European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 09, Issue 07, 2022

A study on Alzheimer Disease Detection using Machine learning and Deep Learning

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Abstract

Dementia, often known as **Alzheimer's disease**, is a serious neurodegenerative condition that kills brain cells and causes irreversible memory loss. The global burden of disease from a Disenormous. In order to stop the course of **Alzheimer's disease** (AD), early detection is essential. For him and his family, early diagnosis of **Alzheimer's disease** is really helpful. In this publication, we examined previous research on detecting **Alzheimer disease** using **Machine Learning (ML) and Deep Learning (DL)** techniques. We examined numerous machine learning and deep learning approaches in this survey to compare them and determine which one performs better**.**

Keyword: AlzheimerDisease Detection, Machine Learning, Deep Learning.

1.Introduction

Alzheimer's disease (AD) is the sixth biggest cause of death in the US. Ad is a neurodegenerative disease that gradually damages brain cells over time, and memory loss is one of its symptoms. People over 65 have a higher risk of AD. By 2025, there will be 1.2 billion people over 60 in the world, according to the US Census Bureau. A neurological form of dementia known as AD starts out gently and gets worse over time [1].

Alzheimer's disease symptoms are divided into three stages. There are three categories: light, medium, and heavy. The early stages of AD are marked by short-term memory loss, including trouble remembering names, appointments, and recent events, as well as numerical difficulties. Mild cognitive impairment (or MCI) is another name for the first stage of AD. The second stage of AD is characterized by severe memory loss, an inability to carry out daily tasks, dependency on others to manage daily activities, language difficulties and an inability to communicate effectively early on, wandering around in public places, and confusion about the time of day and night. Last but not least, signs of the third stage include being totally dependent and immobile, being unable to

grasp or use words to convey simple ideas, being unable to identify people, especially close family members.

Millions of people worldwide are afflicted by Alzheimer's disease (AD), and the condition's recent rise in prevalence has prompted worries about its effects on society and the economy. There is also concern over the lack of understanding of the mechanisms underlying the onset and development of the disease, as well as the absence of early detection methods and efficient medications to treat the condition [2].

It is important to recognize that Alzheimer's disease (AD) is a pathologic entity that is both complex and clinically heterogeneous. Alterations in structure and function can be observed even in the preclinical stage of the disease, which is usually referred to as Mild Cognitive Impairment (MCI). The first step in diagnosing Alzheimer's disease (AD) is a neurocognitive performance test; further steps include clinical staging and further investigation using neuroimaging techniques and CSF-specific examination[3].

Patients with Alzheimer's disease see an increase in the size of their brain's ventricles at the expense of their cerebral cortex and hippocampus. Spatial and episodic memory are affected when the hippocampus is smaller. Communication issues in short-term memory, judgment, and planning result from this neural damage. This decline damages neuronal ends and synapses and causes further cell death. To categorize and identify AD at an early or late stage, numerous research have been conducted. Brain MRI analysis is the most common and early method of Alzheimer's disease detection. Medical experts review these MRI scans to ascertain the existence of sickness. Numerous factors, such as the existence of a brain tissue, degeneration or tumor and others, can affect this assessment. The severity of this condition necessitates in-depth research in this area [4].

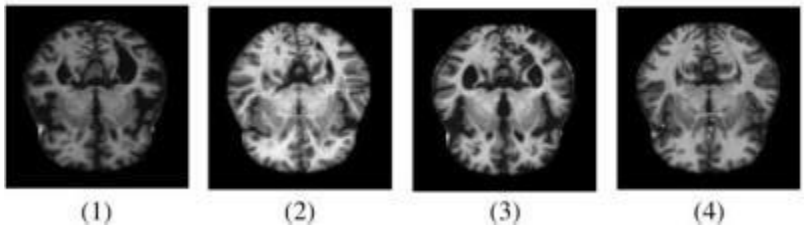

Fig.1. AD stages showing differently in MRI image. (1) MD; (2) MOD; (3) ND; (4) VMD

