Detection Of Alzheimer's Disease Using Artificial Neural Network (ANN) Model

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***Abstract*— The detection of Alzheimer's disease using Artificial Neural Network (ANN) model is presented, Magnetic resonance imaging (MRI) datasets obtained for young and middle aged persons, as well as demented and nondememted older adults were used in the study. The MRI datasets are part of the Open Access Series of Imaging Studies (OASIS) project output published by the Washington University Alzheimer's Disease Research Center. The dataset was preprocessed, normalized and split into 80% for training and 20 % for the validation. The ANN model traing and validation was implemented using Python. The ANN model achieved solid performance with an accuracy of 85.34%, a precision of 84.95%, a recall of 85.34%, and an F1-score of 85.08%. Overall, the ANN model demonstrates reliable and effective performance in categorizing dementia stages.**

Keywords*— *Alzheimer's disease, Artificial Neural Network (ANN) Model, Magnetic Resonance Imaging (MRI) Datasets, demented, Open Access Series of Imaging Studies (OASIS), Nondememted

1. INTRODUCTION

Nowadays, the there is widespread application of machine and deep learning methods in addressing various issues in various disciplines [1, 2, 3]. This is due to the high performance of such methods in both prediction and classification tasks. The machine and deep learning methods have proven to be better in many instances than the traditional analytical models based on linear and nonlinear regression models [4,5,6].

In the health sector, the machine and deep learning models are also applied in facilitating diagnosis of diseases and in early detection of diseases based on machine or deep learning model analysis of sample image dataset or other dataset of the target patients [6, 7, 8, 9, 10]. The use of such method has been extended to the diagnosis of such disease like the Alzheimer's disease which is the focus of this study [11, 12]. In such case, the dataset of the Magnetic Resonance Imaging (MRI) dataset acquired from diverse patients are used to train the model and subsequently, the model can then be applied in the real-time prediction of any patient's Alzheimer's disease status based on the MRI image scan of the patients [13,14,15]. In this work, the Artificial Neural Network (ANN) model is considered and its ability to predict the patient's Alzheimer's disease status based on the MRI image is examined. The study seek to determine the capability of the ANN model in performing such task so as to compare it with the performance of other models for such application in the health sector.

2. METHODOLOGY

The essence of this work is to use available dataset to train and validate Artificial Neural Network (ANN) model for application in the detection of Alzheimer's disease. The flowchart for the training, evaluating, and testing the artificial neural network (ANN) model is shown in Figure 1.

Magnetic resonance imaging (MRI) datasets obtained from young and middle aged persons, as well as demented and nondememted older adults are used for the study. The MRI datasets are part of the Open Access Series of Imaging Studies (OASIS) project output published by the Washington University Alzheimer's Disease Research Center. The dataset was preprocessed, normalized and split into 80% for training and 20 % for the validation,

In the classification task, the Artificial Neural Network (ANN) model was trained using the preprocessed and normalized data. The target variable `y` was first encoded into a categorical format using `to_categorical` from `tensorflow.keras.utils`, transforming the class labels into one-hot encoded vectors, which is essential for multi-class classification.

Next, the ANN model was modeled using TensorFlow's Keras API. The model architecture consisted of a sequential stack of layers, listed as follows:

i. The first hidden layer had 12 units with a ReLU activation function, which helps the model learn non-linear patterns.
ii. The second hidden layer had 8 units with ReLU activation.
iii. The output layer had 4 units corresponding to the four classes of `CDR`, with a softmax activation function to output probabilities for each class.

