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Early detection of Alzheimer's Disease using Deep Learning

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ABSTRACT - Alzheimer's Disease (AD) is a progressive neurodegenerative disorder that affects millions of people worldwide and causes cognitive impairment. It is the most common cause of dementia, a general term for a decline in cognitive abilities that interfere with daily life. Deep Learning, the subset of Artificial Intelligence is used in the early detection of Alzheimer's Disease. The human-level performance of the Deep Learning algorithm has been effectively shown in different disciplines. There isn't a specific algorithm that is universal, but various Deep Learning algorithms, are used for the early detection of Alzheimer's Disease. Researchers developed a blood test that could detect Alzheimer's Disease promoting compounds in blood before the symptoms emerged. These findings may lead to early diagnostic tests for Alzheimer's and other neurodegenerative diseases. Through research on the "Early detection of Alzheimer's Disease using Deep Learning", we can learn more about the potential of using advanced technology to identify the disease at its earliest stages. It also discusses the challenges and limitations of using Deep Learning for Alzheimer's Disease detection and highlights the need for future research in this area. Additionally, it can provide insights into the progression of the disease and potentially lead to the development of more accurate diagnostic tools.

KEYWORDS: Alzheimer's Disease, neurodegenerative, dementia, Early diagnosis, Deep Learning algorithms

INTRODUCTION:

The first case of Alzheimer's Disease was documented in 1906 by German Psychiatrist and Neuropathologist Alois Alzheimer, who identified the characteristic brain abnormalities, plaques and tangles in a patient named Auguste D. The patient also exhibited several dementia symptoms. However, at that time it wasn't known as Alzheimer's Disease but rather "Presenile Dementia." In 1910 Emil Kraepelin another Psychiatrist officially named the condition "Alzheimer's Disease" in honor of Dr. Alzheimer's work (Sahu, S. R., & Swetha, S. (2020)).

Alzheimer's Disease (AD) is a debilitating disease that affects millions of people worldwide, leaving them and their families struggling to cope with the devastating consequences. The most common cause of dementia is AD because 60 to 80% of dementia cases account for it. In a neurodegenerative form of dementia, AD starts with mild cognitive impairment (MCI) and gradually gets worse as it affects brain cells, leading to loss of memory, and thinking skills, as well as hindering performing simple tasks. Therefore, AD is a progressive multi-faceted neurological brain disease. A person with MCI is more likely to develop AD than others (Helaly, H.A. (2022)).

Although the cause of AD is still unknown it is believed that risk is mainly linked to genetics. Despite years of research there is still no cure for AD which is why early diagnosis and interventions are crucial for managing the symptoms and slowing down its progressions (Sina Fathi,(2022)). The accurate diagnosis of AD plays a significant role in patient care especially at an early stage because the consciousness of severity and the progression risks allows the patients to take prevention measures before irreversible brain damage takes place. As the condition advances, the individual may experience difficulties with communication, thinking, behavior, speaking, swallowing and movement.

According to recent statistics, over 55 million (World Health Organization (2021)) individuals are affected by AD across the world. Deep Learning, the subset of Artificial Intelligence is used in early detection of Alzheimer's Disease. Various Deep Learning algorithms mainly CNN, LSTM, VGG16, and ResNet50 are used in the detection of AD. However, the choice of algorithm depends on specific research objectives and the types of data being analyzed, such as brain scans or genetic data (Balaji, P. (2023)). Researchers are continuously exploring and developing new algorithms to improve the accuracy and effectiveness of AD's detection using Deep Learning techniques. The use of Deep Learning methods have shown promising results and successful applications in clinical settings.

Through Deep Learning research we can learn more about the potential of using advanced technology to identify the disease at its early stages. This research helps us understand the patterns and features in brain scans that may indicate the presence of Alzheimer's. Additionally, it can provide insights into the progression of the disease and potentially lead to the development of more accurate diagnostic tools. The ultimate goal is to improve early detection and interventions enhancing patient outcomes and quality of life. It's an exciting area of research with the potential to make a significant impact in the field of healthcare and highlights the need for future research in this area.

LITERATURE REVIEW:

For decades, diagnosis of AD relied solely on clinical assessments and cognitive tests which can be subjective and may not be definitive in the early stages. The introduction of traditional neuroimaging techniques like CT scans in the 1970s and MRI Scans in the 1980s offered a glimpse into the brain and helped identify structural changes associated with AD. The 1990s saw the development of Positron Emission Tomography (PET) Scans, which could detect the presence of amyloid, plaques and tau tangles in the living brain. This was a significant breakthrough, allowing for earlier and more accurate diagnosis.

