UNIVERSITI PUTRA MALAYSIA

P300 DETECTION OF BRAIN SIGNALS USING A COMBINATION OF WAVELET TRANSFORM TECHNIQUES

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By

FARID ESMAEILI MOTLAGH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

October 2012

DEDICATION

To My Parents and My Brother

for their love and support

Abstract of thesis presented to the Senate of University Putra Malaysia
in fulfillment of the requirement for the degree of Master of Science

P300 DETECTION OF BRAIN SIGNALS USING A COMBINATION OF WAVELET TRANSFORM TECHNIQUES

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Chairman: Associate. Professor. Abdul Rahman Bin Ramli, PhD.

Faculty: Institute of Advanced Technology

Brain signals known as electroencephalogram (EEG) carry the huge amount of information which is related to nerves activity sending the orders through the brain. The characteristics of brain signals such as transiency and low voltage of it, make them so complicated in term of signal processing. One of the most useful components of EEG is the event related potentials (ERP). P300 is the most robust and studied ERP among them which is appears in low frequency by applying desired stimuli with the latency of about 300 ms after stimuli. Detection of this component is the main challenge of many diagnostics (such as epilepsy) and research applications such as Brain Computer Interface (BCI) and Guilty Knowledge Test (GKT). Now detection of P300 is possible by using large number of channels and repeating the trial for participant. Objectives in this research are reduction of recording EEG channels, and achieving high accuracy in single trial P300 detection; selecting better P300 features and reducing the complexity

of classifier, which is a need for real time in online applications. In this research the BCI competition data-set has been processed through 5 optimized detection methods. Wavelet transform (WT), student's two-sample t-statistic (T-Test) and support vector machines (SVM) used in designing the algorithms. By using three level of channel reduction, three subgroups of channels with the number of 17, 9, and 5 have been chosen based on their ability in P300 pattern recognition.

By implementing these optimized methods, high accuracy in single trial P300 detection is achieved for small subgroups of channels. By reduction of recording EEG channels in the single trial based algorithms, the processing time of P300 detection decrease dramatically. The results of all 5 methods were so encouraging in term of the tradeoff between accuracy, processing time, and number of channels. The best result (98%) is achieved via combination of Discrete Wavelet Transform (DWT) and Continuous Wavelet Transform (CWT) for feature extraction, T-test for feature selection and SVM for classification by using only five EEG channels. This research is proving the power of combination of discrete and continuous wavelet transform for achieving high accuracy in single trial detection and visualization of P300. Meanwhile the new approaches in channels selection methods help the algorithms for convenient online usage.

Abstrak tesis yang dikemukakan kepada Senat Universiti
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P300 PENGESANAN ISYARAT OTAK MENGGUNAKAN KOMBINASI TEKNIK TRANSFORMASI WAVELET

Oleh

FARID ESMAEILI MOTLAGH

October 2012

Pengerusi: Profesor. Madya. Abdul Rahman Bin Ramli, PhD.

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Isyarat otak yang dikenali sebagai electroencephalogram (EEG) membawa jumlah maklumat yang mana ia berkaitan dengan aktiviti saraf yang menghantar pesanan melalui otak. Ciri-ciri isyarat otak seperti "transciency" dan voltan rendah dalam, menjadikannya begitu rumit dalam jangka masa pemprosesan isyarat. Salah satu komponen yang paling berguna daripada EEG adalah acara berkaitankeupayaan (ERP). P300 adalah yang paling kukuh dan yang dikaji ERP di kalangan mereka yang muncul dalam kekerapan rendah dengan mengaplikasikan rangsangan atau dorongan yang diinginkan dengan tempoh pendam kira-kira 300 ms selepas rangsangan. Pengesanan komponen ini adalah cabaran utama dari banyak diagnosis (seperti epilepsi) dan aplikasi penyelidikan seperti Minda Komputer Antara Muka (IKB) dan Ujian Kesalahan Pengetahuan (UKP). Sekarang pengesanan P300 adalah mungkin melalui dengan menggunakan bilangan saluran yang besar dan mengulangi percubaan untuk peserta. Dalam kajian ini gabungan kaedah pemprosesan pengekstrakan ciri P300 telah

dioptimumkan. Objektif dalam kajian ini adalah mengurangkan penyiasatan saluran EEG, dan mencapai ketepatan yang tinggi di dalam percubaan pengesanan tunggal P300, memilih ciri P300 yang lebih baik dan mengurangkan kerumitan pengkelasan dalam masa nyata dalam aplikasi talian. Dalam kajian ini , persaingan IKB set data telah diproses melalui 5 pengesanan kaedah yang telah dioptimumkan. Transformasi (WT), dua sampel pelajar-tstatistik (T-Test) dan mesin vector sokongan (SVM) yang digunakan dalam rekabentuk algoritma. Dengan penggunaan tiga tahap pengurangan saluran, tiga subkumpulan saluran dengan bilangan 17, 9, dan 5 telah dipilih berdasarkan kemampuan mereka dalam P300 corak pengecaman.

Dengan melaksanakanentasi kaedah yang telah dioptimumkan, ketepatan yang tinggi di dalam perbicaraan pengesanan tunggal P300 dicapai untuk kumpulan kecil saluran. Dengan pengurangan merekodkan saluran EEG dalam algoritma berasaskan percubaan tunggal, masa pemprosesan P300 pengesanan penurunan secara dramatik. Keputusan kesemua lima kaedah yang begitu memberangsangkan dalam jangka luar antara ketepatan, masa pemprosesan, dan bilangan saluran. Hasil terbaik (97.79 %) dicapai menerusi gabungan Transformasi Diskret Wavelet (DWT) dan Tranformasi Wavelet Berterusan (CWT) untuk penyarian sifat. Pengujian-T untuk pemilihan ciri dan SVM untuk pengkelasan dengan meggunakan hanya lima saluran EEG. Kajian ini membuktikan kuasa gabungan wavelet dan selanjar mengubah untuk mencapai ketepatan yang tinggi dalam pengesanan percubaan tunggal visualisasi daripada P300. Sementara itu, pendekatan baru dalam kaedah pemilihan saluran membantu algoritma untuk penggunaan dalam talian yang mudah.

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I certify that a Thesis Examination Committee has met on 24 October 2012 to conduct the final examination of Farid Esmaeili Motlagh on his thesis entitled "P300 Detection of Brain Signals using a Combination of Wavelet Transform Techniques" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Master of Science.

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This thesis submitted to the Senate of University Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and in not concurrently, submitted for any other degree at University Putra Malaysia or at any other institution.

FARID ESMAEILI MOTLAGH

Date: 24 October 2012

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