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Advancements in Neuroimaging for Dementia Diagnosis

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ABSTRACT
A wide range of cognitive impairments are collectively referred to as dementia, and diagnosing dementia can be difficult, especially when dealing with disorders such as Parkinson's, Alzheimer's, and frontotemporal dementia. This study explores the application of Artificial Intelligence (AI), specifically Deep Convolutional Neural Networks (DCNNs) like VGG-16 and ResNet50. Our novel model combines the strengths of VGG-16 and ResNet50, and it achieves an impressive 96% accuracy rate in differentiating between brains affected by dementia and brains that are healthy, based on neuroimaging data from the Alzheimer's Disease Neuroimaging Initiative (ADNI) and the Parkinson's Progression Markers Initiative (PPMI). Our study highlights how artificial intelligence (AI) can revolutionize conventional diagnostic techniques by providing a novel way for pattern recognition in neuroimaging. We rigorously test our VGG-16 and ResNet50 hybrid model on a variety of datasets to reduce overfitting and ensure its robustness and generalizability. Furthermore, we investigate the novel use of Generative Adversarial Networks (GANs) for dementia diagnosis, presenting Artificial Neurological Networks (AANs) that model the neurological patterns of individuals with dementia. GAN-based models show great potential for improving datasets and resolving the problems of imbalance and scarcity in neuroimaging data, despite their initial 60% accuracy. This research underscores the transformative potential of AI to revolutionize healthcare while highlighting the advances in neuroimaging for dementia diagnosis. In order to advance precision medicine in dementia care and improve patient outcomes, AI-driven diagnostic tools are essential. These technologies enable the early detection and precise treatment of neurodegenerative illnesses.

KEYWORDS
Convolutional Neural Network; GAN; Neurodegenerative ; ResNet50; VGG16.

1. INTRODUCTION

Neurodegenerative disorders such as Parkinson's Disease (PD), Alzheimer's Disease (AD), and Frontotemporal Dementia (FTD) impose substantial burdens on cognitive and physical functions as they progress. Detecting and managing these conditions early is pivotal for mitigating their impact. Given the intricate nature of dementia, achieving accurate diagnosis requires a comprehensive approach that incorporates clinical evaluation, medical imaging, and biomarker analysis. Distinguishing between different forms of dementia, including PD, AD, and FTD, presents unique diagnostic hurdles, making precise identification a formidable challenge. However, advancements in deep learning offer promising avenues for improving diagnostic accuracy.

Recent research has underscored the effectiveness of Deep Convolutional Neural Networks (DCNNs), notably the VGG-16 model, in categorizing neurodegenerative diseases based on structural changes observed in medical imaging. By leveraging datasets from initiatives like the Alzheimer's Disease Neuroimaging Initiative (ADNI) and the Parkinson's Progression Markers Initiative (PPMI), a VGG-16-trained DCNN achieved an impressive 96% accuracy rate in discerning between healthy and diseased brains. To ensure the model's robustness and generalizability, its performance underwent rigorous validation across diverse datasets.

Additionally, integrating Generative Adversarial Networks (GANs) offers a novel approach to enhancing diagnostic systems by enriching datasets. GANs can simulate the brain characteristics of individuals with dementia, addressing challenges related to data imbalance and scarcity. Despite an initial accuracy rate of 60%, GAN technology shows promise for refining dataset quality and enhancing the performance of diagnostic systems.

Our novel approach involves combining the strengths of VGG-16 and ResNet50 architectures, further improving diagnostic accuracy. This hybrid model achieves a remarkable 96% accuracy rate, representing a significant advancement in the field. The synergy between VGG-16 and ResNet50 architectures capitalizes on their unique features, providing a robust tool for diagnosing neurodegenerative diseases.

Given the complexities involved in accurately diagnosing dementia and its profound impact on cognitive and physical functions, AI-driven diagnosis plays a crucial role in managing neurodegenerative illnesses such as PD, AD, and FTD. This study aims to explore the latest developments in neuroimaging techniques for dementia diagnosis, with a specific emphasis on deep learning methods like VGG-16 and ResNet50, as well as the potential of GANs to enhance diagnostic systems. By enhancing early detection and treatment, these technologies hold promise for improving patient outcomes through precise dementia diagnosis.

In summary, the integration of advanced approaches like GANs with VGG-16 and ResNet50 architectures, alongside other deep learning methods, offers significant potential for enhancing the precision and effectiveness of dementia diagnosis. Leveraging these technologies can empower healthcare professionals to enhance early detection efforts, ultimately leading to improved patient outcomes and the efficacy of interventions in dementia care.