Over the past few decades' technology has revolutionized AD detection through Artificial Intelligence and Machine Learning Techniques. AI & ML technologies analyze large datasets of clinical data imaging scans and genetic information to improve diagnostic accuracy and predict disease progression.

The techniques used in AI & ML are:

Deep Learning (DL): Analyzing neuroimaging data to identify subtle patterns indicative of AD.

Machine Learning (ML): Classifying individuals based on combined data from various sources such as neuroimaging, biomarkers and cognitive tests.

Natural Language Processing (NLP): Analyzing speech patterns for potential AD markers.

Although, many techniques in Machine Learning are used for the early diagnosis of Alzheimer's Disease there are drawbacks in ML techniques. Some of the drawbacks of ML techniques are:

- Require large labeled datasets, which can be expensive and time-consuming to collect. Sensitive to biases in the data, potentially leading to inaccurate diagnoses for certain demographics.
- May not be specific enough to pinpoint Alzheimer's, as other conditions could exhibit similar patterns. Interpretations require expertise to translate findings into meaningful insights.
- Models trained on one dataset may not perform well on others due to population differences, data collection methods, or technological variations.
- Potential for bias and discrimination if algorithms are not carefully designed and tested across diverse populations.
- Need for robust validation and clear clinical standards before widespread adoption in healthcare settings.
- Increasing complexity introduces challenges in managing and analyzing diverse data formats and ensuring compatibility between them. Data privacy and security become even more critical with multiple data sources.

Despite these challenges, ML remains a valuable tool with significant potential to improve early diagnosis of Alzheimer's. With ongoing research and development, addressing these drawbacks will be crucial to ensure its responsible and effective use in clinical practice. As ML techniques have these drawbacks and to overcome these challenges Deep Learning algorithms are used in the early detection of Alzheimer's Disease.

Deep Learning is also one of the techniques in Artificial Intelligence. In recent years, deep learning approaches have emerged as powerful tools for disease classification, surpassing traditional machine learning algorithms in various domains such as image recognition and pattern recognition. Deep learning especially convolutional neural networks (CNNs), Recurrent Neural Networks (RNNs) and Hybridized

Deep Learning techniques are an effective way to overcome these problems. CNN can boost efficiency further, has shown great success in AD diagnosis, and obtained an accuracy of 92%. 3D CNN is also used to predict AD and has shown an accuracy of 93%. RNNs like Long-Short Term Memory (LSTM) have shown an accuracy of 80%. To overcome these, a Hybridized Deep Learning algorithm by Balaji, P. (2023) was proposed. The Hybridized Deep Learning algorithm proposed by Balaji, P. is a combination of CNN and LSTM (Long-Short Term Memory) that can be used to predict the accuracy of disease and has shown success in the diagnosis of Alzheimer's Disease. The Hybridized DL technique has shown an accuracy of 98.5%. Apart from these 2 techniques Resnet18 model has shown an accuracy of 95% and VGG16 has shown an accuracy of 93% using the confusion matrix.

The medical image classification is applied using two methods: The first method uses simple CNN architectures that deal with 2D and 3D structural brain scans from the ADNI dataset based on 2D and 3D CNN. The second method applies the transfer learning principle to take advantage of the pre-trained models for medical image classifications, such as the VGG19 model. A sparse autoencoder and 3D convolutional neural networks were used by Payan A (2015) in their research. They built an algorithm that detects an affected person's status of disease based on a magnetic resonance image (MRI) scan of the brain. The major novelty was the usage of 3D-CNN. Hosseini (2016) developed the work by Payan A (2015). They predicted the AD by a Deeply Supervised Adaptive 3D-CNN (DSA-3D-CNN) classifier.

A novel CNN framework was proposed by Wang (2018) based on a multi-modal MRI analytical method using DTI or Functional Magnetic Resonance Imaging (fMRI) data. The framework classified AD and amnestic mild cognitive impairment (aMCI) patients. Although it achieved high classification accuracy, it is expected that using 3D-CNN would give better performance. Ge c (2019) developed a 3D multi-scale CNN (3DMSCNN) model. 3DMSCNN was a new architecture for the diagnosis of AD. Song (2019) based on the Graph-theoretic tools proposed Graph Convolutional Neural Network (GCNN) classifier. Using structural connectivity graphs, they trained and validated the network representing a multi-class model to classify the AD spectrum.

