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DETERMINING EFFECTIVE LEVEL OF DEMENTIA DISEASE USING MRI IMAGES

KAUSHAL KISHOR BHATT

Research Scholar, Department of Computer Science, Om Sterling Global University, Hisar, Haryana.

PARVEEN SEHGAL

Professor, Research Supervisor, Department of Computer Science, Om Sterling Global University, Hisar, Haryana.

Abstract

The prevalence of dementia is growing as the world's population ages, making it a major public health issue. The key to successful management and treatment of dementia is an early and precise diagnosis. In this work, we will investigate the Dementia detection model DenseNet-169 in depth. The DenseNet-169 model has been used to classify almost 7,000 magnetic resonance imaging (MRI) scans of the brain. Non-Dementia, Mild Dementia, Severe Dementia, and Moderate Dementia are all categorized using this Convolution Neural Network (CNN) model. The use of deep learning and image processing presents intriguing new directions for the diagnosis and treatment of dementia, with the ultimate goal of enhancing the quality of life for those with the disease.

Keywords: Dementia, Mild, Severe, Image Processing, Deep Learning

1) INTRODUCTION

Dementia is characterized by a gradual but permanent decline in mental faculties. Dementia is one of the biggest health issues of our century, affecting an estimated 40 million individuals throughout the world. Dementia is most commonly brought on by Alzheimer's disease or by vascular problems. One of the most prevalent dementia causes is Alzheimer's disease (AD). Presently, 70–80% of instances impacting 50 million individuals may be traced back to this factor. Dementia symptoms often appear with advancing age, however some might appear much earlier. Brain structure and function are both altered by Alzheimer's disease. Healthcare, finance, transportation, social media, education, etc. all appear to be sectors where machine learning algorithms are being put to good use. Our research goals include the creation of learning and improving algorithms with predictive capabilities. Many academics have presented their work on dementia prediction with an introduction to various machine learning methods. However, there are currently no diagnostic tools available, such as a standardized test for dementia. However, it is difficult to tell whether a dementia diagnosis will result in a decline in cognitive function or a return to normalcy. Machine learning may be used to determine if patients complaining of cognitive issues have dementia or mild cognitive impairment. Since it has been found that 10-15% of MCI patients progress to AD, it is important to take caution while dealing with the diagnosis during the MCI stage. The problem can be quickly and cheaply solved by employing machine learning techniques in health informatics. The goal of developing this proposed model was to design an algorithm and integrate it into the world's existing healthcare infrastructure.

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Most people with dementia are beyond the age of 65. Brain function, regular routines, and the ability to communicate effectively are all impacted. Alzheimer's disease (AD) is the most common form of dementia among older people. However, these studies did not provide credible means for the early identification of AD, despite the fact that they noted that an early diagnosis of dementia is helpful for initiating therapies and predicting outcomes of the illness. On the other hand, there are kinds of MCI that don't progress into full-blown dementia, and there are forms of MCI that are actually extremely mild forms of AD. Therefore, cutting-edge computational methods may serve as a useful resource for the early detection of AD and the forecasting of the progression of prodromal manifestations of the illness or MCI into dementia.

MRI methods are becoming useful for diagnosing early stages of Alzheimer's disease and mild cognitive impairment. Some research has proposed that AD can be predicted only by neuroimaging, based on a comparison with cognitive tests. However, machine learning (ML)-based dementia prognosis is gradually replacing traditional methods in many hospitals. Despite the obvious benefits of calculating AD incidence rates using MRI data, only a small number of research have done so.

Neuroimaging, and especially MRI, is crucial for the categorization and prediction of Alzheimer's disease dementia. When applied to MRI data, ML models greatly improve the diagnosis accuracy of age-related cognitive decline (ARCD) in people with dementia. The feature-knowledge required to correlate AD sample data has been speculated to be generated using ML-supervised algorithms. Logistic regression and cross-validation are said to further improve the precision of AD prediction through linguistic fusion. On the other hand, a combination of support vector machines and feature reduction methods successfully classified people with dementia at a 70% accuracy rate.

2) DIAGNOSIS OF DEMENTIA

Diagnosing dementia can be a challenging task due to its complex nature and the overlap of symptoms with other conditions. However, accurate and early diagnosis is crucial for effective management and treatment of the disease. The diagnosis of dementia typically involves a comprehensive evaluation, including medical history, physical examination, cognitive assessments, and neuroimaging techniques. The following paragraphs outline the diagnostic process and tools commonly used in the diagnosis of dementia.