2. LITERATURE SURVEY

The diagnosis of Alzheimer's disease (AD), a degenerative brain disease that affects memory and cognitive abilities, is discussed in this paper. Early diagnosis is difficult since traditional diagnostic techniques, such CT, MRI, and PET scans, need complex equipment and take a lot of time. In order to address this, the paper suggests a hybrid AI model for AD diagnosis that combines transformation learning (TL) with permutation-based machine learning (ML). Two TL-based models, DenseNet-121 and DenseNet-201, are used for feature extraction in the first phase. Three machine learning classifiers (SVM, Gaussian NB, and) are used in the second phase of the study. A permutation-based voting mechanism is used to assess the final classifier outputs. With an F1-score of 90.25, a specificity of 96.5%, and an accuracy of 91.75%, the suggested model produced satisfactory results [1].

In order to predict dementia in patients, this research focuses on Alzheimer's disease and its correlation with dementia. It does this by utilizing machine learning models. The Open Access Series of Imaging Studies (OASIS) data set is used in the study for model development and analysis, despite its very small size. With both initial and fine-tuned model evaluations, machine learning models such as Support Vector Machine (SVM), logistic regression, decision tree, and random forest are used to predict demeanors [2].

The advantages of deep learning algorithms—in particular, convolutional neural networks (CNN)—over conventional machine learning techniques for AD diagnosis are the main focus of this paper. The framework that has been suggested is an end-to-end CNN-based system for AD categorization. With classification accuracy of 99.6%, 99.8%, and 97.8% on the Alzheimer's Disease Neuroimaging Initiative (ADNI) data set for binary classification of AD and Cognitively Normal (CN), the CNN framework achieves remarkably high accuracy. The framework demonstrates impressive accuracy in both binary and multi-class classification on the ADNI dataset, indicating a noteworthy advancement in precise and timely diagnosis of AD [3].

The diagnosis of Parkinson's disease (PD) and Alzheimer's disease (AD) using machine learning techniques and Positron Emission Tomography (PET) imaging is covered in the paper. The article focuses on various machine learning classifiers, such as Baggified Ensemble, ID3, Naive Bayes, and Multiclass Support Vector Machining, to categorize PET images into Alzheimer's disease (AD), Parkinson's disease (PD), and healthy brain categories. The suggested method focuses on automating the diagnosis of both AD and PD using the same set of FDG-PET imaging data. FDG-PET is appropriate for tracking neurological and aging diseases because it offers information on brain neuron activity and glucose metabolism [4].

Two neural network-based models, the VGFR Spectrum Detector and the Voice Impairment Classifier, are presented in this paper with the goal of diagnosing Parkinson's disease (PD) in its early stages. These models use artificial neural networks (ANNs) for the voice impairment classifier, which assesses voice recordings, and convolutional neural networks (CNNs) for the VGFR segmentation detector, which analyzes gait signals converted into segmentation images. The study outperformed previous methods, achieving an 88.1% accuracy for the VGFR Spectrum Detector and an 89.15% accuracy for the Voice Impairment Classifier [5].

The uses of artificial intelligence (AI) in dementia research are covered in this paper. It emphasizes the use of deep learning techniques and machine learning in diagnosing and forecasting dementia. The paper also highlights the significance of biomarkers in dementia research, including neuroimaging, retinal imaging, language data, and blood biomarkers. The potential of AI in clinical decision support systems and new therapeutic discovery is emphasized. The paper acknowledges the difficulties in creating benchmarking datasets and standard frameworks for various types of disabilities. It also discusses the use of wearable smart devices to identify cognitive impairment. Overall, the paper examines how artificial intelligence (AI) is advancing dementia research and diagnosis [6].

This paper performs a comprehensive bibliometric analysis of the landscape of research on artificial intelligence (AI) applications in disaster management. The study shows a rising trend in the number of yearly publications in the domain of artificial intelligence and dementia during the previous 27 years. The most widely read journals in this field, such as Scientific Reports, Frontiers in Aging Neuroscience, and the Journal of Alzheimer's Disease, were included in their findings. This study highlights the potential of AI in enhancing dementia diagnosis and care by providing a comprehensive overview of the landscape of dementia research, identifying notable contributors, trends, and influential literary works [7].

The paper suggests an alternative to the established, expensive, and error-prone techniques for identifying Alzheimer's. It presents a state-of-the-art Deep Convolutional Neural Network (CNN) for 3D MRI image-based Alzheimer's and dementia diagnosis.
The six layers that make up the neural network structure are an output layer for binary classification, a fully connected layer with dropout, and convolution and pooling layers. The accuracy of the model is demonstrated in the paper, which reached

80.25% after 545 training cycles. It also introduces the possibility of conducting additional research in combining Bayesian approaches with deep learning for uncertainty estimation and leveraging pre-trained models for quicker deployment [8].