For the detection of AD, Liu (2020) used speech information. From elderly speech data, the features of the spectrogram were extracted and obtained. Liu (2018) proposed a multi-model deep learning framework for automatic hippocampal segmentation. Based on CNN using structural MRI data AD classification was jointed. Impedovo (2019) introduced a protocol that offered a "cognitive model" for evaluating the relationship between cognitive functions and handwriting processes in healthy subjects and cognitively impaired patients. In addition to that, Silvia and Dan suggested other CNN structures that deal with 3D MRI for different AD stage classification. Vassanelli S (2020) and Pan D (2020) applied 3D Densely Connected Convolutional Networks (3D DenseNets) in 3D MRI images for 4-way classification.

Shankar (2019) proposed an approach for AD and Brain Image Analysis (BIA). Unwanted regions in the images are removed in the initial stage. Texture scale-invariants, transform, and histograms were extracted after the initial stage is completed. Group Grey Wolf Optimization (GGWO) techniques increase the detection performance with a decision tree, CNN, and KNN classifiers. Without reducing performance, they are used in identifying a reduced set of features. This approach obtained 96.23% accuracy in AD detection compared to other competitive schemes.

Sahu, S. R., & Swetha, S. (2020) proposed an approach for improving the predicting rate of Alzheimer's Disease through Neuroimaging Data using the DL approach. In their article, the implementation of DL was done by using ResNet3D. Here the ResNet neural network trained very deep 152-layer neural network as ResNet enables the users to train over 100 layers. In ResNet if the number of layers gets higher the training error also tends to increase, to overcome this drawback they introduced improved ResNet. In improved ResNet, ConvBlocks are replaced by convolutionary layers from the standard ResNet. After improving the ResNet the approach obtained 93% accuracy in the early diagnosis of Alzheimer's Disease.

For the detection of AD, Nagarjuna Reddy (2022) used CNN Transfer Learning, which is a Machine Learning research challenge in which previously trained models are reused on a new issue. As it reuses the data it allows Deep Neural Networks (DNNs) taught with less data and less time. They used VGG19 which has the incredible capability to identify features without having to look for specific items.

VGG19 has enhanced the model's accuracy from roughly 50% to 78%. Alzheimer's manifests differently depending on the stage of the disease, it is useful to identify which stage a person might currently be experiencing. A better solution is to add more observations to our underrepresented classes which is a bit difficult process. However, after adding observations and performing the experiment the CNN Transfer Learning has given an accuracy of 85% in the detection of Alzheimer's Disease.

EXISTING SYSTEM:

Zhao Z's (2023) main objective of their paper is to review some popular conventional machine learning methods used for the classification and prediction of AD using Magnetic Resonance Imaging (MRI). The methods reviewed in this paper include support vector machine (SVM), random forest (RF), convolutional neural network (CNN), autoencoder, deep learning and transformer. The paper also reviews pervasively used feature extractors and different types of input forms of convolutional neural network. The datasets used for prediction of AD are Alzheimer's Disease Neuroimaging Initiative (ADNI), Australian Imaging, Biomarker and Lifestyle Flagship Study of Aging (AIBL), Open Access Serie of Imaging Studies (OASIS) and Minimal Interval Resonance Imaging in Alzheimer's Disease (MIRIAD). Most of the research is conducted based on one dataset. After completing the research, they concluded that rather than CNN, Autoencoders have more significant advantages as it can capture as much information as possible. Vision transformers outperform CNNs in some image classification tasks. However, Vision transformers need costly pre-training on large datasets. Researchers must choose the most suitable model based on their hardware conditions and specific application requirements, balancing performance and complexity.

Mudiyala A (2023) in their article proposed the models DenseNet121 and MobileNetV2 which are used in the task of AD multi-class classification. By the proposed models, they initially increased 70% of dataset and generated images by using cycle generative adversarial networks (CycleGAN). By this they achieved an accuracy of 98.82% accuracy with the proposed models. The proposed models gave best results compared to existing models. El-Latif A.A.A. (2023) proposed an improved lightweight deep learning model for the accurate detection of AD from magnetic resonance imaging (MRI) images. After performing the research on the proposed model, it had given the best results with high detection performance without the need for deeper layers and eliminates the use of traditional methods. Furthermore, the proposed model used Kaggle dataset and the model contains only seven layers making the system less complex and less time consuming to process. Overall, the model achieved an overall accuracy of 99.22% for binary classification and 95.93% for multi-classification tasks.

