epochs to calculate the hyperplane. This selected epoch is used to validate the model.

*LOSO: leave-one-subject-out, we pick out one subject and use the rest to calculate the hyperplane.

Comparing LOSO to LOEO, more epochs will be used to validate the model, however, less epochs for the training.

5 Display the results of the training phase





We use 20 best features and a LDA (linear discriminant analysis). The true positive proportion is 76.19% and the true negative proportion is 63.16%. The result is not really good because the accuracy should be above 80% for an applicable Bci.