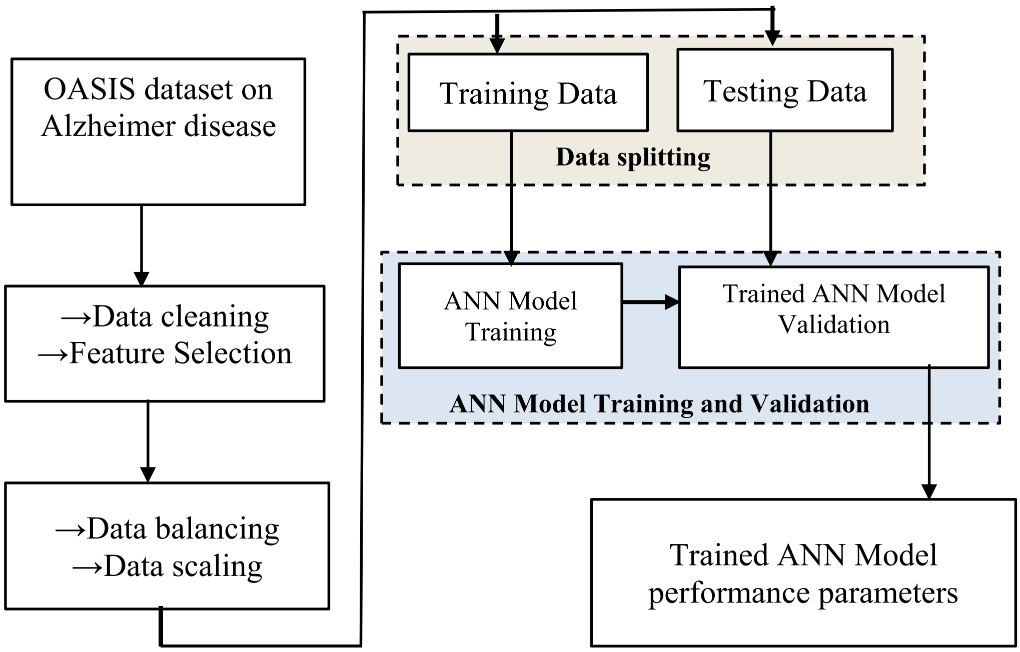

Figure The flowchart for the training, evaluating, and testing the artificial neural network **(ANN)** model

The ANN model architecture is presented in Figure 2. The model was compiled using the Adam optimizer, which is efficient for deep learning tasks, and the categorical cross-entropy loss function, which is appropriate for multi-class classification. Additionally, accuracy, precision, and recall were used as metrics to evaluate model performance comprehensively.

The model was trained on the training set with a 20% validation split, using a batch size of 16 and running for 150 epochs. After training, the model was evaluated on the validation set, achieving an accuracy of 85.34%, along with calculated precision and recall. These metrics provide a robust assessment of the model's ability to classify brain MRI scans accurately, offering insights into its performance on unseen data.