Medical History and Physical Examination

The initial step in diagnosing dementia involves obtaining a detailed medical history, including information about the onset and progression of cognitive symptoms, any underlying medical conditions, and family history of dementia. The healthcare provider may also conduct a physical examination to identify any underlying conditions or factors that may contribute to cognitive impairment. This examination may include tests to assess sensory function, reflexes, and motor abilities.

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Cognitive Assessments

Cognitive assessments are fundamental in the diagnosis of dementia and help evaluate the individual's cognitive abilities and identify any patterns of impairment. Various standardized tests and scales are used to assess memory, attention, language, executive functions, and visuospatial skills. The Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are widely used screening tools to assess general cognitive function. These tests provide an overall cognitive score that helps determine the severity of cognitive impairment.

Neuropsychological Testing

Neuropsychological testing involves a more comprehensive evaluation of cognitive abilities and is typically conducted by a trained neuropsychologist. These tests assess various cognitive domains, including memory, attention, language, problem-solving, and visuospatial skills. Neuropsychological testing helps in identifying specific patterns of cognitive impairment, which can aid in distinguishing different types of dementia and ruling out other potential causes of cognitive decline.

Neuroimaging Techniques

Neuroimaging plays a crucial role in the diagnosis of dementia by providing structural and functional information about the brain. Magnetic resonance imaging (MRI) is commonly used to evaluate brain structure and identify any structural abnormalities, such as brain atrophy or the presence of lesions. MRI can also help differentiate between different types of dementia based on specific patterns of brain changes. Positron emission tomography (PET) scans can assess brain metabolism and the accumulation of abnormal proteins, such as beta-amyloid plaques or tau tangles, which are associated with Alzheimer's disease.

Laboratory Tests

Laboratory tests are conducted to rule out other medical conditions that may cause or contribute to cognitive impairment. Blood tests are performed to assess thyroid function, vitamin B12 levels, liver and kidney function, and check for infections or other metabolic disorders. These tests help identify reversible causes of cognitive decline, such as thyroid dysfunction or vitamin deficiencies.

Collaborative Approach and Diagnostic Criteria

Diagnosing dementia often requires a collaborative approach involving multiple healthcare professionals, including neurologists, geriatricians, psychiatrists, and neuropsychologists. The healthcare team reviews the patient's medical history, examination findings, cognitive test results, and neuroimaging data to make a comprehensive diagnosis. Diagnostic criteria, such as those outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) or the International Classification of Diseases (ICD-10), provide guidelines for diagnosing different types of dementia based on specific criteria and clinical features.

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Longitudinal Assessment

Dementia is a progressive condition, and a single assessment may not always capture the full extent of cognitive impairment. Longitudinal assessment, involving repeated evaluations over time, is often necessary to monitor cognitive decline and confirm the diagnosis of dementia. Serial cognitive testing and periodic neuroimaging can help track changes in cognitive function and provide insights into disease progression.

The diagnosis of dementia involves a comprehensive evaluation, including medical history, physical examination, cognitive assessments, neuroimaging, and laboratory tests. A multidisciplinary approach, utilizing various diagnostic tools and expertise, is essential for accurate diagnosis and appropriate management of dementia. Early diagnosis allows for timely interventions and support, improving the overall quality of life for individuals living with dementia and their caregivers.

3) REVIEW OF LITERATURE

GUPTA, ASHISH et al., (2023) The effectiveness of deep learning models is crucial for solving this issue. Several new methods of education were presented, including deep feature extraction and categorization. The conditional loss function is used in the deep triplet network illustrated here. To compensate for the small sample size and improve the model's accuracy. The conditional loss function is a part of the deep triplet network discussed. This architecture's testing is now being conducted using publicly available imaging data, which was used to inform the design of the architecture's foundational network. The experimental results demonstrate the superiority of the provided method over state-of-the-art methods. However, in an effort to halt the course of AD, a number of academics and experts are developing strategies for earlier detection using MRI imaging. This research makes use of two MRI datasets, including 6900 and 6136 pictures, respectively, to detect AD at an early stage. Accuracy, sensitivity, precision, and F1-score are (99.62%), (97.25), (98.39), and (97.14), and (96.1%), (95.71), (95.75), and (95.11) for Dataset 1 and Dataset 2, respectively, after applying the DL technique using a deep Triplet network. We also compare these outcomes to those of prior research and find that the provided method yields superior outcomes. Last but not least, the work is helpful for determining whether ML and DL approaches may be used to investigate early AD stage detection and identification.