Although there is currently very little understood about this neurodegenerative illness, there are a number of palliative treatments that can be used to halt its progression. Therefore, early diagnosis is crucial for enhancing the quality of life of those who are afflicted and their loved ones. Clinical, psychological, and cognitive assessments help arrive at this conclusion. Magnetic resonance imaging (MRI) brain images are among the most often used in clinical trials (MRI). This is because the images show changes in brain morphology and have a strong correlation with brain architecture. The main benefit of using MRI images is the capacity to detect changes in brain morphology. The areas of the MRI scans containing the disease's degenerating cells have relatively low intensities, making them appear darker than healthy areas [5].

Over the past decade, machine learning algorithms have proven to be highly useful in the detection of Alzheimer's disease. Deep learning, ANNs, and SVMs are the most often used methods of classification (SVM). The nature of the optimization issue is the key differentiator

between SVM and ANN. In contrast to SVM's globally optimal solution, ANN's is only optimal inside a certain region. Feature extraction is a critical process in both SVM and ANN. Neuronal networks and intelligent agents have been proposed as a potential improvement in the analysis of medical images. But deep learning builds the feature extraction procedure right into the model. Deep learning has proven effective for large datasets, especially those rich in image data. Some researchers have tried using ensemble approaches [6] to boost the accuracy of Alzheimer's categorisation. The early diagnosis of AD will be very helpful for him and his loved ones. In this research, we reviewed previous studies that used ML and DL to detect Alzheimer's disease. In this survey, we compared a wide range of ML and DL methods in an effort to identify the most effective one.

2. Machine Learning Techniques- A Survey

The subject of Alzheimer's disease has been extensively researched. Our research's main objectives are to identify the most effective technique for clinically identifying Alzheimer's disease as soon as possible, for expediting the diagnostic procedure, and for minimizing the role of humans in the diagnosis process. As a result, a few of the associated methods for detecting Alzheimer's are described below.

Three important machine learning methods—SVM, ANN, and DL—were studied by TANVEER M. et al. [6] for the detection of AD. Methods in this category include, among others, transfer, group learning, and multi-kernel learning. Researchers interested in pursuing any of these strategies for Alzheimer's disease can benefit from this. This analysis of usage rates demonstrates the validity of SVM-based models for Alzheimer's disease. This is because, unlike methods like ANN, SVM is immune to the negative effects of local minima. When it comes to incremental learning, modeling sequential data, and describing high-dimensional areas, however, ANNs are more resilient and flexible. Some ANN variations may one day be employed as a therapy for AD. DL and ensemble learning algorithms accurately represent extremely complex data to yield promising outcomes. SVM is more often used since it is more understandable than deep neural networks, which are black box models.

Despite the need for more testing with more patients, Lucas R. et al.[7] demonstrated that several combinations of coherences and spectral peaks are suitable input characteristics for SVM classifiers for automated AD diagnosis. They suggest using SVM in the EEG investigation of dementia patients due to their proven good generalization ability and robustness to deal with high dimensional data. The most significant result of this study was that SVMs performed best when fed only the frequencies of the spectrum peaks captured using bipolar recording. Therefore, they propose using bipolar peaks to generate a set of features from EEG data for SVMs to utilize in categorizing people with AD.

Classification models were employed by Gokce Uysal et al. [8] based on ADNI data to estimate the diagnosis within the limits of right and left hippocampus volume, age, and gender. Using the confusion matrix to evaluate performance, significant success was discovered. With the use of the collected data, it was determined that the characteristics looked at—biomarker combinations—offered a more accurate estimation than did the evaluation of each biomarker alone. It has been shown that gender, which is taken into account when determining hippocampal volume, might influence performance. In this instance, it has been shown that gender may have an impact on diagnosis choices, particularly when it comes to the diagnosis of AD, in addition to atrophy values. Better estimations have been reported in a variety of classification methods when the left

hippocampal volume is used, which is directly related to analytical thinking ability.