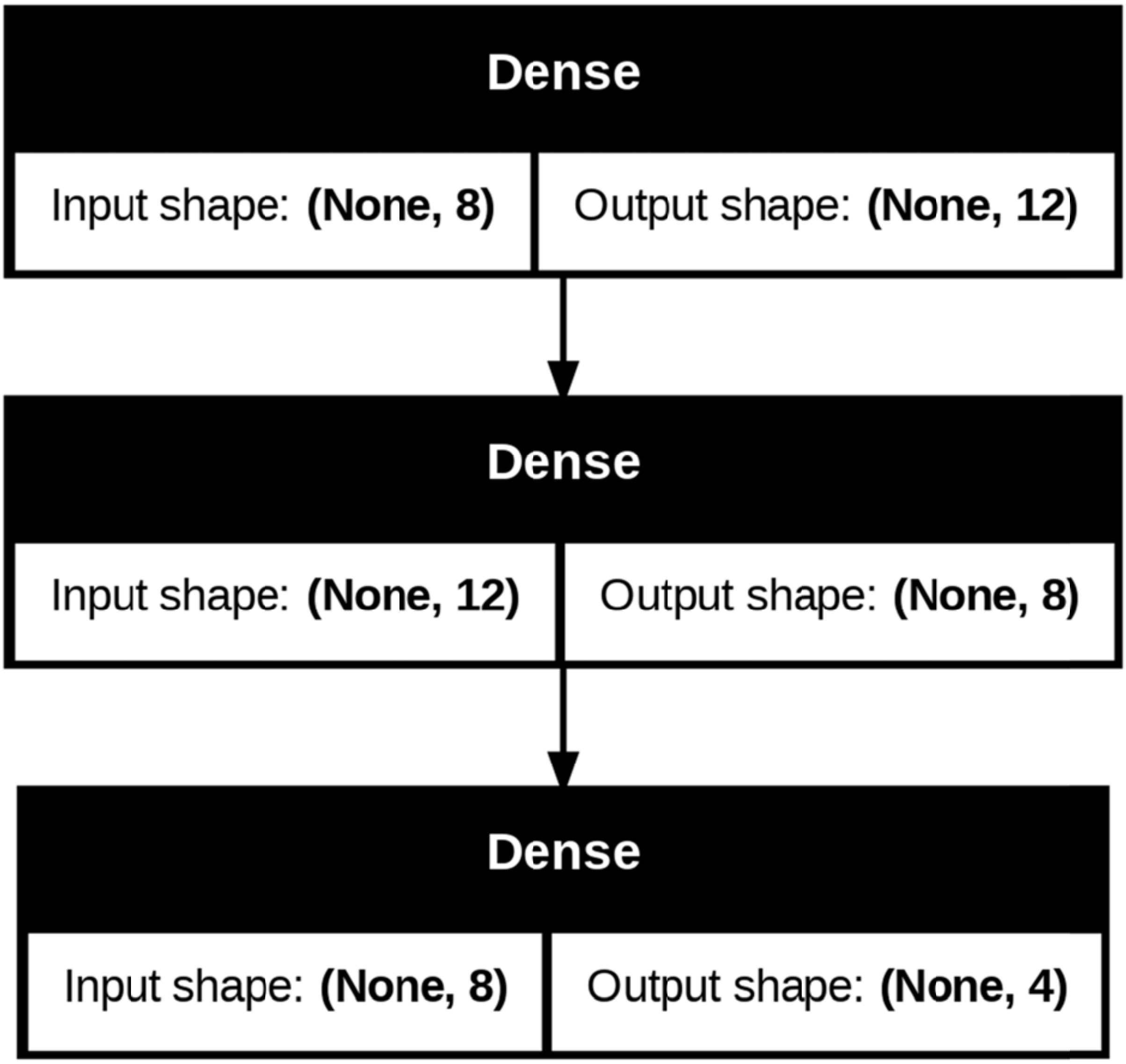

Figure 2
The ANN Model Architecture

3. RESULTS AND DISCUSSIONS

The ANN model training history was plotted on the chart in Figure 3 and Figure 4 and the graphs show a consistent improvement in both accuracy and precision over the course of 150 epochs. Also, the loss function history of the model is plotted in Figure 5 while the one for recall is presented in Figure 6.

As shown in the graphs, initially, the model struggled with low precision and recall, but as training progressed, significant gains were observed. By the midpoint of training, the model had achieved over 80% accuracy and continued to refine its performance, with precision and recall metrics also improving steadily. In the final epochs, the model's performance stabilized, reaching an accuracy of around 84%, with precision and recall metrics reflecting a well-calibrated model. Validation loss gradually decreased, indicating effective learning and minimal overfitting. Overall, the model exhibited strong learning progress and robustness throughout the training process.