Sharma, Payal & Bansal, Deepika (2023) Dementia is a disease of the brain and nervous system that affects countless people all over the world. Several machine learning strategies for assessing dementia are explored. The primary goal of this research is to examine the causes of dementia and methods for reducing the high-risk population using a variety of machine learning techniques. In this study, we give a systematic literature review on machine learning in dementia, which surveys 15 studies including a range of approaches.

Dashtipour Kia et al., (2022) The proportion of the world's population that is 65 and up is increasing at a higher rate than the overall population. Therefore, the prevalence of Alzheimer's disease dementia is projected to skyrocket during the next years. Correct diagnosis is essential

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for effective treatment and illness prevention in today's healthcare systems. As a result, establishing a system for the diagnosis of Alzheimer's disease at an early stage is crucial for preventing further difficulties. This paper proposes a novel paradigm for identifying Alzheimer's disease using machine learning (ML) and deep learning (DL). Detection accuracy has been used as a metric to compare the efficacy of various ML and DL algorithms. According to the experiments, the detection accuracy of BiLSTM is 91.28%, which is much higher than that of the ML approaches. In addition, when compared to the state-of-the-art, our framework clearly stands out as the best of its kind.

Tuan, Tran et al., (2022) Dementia is a disorder of the brain that causes major cognitive impairments including memory loss. The number of individuals with dementia is expected to increase from its current 47 million to 131 million by 2050, as reported in the World Alzheimer Report 2016. Because there is no agreed-upon way to identify dementia, those in need of treatment have limited options. Therefore, brain Magnetic Resonance Image (MRI) scans for computational diagnosis play a significant role in assisting with early diagnosis. Disorientation, mood changes, inability to manage self-care, and behavioral disorders are all symptoms of Alzheimer's disease (AD), the most prevalent form of dementia. Here, we provide a novel computational approach to detecting Alzheimer's disease in 3D brain MR scans. It is hypothesized that a two-step process based on deep learning may efficiently diagnose Alzheimer's disease using brain MRI images. The first step is segmentation, and the second is classification. An initial model based on Gaussian Mixture Model (GMM) and Convolutional Neural Network (CNN) is used to segment brain tissues; a second model based on Extreme Gradient Boosting (XGBoost) and Support Vector Machine (SVM) is then used to categorize Alzheimer's disease using the segmented tissues. We provide two classification and segmentation assessments. Using the AD-86 and AD-126 datasets as benchmarks, the new technique achieved Dice 0.96 for segmentation and accuracies of 0.88 and 0.80 for classification, respectively. When applied to segmentation and feature extraction in medical image processing, deep learning yields striking results. The outcomes are enhanced when XGboost and SVM are used together.

Kim, Jungyoon & Lim, Jihye (2021) Early warning for dementia and correct reactions to the emergence of dementia can improve medical treatment as the prevalence of dementia among Korea's aging population fast becomes a costly burden on society. A prescreening method that makes use of readily available data, such as health behavior and medical service consumption, might be an effective response to dementia-related issues. In this study, we use the 2001 and 2005 waves of the Korea National Health and Nutrition Examination Survey (KNHANES) to train a deep neural network (DNN) to predict dementia using information about health behavior and medical service usage. Principal component analysis (PCA) featuring and min/max scaling are utilized for feature extraction and preprocessing in the suggested model. We looked at five popular machine learning techniques and compared them to our suggested DNN/scaled PCA approach. The suggested technique achieves an improved area under the curve (AUC) of 85.5% compared to alternative methods. Everyone, from patients to physicians, will benefit from the suggested prescreening procedure for early signs of dementia.

