UNIVERSITY OF SOUTHERN QUEENSLAND, AUSTRALIA

ANALYSIS AND CLASSIFICATION OF EEG SIGNALS

A Dissertation Submitted by

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For the Award of

Doctor of Philosophy

July, 2012

Abstract

Electroencephalography (EEG) is one of the most clinically and scientifically exploited signals recorded from humans. Hence, its measurement plays a prominent role in brain studies. In particular, the examination of EEG signals has been recognized as the most preponderant approach to the problem of extracting knowledge of the brain dynamics. EEG recordings are particularly important in the *diagnosis of epilepsy* and in *brain computer interface (BCI)*. In BCI systems, EEG signals help to restore sensory and motor functions in patients who have severe motor disabilities. Analysing EEG signals is very important both for supporting the diagnosis of brain diseases and for contributing to a better understanding of cognitive process.

Although EEG signals provide a great deal of information about the brain, research in classification and evaluation of these signals is limited. Even today the EEG is often examined manually by experts. Therefore, there is an ever-increasing need for developing automatic classification techniques to evaluate and diagnose neurological disorders. Classification techniques can help to differentiate EEG segments and to decide whether a person is healthy. A big challenge is for BCI systems to correctly and efficiently identify different EEG signals of different motor imagery (MI) tasks using appropriate classification algorithms to assist motor disabled patients in communication.

In this dissertation, we aim to develop methods for the analysis and classification of epileptic EEG signals and also for the identification of different categories of MI tasks based EEG signals in BCI's development.

In order to classify epileptic EEG signals, we propose two methods, simple sampling technique based least square support vector machine (SRS-LS-SVM) and clustering technique based least square support vector machine (CT-LS-SVM). The experimental results show that both algorithms perform well in the EEG signal classification and the CT-LS-SVM method takes much less execution time compared to the SRS-LS-SVM technique. The research findings also indicate that the proposed approaches are very efficient for classifying two categories of EEG signals. This

research can help to provide clinical information about patients who have epilepsy, neurological disorders, mental or physiological problems.

In BCI systems, if the MI tasks are reliably distinguished through identifying typical patterns in EEG data, motor disabled people could communicate with a device by composing sequences of these mental states. In this dissertation, for the identification of MI tasks in BCI applications, we developed three methods:

(1) Cross-correlation based logistic regression (CC-LR).
(2) Modified CC-LR with diverse feature sets.
(3) Cross-correlation based least square support vector machine (CC-LS-SVM).

The experimental results have demonstrated the effectiveness of the methods for the identification of MI tasks. These techniques can assist clinical diagnoses and rehabilitation tasks.

Finally we investigated two issues for the MI classification:
(1) Which algorithm performed better.
(2) Which EEG data is more suitable for getting information about MI tasks.
    Is it the motor area data or the all-channels data?

To answer these two questions, we considered the three algorithms: the CC-LS-SVM, the CC-LR and the cross-correlation based kernel logistic regression (CC-KLR). Based on the experimental results, we concluded that the CC-LS-SVM algorithm is the best algorithm for the MI tasks EEG signal classification, and the all-channels EEG data can provide better information than the motor area EEG data for the MI tasks classification. Furthermore, the CC-LS-SVM approach can correctly identify the discriminative MI tasks, demonstrating the algorithms superiority in the classification performance over other existing methods.

Certification of Dissertation

I hereby declare that the work presented in this dissertation is my own and is, to the best of my knowledge and belief, original except as acknowledged in the text. This dissertation has not previously been submitted either in whole or in part for a degree at this or any other university.

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Acknowledgements

First of all, I would like to thank almighty Allah, for His guidance and strength.

I would like to express my sincere gratitude and appreciation to my supervisor, Associate Professor Yan Li, for her continuous inspiration, support, guidance, encouragement, advice, patience, and individual feedback throughout the course of my PhD study. She was an approachable supervisor who motivated me to achieve my goals. I feel very grateful and blessed to have worked under her supervision. I would not imagine carrying out this research without her constant support and help. I would also like to express my sincere gratitude and appreciation to my associate supervisor Associate Professor Peng (Paul) Wen, for his continuous encouragement, support, valuable advice, and suggestions.

I gratefully acknowledge the University of Southern Queensland (USQ) for offering me the 2009 USQ Postgraduate Research Scholarship to perform this research successfully, without which, this work would not have been possible.

I would also like to thank Professor Mark Sutherland, Director of Centre for Systems Biology (CSBi) for granting me half-tuition fees support, and supporting me to attend conferences.

I would also like to thank to all of the staff in the Department of Mathematics and Computing for their co-operation. I would also like to express my gratitude and appreciation to my postgraduate colleagues in our research group for their discussions, comments and advice, especially during our group seminars. I would also like to thank all of my friends for their encouragement and supports.

I wish to express my appreciation to my honourable parents, loving brothers and sisters for their support. Last and most importantly, I wish to thank my husband, Dr. Enamul Kabir who stands beside me and encourages me constantly for every step of my work in this thesis. My thanks are also to my son, Shadman Enam Srijon for giving me happiness, joy and enduring love. I would like to dedicate this dissertation to my son, my beloved husband and my respectable parents.

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Publications Based on This Dissertation

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