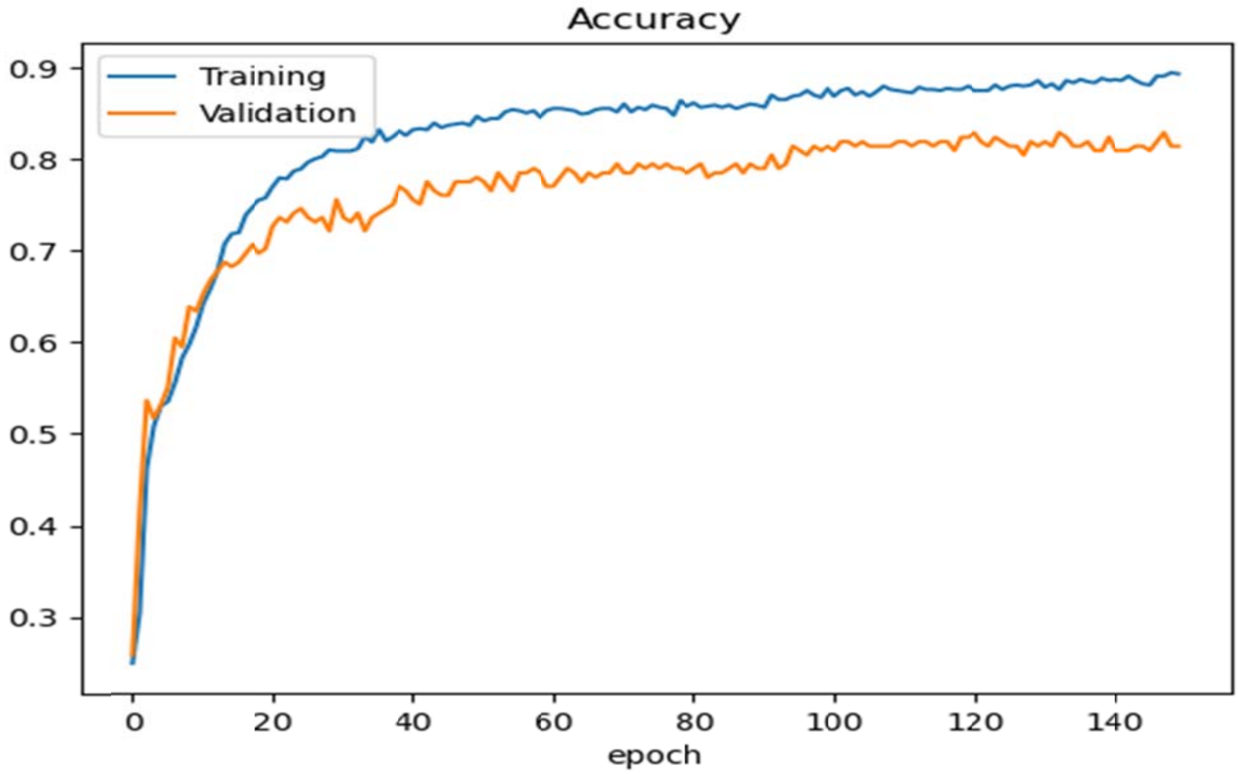

Figure 3 The ANN model accuracy history for the training and validation dataset

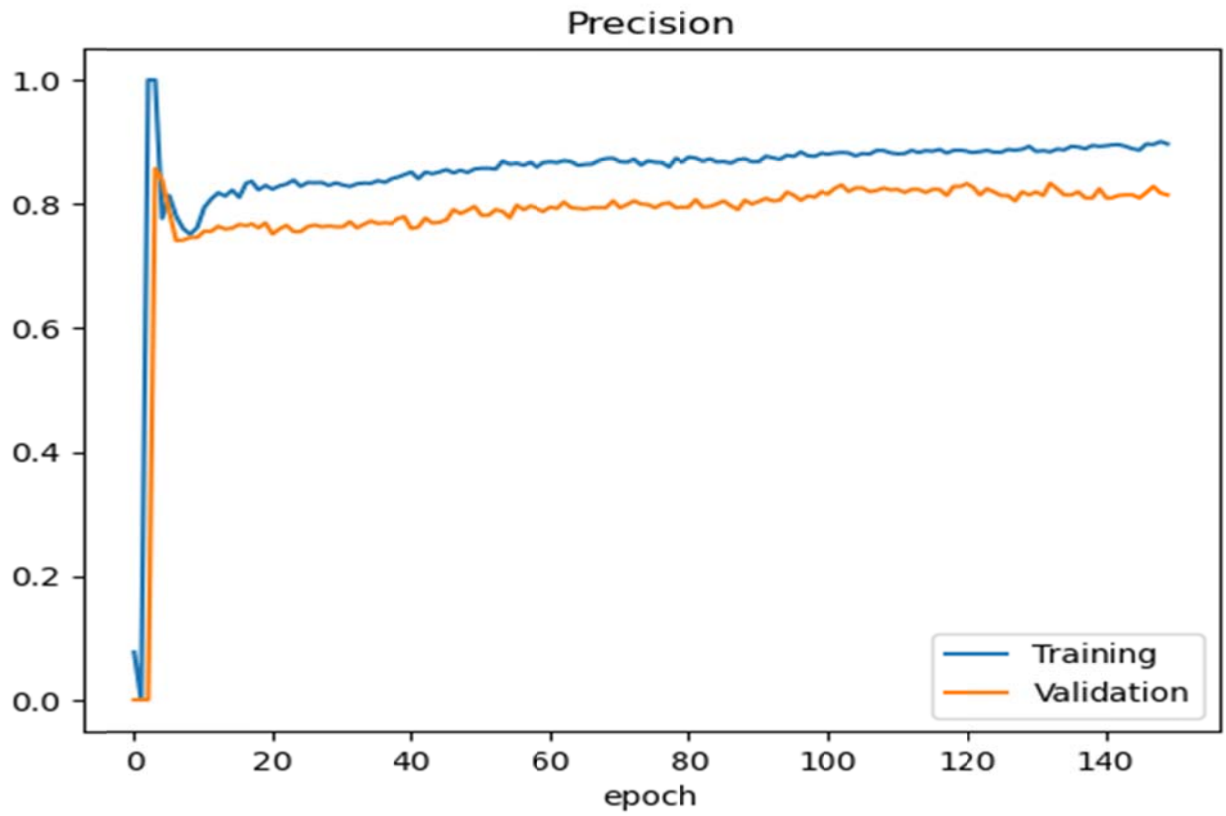