In order to identify AD, Lin Liu et al. [9] developed a novel method that used spectrogram characteristics collected from speech data. This method could assist families in early illness understanding of patients, enabling them to take preventive measures. In addition to the new methodology that was suggested, a fresh dataset (the VBSD dataset) was gathered. This study presents a method for segmenting a person's speech data that involves adding samples from a dataset. Different ML strategies were used to investigate the AD and HC voice data. The LogisticRegressionCV model outperformed the others, according to the final experimental data. A speech system application may one day help concerned loved ones keep tabs on their elderly loved ones. The accuracy with which each group is classified can be improved by conducting experiments with more data. The identifying category may be further divided into multiple AD levels for experimentation.

Golrokh Mirzaei et al. [10] intheir study, multiple imaging and ML techniques for diagnosing AD were examined. Alzheimer's disease cannot yet be diagnosed with any certainty. The detection accuracy in all techniques is significantly influenced by the biomarkers' sensitivity. The majority of the biomarkers used in the imaging investigations focused on the types of brain tissue and hippocampal volumetry. To isolate the target area from the images, several segmentation methods were tried (ROI). The cerebrospinal fluid (CSF), the white matter (WM), the hippocampus, the entire brain, and the GM are some of the most commonly used regions of interest (ROIs). Segmentation is an essential step in virtually every type of data processing. In order to classify the ROI, classification algorithms are utilized, but first a labeled data set (training set) must be created. Comparing SVM to the other categorization algorithms studied for AD, it appears that SVM has a greater rate of accuracy.

Images of people with Alzheimer's disease were processed to determined by Priyanka Lodha et al. [11]. They use MRI scans of the brain to collect high-quality images of the regions affected by Alzheimer's disease, analyze them for quantitative data, and then run the data through a machine learning pipeline. It has been found that neural networks and random forests are more accurate than the most popular alternative methods. This method can be used right now to get reliable outcomes. Two effective classification methods that work well with this issue are the Support Vector Machine and the Gradient Boosting. When diagnosed early, persons with Alzheimer's disease have a better chance of receiving effective treatment and avoiding further complications.

M. Shahbaz et al.[12] The early detection and diagnosis of a wide range of illnesses is made possible by ML and data mining techniques, which are incredibly helpful in medical and healthcare research. According to the study's findings, the GLM's overall accuracy over the test period was 88.24%. The findings also demonstrate that the most distinguishing characteristics for the various stages of AD are the CDRSB cognitive test, the total brain volume, the clinical assessment, and the patient's age, among the demographic characteristics. The results also showed that data mining and machine learning techniques can be successfully used in the early detection, prognosis, and diagnosis of a range of diseases. By increasing the amount of examples for the EMCI and SMC classes, the model could be trained with adequate and balanced data for all classes, thus improving the accuracy of the AD phases categorisation.

Research on 3D brain MR image slices for AD diagnosis was done by Srinivasan Aruchamy et al. [13]. Gray and white matter slices from the axial, sagittal, and coronal planes were used in this study. Multiple indicators led to the selection of slice 51 for further study. Each slice's first statistical characterisation has been retrieved. With the help of the characteristics, a correlation heat map may be generated. It is common practice to use PCA for the purpose of feature reduction. In

order to evaluate the efficacy of the suggested method, it has been subjected to logistic regression, Naive Bayes, SVM, and Adaboost classification. These studies make use of OASIS, a free MR imaging data set for the human brain. According to the findings of the study, coronal white matter slices were the most reliable. The proposed method has achieved an accuracy of 90.9% in identifying AD.