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Bs, Vandana & Alva, Sathyavathi (2021) The degenerative neurological brain illness known as Alzheimer's is now without a cure. Alzheimer's disease can be better treated and brain tissue damage prevented if diagnosed earlier. Two approaches were proposed in this paper. Using a deep learning method, we can analyze the stage of Alzheimer's disease based on radiological features extracted from MRI scans. The initial step of the algorithm is normalizing and de-skulling the MRI pictures. To separate the picture into white matter (WM), grey matter (GM), and black holes (BH), a modified K-Means method is employed. The diagnostic characteristics needed are taken from the picture segmentation. The classifier learns to make predictions based on the test data by analyzing the training data. Support Vector Machine is used to define the characteristics needed to build a classification model. Certain characteristics were applied to the task in the aforementioned methods. Instead, the deep learning approach investigates deep characteristics automatically from lower to higher levels. There are 1,000 photos in the database, all scaled down to 350 by 350 pixels without quality loss. Since Deep Learning relies heavily on a big data set of photos, the power of the algorithm was amplified using an augmentation approach. To train the SVM classifier, the first step of the procedure selects 1000 photos with varying characteristics. The resulting accuracy is 92%. The contribution of this work is the categorization of photos into categories like Alzheimer's disease (AD) and normal, with a second-phase success rate of 85.6%. In the initial stages, we focused on using the software itself to extract characteristics.The second stage focuses on the numerous layers of the CNN, which are investigated from the most fundamental to the most abstract aspects of the images.

Salehi, Waleed et al., (2020) The most prevalent form of dementia is Alzheimer's disease (AD), a neurological brain ailment that damages brain cells and causes gradual loss of memory and the person's ability to carry out everyday tasks. This is a rare and deadly illness. Because of the degenerative nature of AD and the global prevalence of the disease, early diagnosis is crucial. The ability to predict the future health of a large patient population is an exciting prospect made possible by early diagnosis. Therefore, we can categorize AD patients as having or not having the illness in the future by evaluating the effects of the disease using MRI scans with the use of Artificial intelligence (AI) technology. Recent years have seen a lot of progress in the diagnosis of AD thanks to AI-based Machine Learning (ML) approaches. In this paper, we apply a variety of machine learning methods, including Logistic Regression, Decision Tree, Random forest classifier, Support Vector Machine, and AdaBoost, to the Open Access Series of Imaging Studies (OASIS) dataset for the purpose of early diagnosis and classification of Alzheimer's disease. Random Forest classifier achieves the best performance and results.

Bidani, Amen et al., (2019) In this study, we introduce a novel method for detecting and classifying dementia within the field of Deep Machine Learning by combining a DCNN (Deep Convolutional Neural Network) model with a Transfer Learning model. In this work, MRI (Magnetic Resonance Imaging) brain scans from the OASIS dataset were used to detect this neurodegenerative illness, the symptoms of which include a deterioration in memory, language, and other cognitive abilities needed to carry out everyday tasks. Before picture extraction from these MRI images of the brain, no-dementia, very mild-dementia, and mild-dementia groups are established using Bag of the characteristics and Learning classification algorithms. The

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DCNN model demonstrated considerable improvement in accuracy for diagnosing dementia.

Raju, Anitha et al., (2017) Alzheimer's disease is the leading cause of dementia, responsible for between 60 and 70 percent of all cases. There is currently no cure or treatment that can reverse the disease's course. The creation of trustworthy ways to establish a targeted prognosis at the earliest degree is crucial to improving prognosis of the condition, and setting up suitable care and therapy, because the etiology for most cases of Alzheimer's is still mainly unknown. We apply and compare the image processing methods of an Artificial Neural Network (ANN) and a Deep Neural Network (DNN) to extract features based on factors including cortical thickness, hippocampal shape, and corpus callosum length. Artificial neural networks and deep learning neural networks are examined for their ability to distinguish between healthy and diseased samples in our research.

Mirzaei, Golrokh et al., (2016) Alzheimer's disease (AD) is one of the most prevalent forms of dementia in the senior population. Over the past decade, a lot of work has gone into finding better ways to identify and diagnose this illness early on. The key to a correct diagnosis has been identified as the sensitivity of biomarkers and the precision of detection methods. This document provides an up-to-date summary of studies investigating the feasibility of using imaging and machine learning for the diagnosis of AD. Thresholding, supervised and unsupervised learning, probabilistic techniques, Atlas-based approaches, and the merging of diverse visual modalities are only some of the segmentation and machine learning techniques discussed. The diagnostic accuracy might be improved by looking at more modern and potent classification algorithms, such as the augmented probabilistic neural network of Ahmadlou and Adeli. The diagnostic success rate can be increased by using many imaging modalities. Multi-modal biomarkers can only be found through research into their combination.

