BCI-Driven Personalized Stress Detection and Management Solution using Deep Q-Network

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

2025/06/26

Signature of the Student Date

The above candidate has carried out research for the Master's thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Prof A T P Silva

Name of the Supervisor

28/06/2025

Signature of the Supervisor Date

DEDICATION

This thesis is dedicated to those who have played a pivotal role in my academic journey and supported me unconditionally.

To my supervisor, Professor Thushari Silva, for their continuous support, insightful feedback, and encouragement throughout this research.

This thesis is also gratefully dedicated to all the other lectures of Department of Computational Mathematics, Faculty of Information Technology, University of Moratuwa.

To my family, for their unwavering love, patience, and belief in me, which has been my greatest source of strength.

To my friends, for their constant support, understanding, and for always being there when I needed them.

And to all the individuals who have inspired me to strive for excellence and never give up.

Thank you all for making this possible.

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ABSTRACT

Brain Computer Interface (BCI) is one of the hottest topics in today's world. Brain computer interface has been heavily used for medical domain. In BCI, Researchers are working with the Brain signals. So, they are deal with EEG signals that are non-invasive. Specially most Researchers are committed to find out various treatments to various disorders using BCI technology. But EEG signals are non-stationary. That means statistical features of the signal is changing time to time. Distribution is varying. Specially with various Artifacts such as eye blinks or some other environmental changes may be effect to the EEG signals that we are capturing. Therefore, in order to get the most accurate results of the BCI applications handling the non-stationary of the EEG signal is crucial. Stress management is also a major concern today. Having too much of stress can be effect to the mental health as well as physical health. People will gain negative thoughts when they are in stressful situation. They try to commit suicide if they unable to handle their stress level. In phycology councilors are practicing various therapy sessions for managing the stress. Music therapy is the therapy they have most commonly used and shows as a most effective way to managing the stress. And also, it has found that BCI technology is used for monitor and managing the stress level. But there is a lack of Research explored Reinforcement Learning technology to accurately detect stress from the non-stationary EEG signal. So, to fill that gap this research focuses on Reinforcement Learning (RL) technology for accurately classify stress from the non-stationary dynamic EEG signals. Reinforcement Learning in the sense specially this research uses Deep Q-Learning (DQN) which is coming under Reinforcement Learning. And finally combined machine learning for recommending the suitable relaxing music from Spotify if the stress has been detected for management of the stress. Desktop application has also been implemented in the part of this work that can be used by anyone for personalized stress management as well.

Keywords: Stress Management, Music Therapy, Brain Computer Interface, Reinforcement Learning, Deep Q-Network, Machine Learning

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LIST OF ABBREVIATIONS

Abbreviations	Description
RL	Reinforcement Learning
DQN	Deep Q-Network
BCI	Brain Computer Interface
SVM	Support Vector Machine
KNN	K Nearest Neighbors
PEACE	Personalized EEG-Adapted Calm Environment
EEG	Electroencephalogram
AI	Artificial Intelligence
RLHF	Reinforcement Learning with Human Feedback

LIST OF APPENDICES