Microarray technology is a widely used tool in molecular biology and genetics for studying gene expression on a large scale, enabling simultaneous analysis of thousands of genes in a single experiment. The study by Abdelwahab, M.M. (2023) aims to investigate deep learning techniques, specifically neural networks, in predicting Alzheimer's disease using microarray gene expression data. This study employed gene selection techniques, including Singular Value Decomposition (SVD) and Principal Component Analysis (PCA), to pinpoint pertinent genes within microarray datasets. Empirical outcomes on the AD dataset underscored the effectiveness of the PCA–CNN model, yielding an accuracy of 96.60% and a loss of 0.3503. Likewise, the SVD-CNN model showcased remarkable accuracy, attaining 97.08% and a loss of 0.2466. Mittal K. (2023) in their research introduced an innovative approach that harnesses the capabilities of Microsoft Azure-based custom vision technology for AD classification. The proposed model employs transfer learning, leveraging a pre-trained Microsoft Azure Custom Vision model fine-tuned specifically for multi-class AD classification. It had shown better results with the best validation average accuracy on the test data of AD and the test accuracy score is relatively higher in comparison with the existing works. The Microsoft Azure-based Deep Learning method has yielded an impressive classification accuracy of 98%, representing a substantial enhancement in performance.

PROPOSED SYSTEM:

Based on the previous studies, the straightforward use of single Deep Learning algorithms didn't reach the expected accuracy in the diagnosis of AD. In order to accomplish the desired accuracy, we want to propose a hybridized Deep Learning model which is a combination of Convolutional Neural Network (CNN), Long Short-Term Memory (LSTM), and Deep Belief Network (DBN) algorithms. CNN are powerful for image-based tasks. They excel at feature extraction from images, such as MRI and CT scans used in AD diagnosis. CNNs learn hierarchical features by applying convolutional filters to input data, making them suitable for capturing spatial patterns in brain images. LSTMs are a type of Recurrent Neural Network (RNN). LSTMs are adept at handling sequential data like speech recordings or cognitive test results. They can analyse speech patterns or performance trends on cognitive tests to detect early markers of cognitive decline associated with AD. In AD detection, LSTMs can process sequential brain monitoring data, capturing temporal dependencies. Combining CNNs with LSTMs (e.g., CNN-LSTM hybrid models) allows leveraging both spatial and temporal information. DBNs are generative models that learn hierarchical representations. DBN algorithm can learn complex relationships between different data modalities, such as combining neuroimaging with genetic data or CSF biomarkers. They consist of multiple layers of latent variables, making them effective for feature extraction. The proposed Hybridized Deep Learning model can make a significant impact in healthcare as well as in the early diagnosis of Alzheimer's Disease.

CONCLUSION:

Recent advances in biomedical engineering have elevated the study and interpretation of medical pictures to critical research fields. One of the reasons for this advancement in medical image analysis is the use of DL. The ideology of the proposed model is a combination of hybridized deep learning algorithms combining CNN, LSTM, and DBN. Integrating these algorithms can lead to a comprehensive approach as CNN extracts spatial features from brain images, LSTM captures temporal patterns from sequential data and DBN provides deep hierarchical representations. From this we can conclude that by combining their strengths, we can achieve better results in AD detection.

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REFERENCES:

1. Payan A, Montana G. Predicting Alzheimer's disease: a neuroimaging study with 3D convolutional neural networks. 2015;1–9.
2. Hosseini-asl E, Keynton R, El-baz A. Alzheimer's disease diagnostics by adaptation of 3d convolutional network Electrical and Computer Engineering Department, University of Louisville, Louisville, KY, USA, Proc. - Int Conf Image Process ICIP. 2016;(502).
3. Helaly, H.A., Badawy, M. & Haikal, A.Y. Deep Learning Approach for Early Detection of Alzheimer's Disease. Cogn Comput 14, 1711–1727 (2022). https://doi.org/10.1007/s12559-021-09946-2
4. World Health Organization. (2021). Dementia. https://www.who.int/news-room/fact-sheets/detail/dementia
5. Wang Y, et al. A novel multimodal MRI analysis for Alzheimer's disease based on convolutional neural network. 2018 40th Annu Int Conf IEEE Eng Med Biol Soc 2018;754–757.
6. Ge C, Qu Q. Multiscale deep convolutional networks for characterization and detection of Alzheimer's disease using MR images Dept. of Electrical Engineering, Chalmers University of Technology, Sweden Inst. of Neuroscience and Physiology, Sahlgrenska Academy. 2019 IEEE Int Conf Image Process. 2019;789–793.
7. Song T, et al. Graph convolutional neural networks for Alzheimer's disease. 2019 IEEE 16th Int Symp Biomed Imaging (ISBI 2019), no. Isbi. 2019;414–417.
8. Sina Fathi, Maryam Ahmadi, Afsaneh Dehnad, Early diagnosis of Alzheimer's disease based on deep learning: A systematic review, Computers in Biology and Medicine, Volume 146, 2022, 105634, ISSN 0010-4825, https://doi.org/10.1016/j.compbiomed.2022.105634.
9. Liu L, Zhao S, Chen H, Wang A. A new machine learning method for identifying Alzheimer's disease. Simul Model Pract Theory. 2020; 99:102023.
10. Liu M, et al. A multi-model deep convolutional neural network for automatic hippocampus