4) METHODOLOGY

There are over 7,000 Brain MRI scans from dementia patients in the Dementia dataset. These images may be divided into four categories, corresponding to the four main types of dementia. There are 2,000 samples from people with mild dementia, 1,800 from those with moderate dementia, 60 from those with severe dementia, and 2,600 from people without dementia. Several machine learning algorithms were put to the test on these photographs while they were being used to develop a tool for identifying the progression of dementia in individuals. Our project relied on.JPEG pictures for its visuals.

The researchers have built a machine-learning Convolution Neural Network model to categorize the illness stages using Python and Jupyter notebook. Tensorflow is the primary library used in the development, training, and testing of the DenseNet-169 model, however we've also made use of Keras, another framework. Since the DenseNet-169 is optimized for 224x224 pixel pictures, we preprocess them using the Tensorflow and Keras frameworks. We also made use of additional libraries, such as the Matplotlib package, to present pictures and create plots of validation and training loss data.

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5) RESULTS AND DISCUSSIONS

Dementia can be diagnosed earlier with the use of this model. This model is being built with Python. The task will be carried out using Jupyter notebook. With Jupyter notebook, you can easily write code on each slide and quickly locate it when you need it. It also allows for the visual presentation of results through the use of graphs and other visual aids. Participants with and without dementia who had MRI scans were compared. A patient's final diagnosis of dementia is displayed below. Dementia's existence and severity were also quantifiable with our methodology. Initially, a set of MR images was chosen for further analysis.

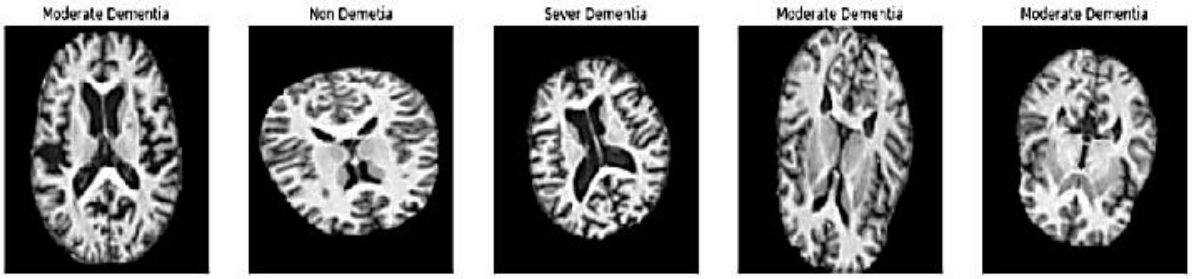

Figure 1: Classification of the stages the patient is suffering from

Some of the MRI scan pictures that were utilized to train the model are displayed in Figure 1. This algorithm accurately forecasts the phases of the disease and classifies photos as either normal, mild, moderate, or severe dementia. The results of your prediction and accuracy calculations will be shown in the number of batches specified by the code. The training of the model occurs in stages in this work. The validation loss and training loss are determined after 44 forward and backward propagation iterations, respectively. As we progress through the evaluation, a higher rate of correctness is met with a corresponding reduction in validation loss. When the performance meets the requirement (the criterion is set in the code), the training process terminates. Training accuracy, as well as train and validation loss, are displayed in Figure 2.

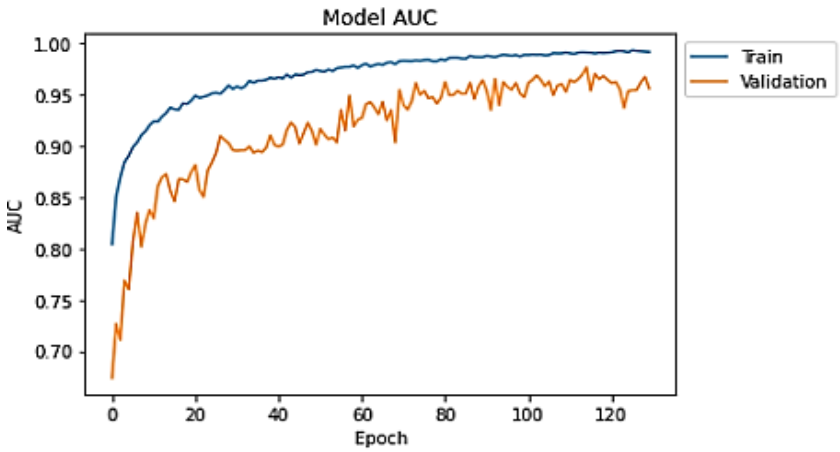

Figure 2: Model Training

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After the model has been trained, it must be evaluated to see if it has improved in accuracy over its predecessor. The goal is to get a precision of 98%. The model's forecast turned out to be correct. The model's predicted probability for non-dementia, mild-dementia, moderate-dementia, and severe-dementia Brain MRI scans are 98%, 96%, 87%, and 91%, respectively, as shown in Figure 3.

