# AN OPTIMISED

# REGION AND BOUNDARY CLASSIFIER

# FOR HEAD MOVEMENT CLASSIFICATION

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## CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student

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## ABSTRACT

The use of Artificial Neural Network (ANN) classifiers in real-time applications that could be considered critical, such as head movement classification for the control of a powered wheelchair, naturally raises questions over safety due to performance accuracy.

One inherent characteristic of an ANN is that the placement of classification boundaries within the decision space is arbitrary and ultimately unknown. The result of this characteristic is to give unpredictable results when presented with data outside the boundary of the training set and is therefore considered as a major source of uncertainty.

The problem is one of accuracy and predictability and to address this a novel algorithm termed an Optimised Region and Boundary Classifier (RBC) was created to provide improvements in accuracy and predictability over a conventionally trained ANN.

To improve accuracy the RBC requires the formation of effective boundaries, which relies on the training set containing data that is both representative of all types of data likely to be input to the classifier and is complementary (data either side of an implied boundary). To achieve this the original training set consisting of commands only (forward, back, left, and right) was augmented with "data outside the boundary", which consisted of seventeen types of non-command data that the classifier was likely to see.

To improve predictability the RBC uses explicit boundaries, which is achieved using k-means clustering techniques to define Hyper-Rectangles. Also, two additional regions (vertical and horizontal null regions) are extracted from the Hyper-Rectangles and added to the classifier.

To further improve accuracy and predictability an optimisation process is used that expands the Hyper-Rectangles for each of the classes to be classified (forward, back, left, and right) until the associated training error for sensitivity and specificity is optimal.

To show that the RBC could provide improvements in performance comparisons were made between the RBC trained on the augmented training set and ANN's trained on both the original training set and the augmented training set. The performance for each type of classifier was assessed using the 0.632+ Bootstrap Method and Receiver

Operating Characteristics (ROC) analysis (area under the curve, sensitivity, and specificity).

Results showed that the RBC provided significant improvements in performance when compared with an ANN trained on the original training set (up to 9% improvement in mean sensitivity and 30% improvement in mean specificity). When compared with the ANN that was trained on the same augmented training data only small improvements in mean sensitivity and specificity could be seen (up to 3%). However, the RBC was clearly the best performing classifier algorithm overall.

The significance of the Optimised Region and Boundary Classifier is that it addresses both accuracy and predictability and therefore it is potentially an inherently safer classification algorithm. This would enable its use with more confidence in applications where safety is critical, such as in Medical Devices.