

UNIVERSITI TEKNOLOGI MARA

**DETERMINATION AND
CLASSIFICATION OF HUMAN
STRESS INDEX USING NON-
PARAMETRIC ANALYSIS OF EEG
SIGNALS**

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Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy

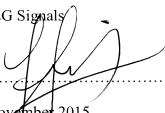
Faculty of Electrical Engineering

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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ABSTRACT

Regardless of type of stress, either mental stress, emotional stress or physical stress, it definitely affects human lifestyle and work performance. There are two prominent methods in assessing stress which are psychological assessment (qualitative method) and physiological assessment (quantitative method). This research proposes a new stress index based on Electroencephalogram (EEG) signals and non-parametric analysis of the signals. In non-parametric method, the EEG features that might relate to stress are extracted in term of Asymmetry Ratio (AR), Relative Energy Ratio (RER), Spectral Centroids (SC) and Spectral Entropy (SE). The selected features are fed to the k-Nearest Neighbor (k-NN) classifier to identify the stressed group among the four experimental groups being tested. The classification results are based on accuracy, sensitivity and specificity. To support the classification results using k-NN classifier, the clustering techniques using Fuzzy C-Means (FCM) and Fuzzy K-Means (FKM) are implemented. To ensure the robustness of the classifier, the cross-validation technique using k-fold and leave-one-out is performed to the classifier. The assignment of the stress index is verified by applying Z-score technique to the selected EEG features. The experiments established a 3-level index (Index 1, Index 2 and Index 3) which represents the stress levels of low stress, moderate stress and high stress at overall classification accuracy of 88.89%, classification sensitivity of 86.67 % and classification specificity of 100%. The outcome of the research suggests that the stress level of human can be determined accurately by applying SC on the ratio of the Energy Spectral Density (ESD) of Beta and Alpha bands of the brain signals. The experimental results of this study also confirm that human stress level can be determined and classified precisely using physiological signal through the proposed stress index. The high accuracy, sensitivity and specificity of the classifier might also indicate the robustness of the proposed method.

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CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

Stress is one of the major health issues where too much stress may lead to depression, fatigue and insomnia. Regardless of weight and type of stress, it affects human lifestyles and work performance. Stress can either be positive (eustress) or negative (distress) [1-3], and the prominent definition of stress is the failure of the human body to challenge stressors or stress factors mentally, physically and emotionally [3-5]. Among the major stressors are high workloads, noisy working area, improper sleep, unfinished work, fear of something and conflict in family. Stress disturbs the balance of sympathetic and parasympathetic level in the human Autonomous Nervous System (ANS), resulting in the release of stress hormone (*cortisol*) and leads human to experience negative stress (distress) such as depression, anxious, angry, fatigue and frustrated.

Researchers have introduced qualitative and quantitative methods to detect stress, the former method normally employs self-report questionnaires while the latter method analyses human physiological signals [6]. Physiological signals such as Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Galvanic Skin Response (GSR), Skin Temperature, Blood Volume Pulse (BVP) and respiration rate can be utilised to identify stress. Meanwhile, Cohen's Perceived Stress Scale (PSS), Stress Response Inventory (SRI) and Hamilton Depression Rating Scale (HDRS) are widely used self-report questionnaires on stress. In spite of the various methods implemented to detect stress and provide a solution to overcome it, there is still lacking in methods for indicating the level of stress of healthy person.

Since stress is dependent on human emotions and linked with the Autonomous Nervous System (ANS), this research attempts to provide the stress index as a stress indicator based on cerebral activities and change of cognitive state in the human brain due to the putative stressors. EEG signals are selected to recognize human stress since the signals are generated from the electrical activity in the human brain due to the