For the accurate detection of AD, Swathi S. Kundaram et al. [14] developed a deep convolutional neural network-based technique. Without introducing any custom features into the network during training, they achieved 98.57% accuracy on their dataset. The obtained validation accuracy is 87.72%. In order to collect experimental data, ADNI is used. A total of 13,733 images taken from 266 participants are used. The focus of future research will be on improving the DCNN model in order to obtain performance traits like specificity, sensitivity, recall, and F1-score. As a result, another experiment to evaluate illness prediction by modifying hyper parameters can be conducted. In the future, support vector machine will be used to classify DCNN features.

In order to differentiate AD patients from healthy controls, Ahmad Waleed Salehi et al. [15] evaluated a plethora of linked papers for the diagnosis of the condition. Prior research has mostly concentrated on using DL and the CNN technique to diagnose AD and MCI with data from the ADNI dataset. In their investigation of prior literature, they discovered that many studies offered multi-modal CNNs, multi-class classifications, and binary classifications based on deep neural networks on various populations, all of which achieved higher accuracy. They came to the conclusion that the majority of the studies employed machine learning and deep learning techniques to different datasets.

Jyoti Islam et al. [16] illustrated a framework for Alzheimer's disease identification and categorization is crucial for the timely diagnosis and treatment of patients suffering from the disease. They suggested a DCNN model for automated AD detection and classification. They used the OASIS dataset to show the model's effectiveness. Their approach is quicker, doesn't call for any custom features, and works with small collections of medical images. They presented a one-step technique for AD identification and categorization for the brain MRI data.

Four different optimization techniques—GA, PSO, CS, and GWO—along with a DL classifier were utilized by Chitradevi D. et al. [17] to identify normal and AD structural abnormalities in all of the aforementioned regions. Due to the low quality of the images collected from the hospital, an effort was made to retain and increase image quality using contrast augmentation and skull stripping. Algorithms for optimizing the segmentation of internal brain regions are developed using the improved images. Segmented images are compared to the truth in order to determine how well they match up and validate the segmentation's accuracy. The results show that 97% of the data can be explained by a relationship between segmented images and ground truth. Statistical measurements, including overlapping measures, also revealed a 98% degree of similarity between the ground truth and segmented images. The deep learning classifier, which is more accurate than the other algorithms at classifying normal and AD images, is then fed the segmented brain subregions. The classification findings show that GWO has a better outcome in the HC region with a score of 95%.

A deep learning-based method for the early identification of AD and MCI was proposed by Siqi Liu et al. [18]. The recommended technique simultaneously completes dimensionality reduction and data fusion in order to retain the synergy between data modalities. Both two- and four-class categories saw gains in efficiency.They also showed how high-level biomarkers might be extracted from less biomedical datasets using a multi-layered parametric learning model. This finding might pave the way for computer-aided diagnoses in other biomedical specialties.

A compilation of DL methods for diagnosing Alzheimer's and dementia illnesses, which are frequently seen in neurologic and neuropsychiatric disorders, was published by Emre Altinkaya et al. [19]. Alzheimer's and dementia illnesses can be diagnosed with the help of MRI imaging data. They briefly introduce four common deep learning illness detection strategies. When used on MRI scans, these DL algorithms have great accuracy rates for identifying illnesses. Additionally, the rates of application of these four strategies for additional significant neuropsychiatric and neurological disorders have been identified. This study did not set out to compare methods. Without a doubt, new techniques will be developed as biomedical imaging and deep learning techniques advance.

A 12-layer CNN model for binary Alzheimer's disease categorization and detection was introduced by Emtiaz Hussain et al. [20]. They used the OASIS dataset to carry out their investigation. As data pre-processing methods, image scaling and image denoising were used. The 12-layer CNN architecture they propose is based on DL and ML methods. Their proposed approach beats four pre-trained CNN models as well as an existing 8-layer CNN model. On the OASIS dataset, multi-class classification is what they hope to achieved in the long run, along with early Alzheimer's disease detection.