Figure 4 The ANN model precision history for the training and validation dataset

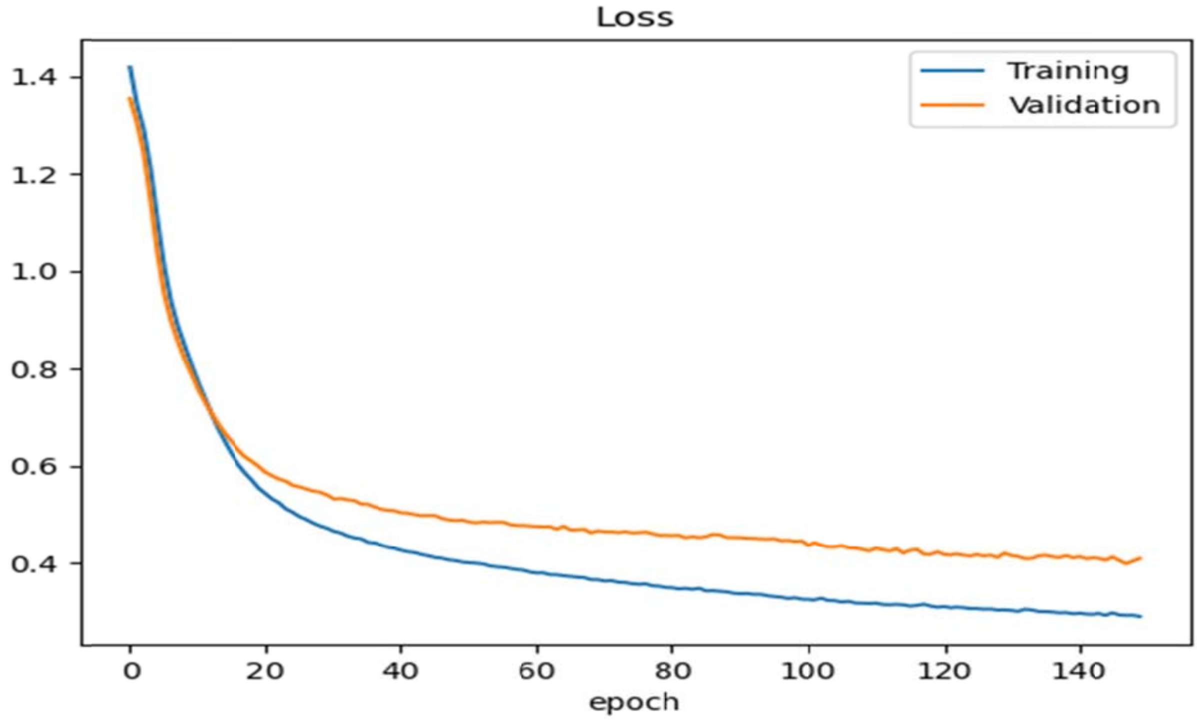

Figure 5 The ANN model loss function history for the training and validation dataset

