Signal Processing for a Brain Computer Interface

By

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Contents

Declaration

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Abstract

Brain computer interface (BCI) systems measure brain signal and translate it into control commands in an attempt to mimic specific human thinking activities. In recent years, many researchers have shown their interests in BCI systems, which has resulted in many experiments and applications. However, most methods are just based on a specific selected dataset or a typical feature. As a result, there are questions about whether some methods generalise well on other datasets. Therefore, the major motivation of this thesis is to compare various features and classifiers described in the literature.

Pattern recognition is considered as the core part of a BCI system in our research. In this thesis, a number of different features and classifiers are compared in terms of classification accuracy and computation time. The studied features are: time series waveform, autoregressive (AR) components, spectral components; these are used with different classifiers: such as template matching, nearest neighbour, linear discriminant analysis (LDA), Bayesian statistical and fuzzy logic decision classifiers.

In order to assess and compare these different features and classifiers, an extensive investigation was carried out on a public dataset (imagined left or right hand movement) from an international BCI competition and the results are reported in this thesis. The classification was done in a continuous fashion, to match a real time application. In this process, the average and best accuracy, as well as the computation time, were analysed and compared. The results showed that most classifiers achieved very high accuracies and short computation times for most features.

A BCI experiment based on imagined left or right hand movement was carried out at the University of Adelaide and some investigations on the data from this experiment are discussed. The result shows that the selected classifiers can work well with this new dataset without much additional preprocessing or modifications.

Finally, this thesis culminates with some conclusions based on our research, and discusses some further potential work.

Abbreviations

ALS:	Amyotrophic Lateral Sclerosis
ANN:	Artificial Neural Network
AR:	Autoregressive
BCI:	Brain Computer Interface
CSP:	Common Spatial Pattern
CSSD:	Common Subspace Decomposition
DFT:	Discrete Fourier Transform
ECoG:	Electrocorticography
EEG:	Electroencephalography
EM:	Expectation Maximization
EMG:	Electromyography
EOG:	Electrooculography
ERD:	Event Related Desynchronization
ERS:	Event Related Synchronization
FFT:	Fast Fourier Transformation
FMRI:	Functional Magnetic Resonance Imaging
GMM:	Gaussian Mixture Models
LDA:	Linear Discriminant Analysis
LMS:	Least Mean Square
LOO:	Leave One Out
MLP:	Multi-Layer Perceptron
PDF:	Probability Density Function

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