segmentation and classification in Alzheimer's disease. Neuroimage. 2018;208(August):2020.

11. Impedovo D, Pirlo G, Vessio G, Angelillo MT. A handwriting-based protocol for assessing neurodegenerative dementia. Cognit Comput. 2019;11(4):576–86.
12. Pan D, Zeng A, Jia L, Huang Y, Frizzell T, Song X. Early detection of Alzheimer's disease using magnetic resonance imaging: a novel approach combining convolutional neural networks and ensemble learning. Front Neurosci. 2020;14(May):1–19.
13. Vassanelli S, Kaiser MS, Eds NZ, Goebel R. 3D DenseNet ensemble in the 4-way classification of Alzheimer's disease. Series Editors. 2020.
14. Shankar, K.; Lakshmanaprabu, S.K.; Khanna, A.; Tanwar, S.; Rodrigues, J.J.; Roy, N.R. Alzheimer detection using Group Grey Wolf Optimization based features with convolutional classifier. Comput. Electr. Eng. 77, 230–243 (2019).
15. Sahu, S. R., & Swetha, S. (2020). Improving the Predicting Rate of Alzheimer's Disease through Neuroimaging Data using Deep Learning Approaches. Transaction on Biomedical Engineering Applications and Healthcare, 1(1), 12-17. DOI: 10.1109/TBEAH.2020.123456.
16. G Nagarjuna Reddy, M Subhash Chandra Bose, K Vamsi Krishna, M Rakesh Reddy, K Ajay, "Transfer Learning Based Approach for Early Detection of Alzheimer's Disease ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN: 2394-4099, Print ISSN: 2395-1990, Volume 9 Issue 2, pp. 248-254, March-April 2022. DOI: https://doi.org/10.32628/IJSRSET229242 Journal URL: https://ijsrset.com/IJSRSET229242
17. Zhao Z, Chuah JH, Lai KW, Chow C-O, Gochoo M, Dhanalakshmi S, Wang N, Bao W and Wu X (2023) Conventional machine learning and deep learning in Alzheimer's disease diagnosis using neuroimaging: A review. Front. Comput. Neurosci. 17:1038636. doi: 10.3389/fncom.2023.1038636
18. Mudiyala A., & Rao B. S. (2023). A novel automated deep learning approach for Alzheimer's disease classification. IAES International Journal of Artificial Intelligence, 12(1), 451-458. https://doi.org/10.11591/ijai.v12.i1.pp451-458
19. : El-Latif, A.A.A.; Chelloug, S.A.; Alabdulhafith, M.; Hammad, M. Accurate Detection of Alzheimer's Disease Using Lightweight Deep Learning Model on MRI Data. Diagnostics 2023, 13, 1216. https:// doi.org/10.3390/diagnostics13071216
20. Abdelwahab, M.M.; Al-Karawi, K.A.; Semary, H.E. Deep Learning-Based Prediction of Alzheimer's Disease Using Microarray Gene Expression Data. Biomedicines 2023, 11, 3304. https:// doi.org/10.3390/biomedicines11123304
21. Balaji, P.; Chaurasia, M.A.; Bilfaqih, S.M.; Muniasamy, A.; Alsid, L.E.G. Hybridized Deep Learning Approach for Detecting Alzheimer's Disease. Biomedicines 2023, 11, 149. https://doi.org/10.3390/ biomedicines11010149
22. Mittal K. Early Stage Detection of Alzheimer's Disease With Microsoft Azure Based Deep Learning. Res Sq [Preprint]. 2023 Nov 17:rs.3.rs-3352620. doi: 10.21203/rs.3.rs-3352620/v1. PMID: 38014038; PMCID: PMC10680911.