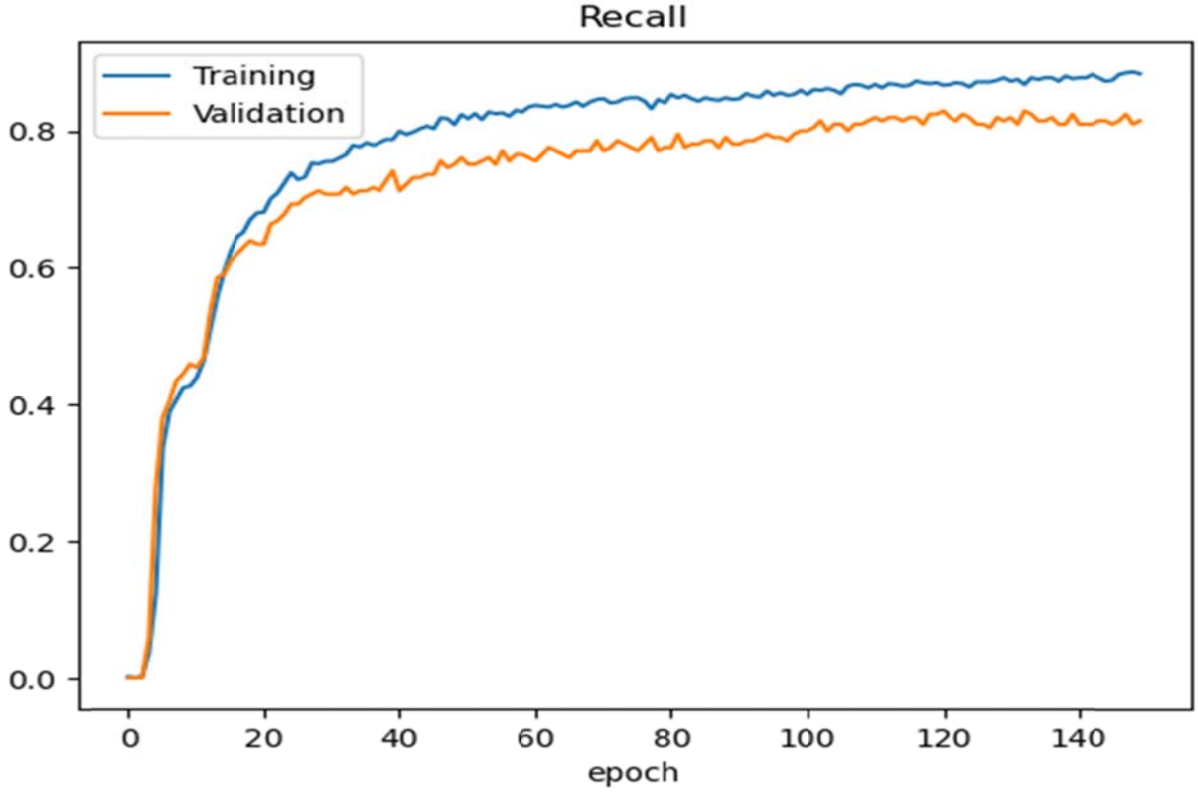

Figure 6 The ANN model recall history for the training and validation dataset

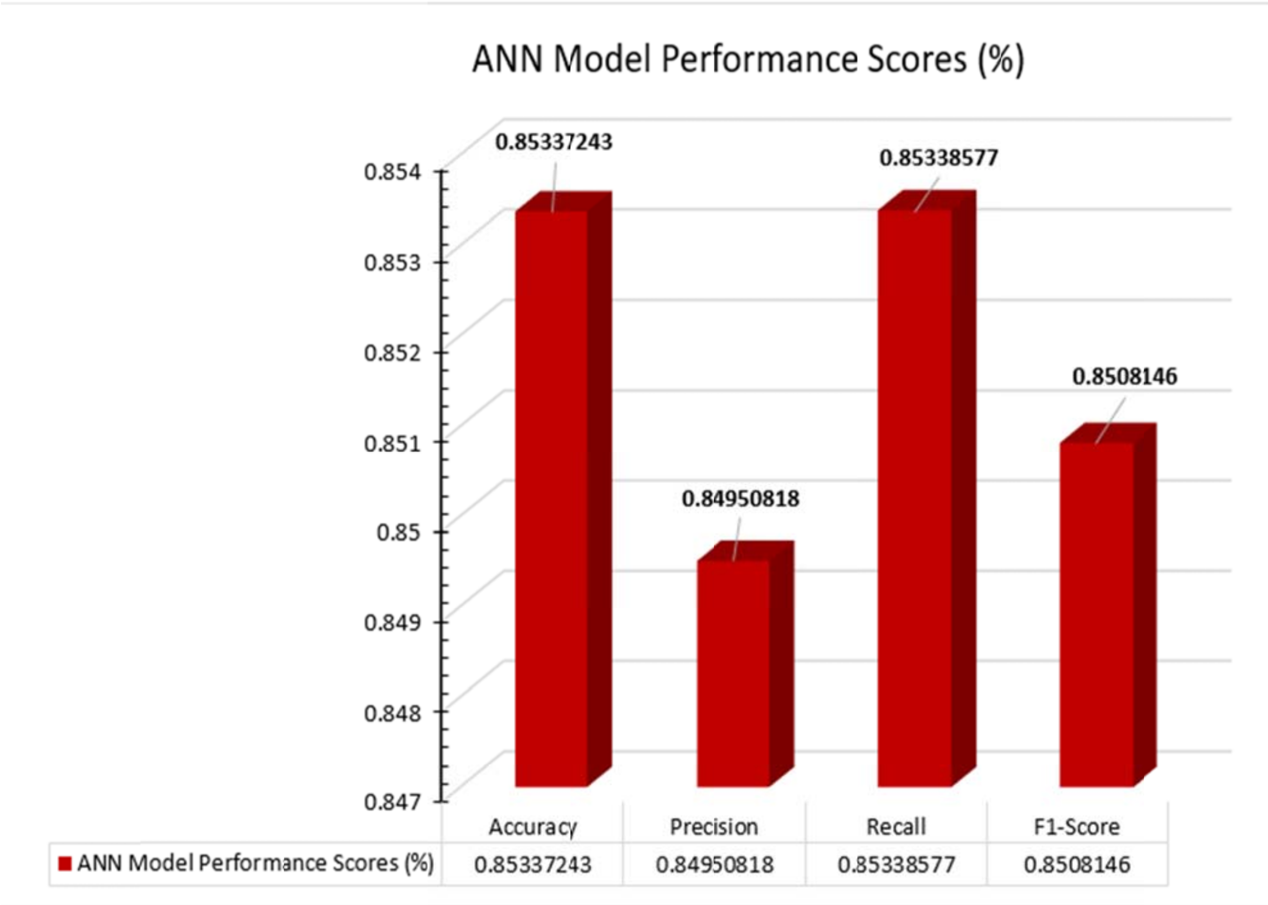

Figure 7 The bar chart for the performance of the ANN Model

In all, as shown in Figure 7, the Artificial Neural Network (ANN) model achieved solid performance with an accuracy of 85.34%, a precision of 84.95%, a recall of 85.34%, and an F1-score of 85.08%. The confusion matrix (in Figure 8) further details the model's classification abilities across the four categories: mild dementia, very mild dementia, moderate dementia, and non-dementia. The model correctly classified most instances, particularly non-dementia cases (85 correct out of 85), indicating strong discriminatory power. However, there were some misclassifications, especially between mild and very mild dementia, reflecting the inherent challenge in distinguishing these closely related categories. Overall, the ANN model demonstrates reliable and effective performance in categorizing dementia stages.