3. Results and Discussion

Table1.Accuracyofthe related papers

Authors	Methods	Accuracy
PriyankaThakare	SVM	95%
TaherM.Ghazal	CNN	91.70%
GokceUysal	KNN	80%
LinLiu	LogisticRegression	84.4%
PriyankaLodha	Randomforest	97.86%
SwathiS.Kundaram	DCNN	98.57%
EmtiazHussain	CNN	97.75%

ISSN 2515-8260 Volume 09, Issue 07, 2022

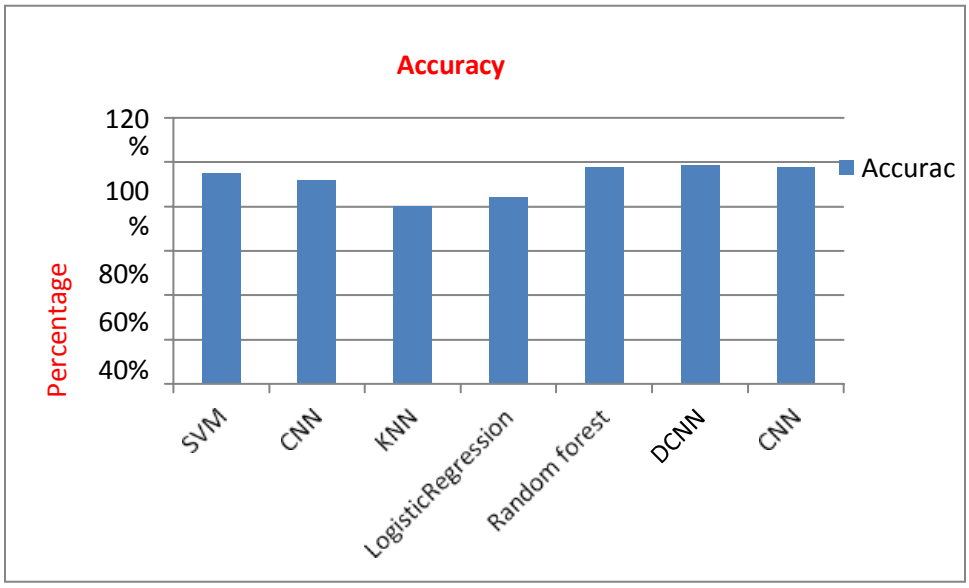

Fig.2.Accuracyoftherelatedpapers

The accuracy of several of the recognized methods for identifying Alzheimer's disease is shown in Table 1 and Figure 2. In comparison to previous techniques for diagnosing Alzheimer's disease, the DCNN has a high level of accuracy, as seen in the graph above. The identification of Alzheimer's illness may be improved using deep learning algorithms.

3.1 Summary

- Because more recent models can offer novel insights into the diagnosis of AD.
- More research is also needed to develop machine learning models that can combine data from many sources in order to detect AD at an early stage.
- Research into the fusion of modalities is necessary to develop multimodal biomarkers for the accurate and conclusive diagnosis of AD. The ability to recognize illness early is greatly aided by this.
- Future studies ought to investigate the brain's transformation from pre-AD to early-onset and progressive AD in AD patients. One day, the findings from these research may be used to determine a therapeutic strategy that can halt or even reverse the disease's progression.
- We can combine multiple datasets with cutting-edge deep learning algorithms to increase the effectiveness and efficiency of AD prediction at early stages.

4. Conclusion

In this research, we examined related works on Alzheimer Disease Detection Using Machine Learning (ML) and Deep Learning (DL) Techniques. In this survey, we reviewed numerous ML and DL techniques in order to determine which one performs better. According to the research, Deep Convolutional Neural Network (DCNN) has a high accuracy when compared to other methods for detecting AD. The use of DL algorithms for Alzheimer's disease diagnosis shows

potential. We can employ advanced deep learning algorithms in numerous datasets together to increase the efficiency and efficacy of AD prediction at earlier stages.

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