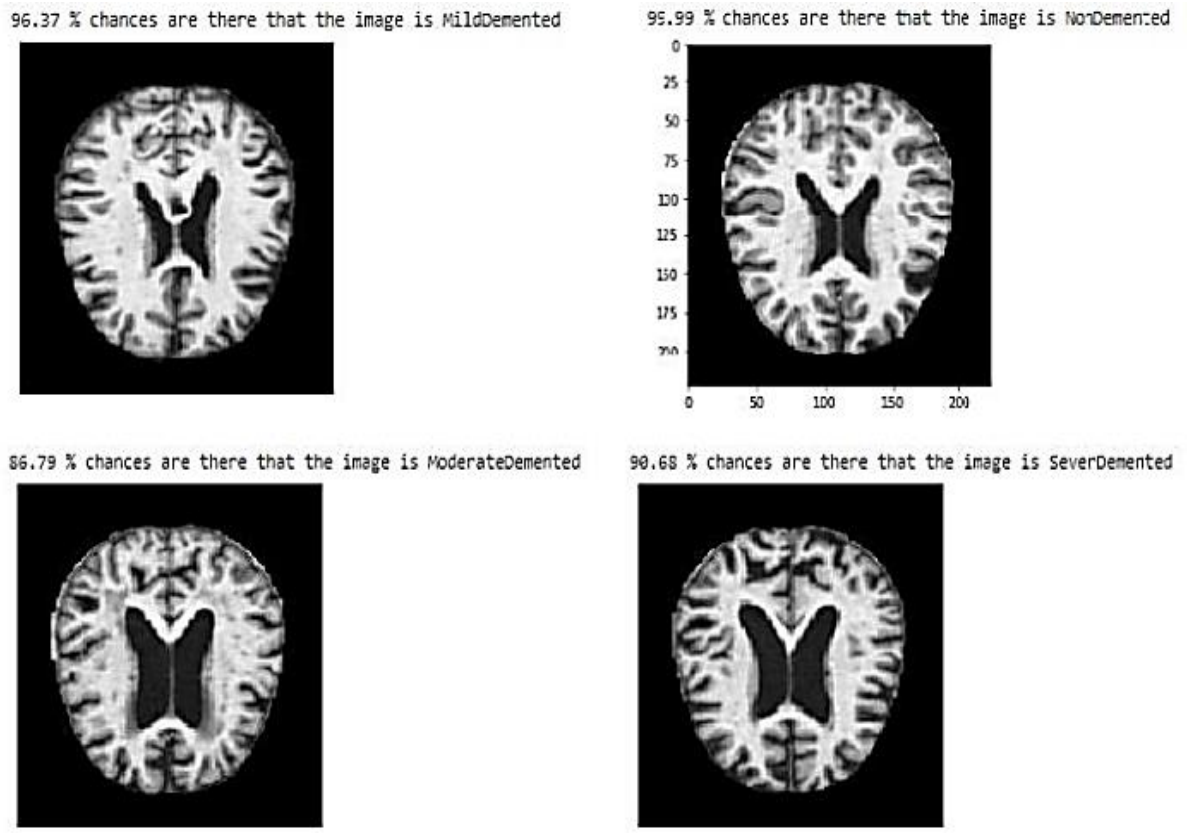

Figure 3: Final predictions

6) CONCLUSION

To tell dementia apart from other illness types, this DenseNet-169 model is useful. For all the reasons stated above, this model is an excellent aid in the fight against dementia, since it has shown a 98% success rate in predicting the four types of dementia used in this study. The process of making a diagnosis of dementia is multifaceted and involved, requiring input from a variety of medical experts. The ability to provide timely and accurate diagnosis has far-reaching ramifications for the quality of life of both the patient and their loved ones. Dementia is a difficult disorder with poor results, thus it is crucial that research and diagnostic methods be continuously refined to increase the likelihood of a correct diagnosis, increase the number of people who can receive a diagnosis, and enhance treatment options.

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