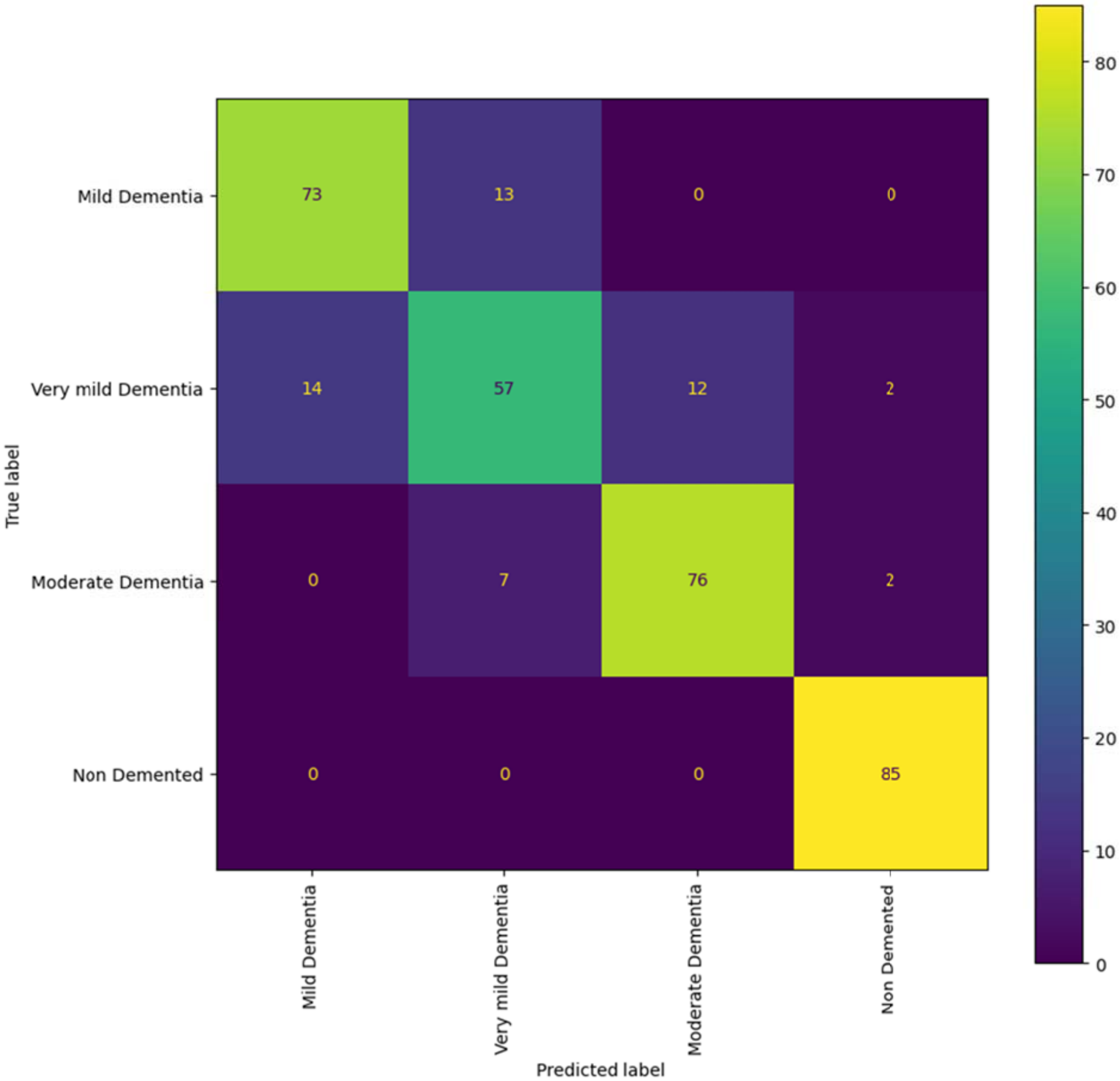

Figure 8 The confusion matrix for the ANN Model

4. CONCLUSION

The application of Artificial Neural Network (ANN) in detection of Alzheimer's disease. The Magnetic resonance imaging (MRI) datasets obtained from young and middle aged persons, as well as demented and nondememted older adults are used for the study. The model was trained and validated using the dataset and the implementation was done in Python environment.

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