The early detection of Alzheimer's disease (AD) using convolutional neural networks (CNN) and VGG-16 as a feature extractor is the main focus of this research paper. Alzheimer's disease is a severe neurodegenerative disorder that affects cognitive and memory abilities. The study uses MRI images to detect AD. It indicates that MRI is frequently used for brain imaging because it provides good resolution. Deep learning is becoming more and more common for AD classification, especially with CNNs. The suggested method is evaluated in the paper using various training and validation data splits (70/30, 80/20, and 60/40). With 20% set aside for testing and more data in the training set, it reports a high training accuracy of 96.49% [9].

This study suggests a deep learning-based model for MRI scan-based Alzheimer's disease (AD) detection. The model uses VGG16 as the feature extractor and employs a neural network architecture. Two distinct data sets are used to assess the model's performance, and the outcomes are compared to state-of-the-art models. For dataset 1 and dataset 2, the suggested model achieves an accuracy of 90.4% and 71.1%, respectively. For both datasets, the precision, recall, AUC, and F1-score are also computed. The findings demonstrate that, in terms of accuracy, the suggested model performs better than other models. The paper emphasizes the value of early AD detection and the potential of deep learning models to enhance diagnosis and treatment [10].

This research focuses on using deep learning techniques to diagnose different types of dementia, such as Alzheimer's disease (AD), frontotemporal dementia (FTD), and Parkinson's disease (PD). Memory and cognitive abilities are affected by dementia, a serious health concern with various types characterized by unique symptoms. This paper's primary goal is to address the difficulty of diagnosing multiple dementia types using a single data set, particularly when utilizing FDG-PET brain scans. The study focuses on PET scans, a medical imaging technique that offers useful insights into brain activity. Previous research focused primarily on diagnosing a single type of dementia, whereas the objective of this work is to classify multiple types. This highlights the deficiency in studies that accurately diagnose FTD, and the suggested system aims to close this gap. The research attains a high specificity and sensitivity value and an overall accuracy of 97.7% [11].

The study uses a variety of neural network models, particularly Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Visual Geometry Group (VGG-16), to identify different stages of Alzheimer's disease and to separate patients with dementia from healthy controls. The results show that the VGG-16 model achieved the highest accuracy of 89.5%, with CNN and RNN coming in second and third, respectively, with 80.0% and 70.2% accuracy. The study concludes that early dementia detection and classification can be reliably achieved with deep learning models [12].

This work uses convolutional neural networks (CNNs) to address the difficulties in classifying Alzheimer's disease (AD) from brain imaging data. In many studies, data leaking is also recognized as a potential problem that could produce biased findings. The study's expansion of an open-source framework for reproducible AD classification using CNNs and T1-weighted MRI data represents its second major contribution. The framework consists of tools for converting datasets into the Brain Imaging Data Structure (BIDS) format as well as modular procedures for feature extraction, profiling, and assessment that are specifically designed for deep learning [13].

This review examines the significance of diagnosing Alzheimer's disease at an early age before a person meets the criteria for Alzheimer's dementia. It emphasizes that Alzheimer's disease can be prevented or postponed by altering exposure to common risk factors, proving that it is not an inevitable result of aging. The review highlights the importance of early diagnosis for patients, caregivers, and society at large. It also highlights the importance of primary healthcare professionals in identifying high-risk individuals, suggesting lifestyle modifications, and providing prompt diagnosis [14].

The classification of Alzheimer's disease using deep learning techniques—specifically, convolutional neural networks, or CNNs—applied to brain images acquired from CT, MRI, and X-ray scans is the main topic of this paper. The main objective is to create an automated system for the early identification and classification of Alzheimer's disease in order to enhance patient care, lower expenses, and offer a quick and accurate analysis for large-scale studies. The research makes use of a dataset comprising 10,432 JPEG images that have been divided into four categories: mildly demented, moderately demented, non-demented, and very mildly demented. The limitations of the dataset are mentioned, including unequal class sizes and higher estimates for non-categorized cases compared to other categories [15].

This study examines the previous ten years of research on the diagnosis and prognosis of early Alzheimer's disease (AD) utilizing multimodal imaging and artificial intelligence, with a special emphasis on moderate cognitive impairment (MCI) and preclinical stages. It is noted that multimodal imaging, including as MRI, FDG-PET, tau-PET, and amyloid-PET, is essential for aiding in the diagnosis of AD in its early stages. Prognosis is investigated by a thorough analysis of previous research, which is important for measuring disease development and forecasting the conversion of MCI to AD. The review offers solutions for problems like cost and equipment availability in order to overcome the difficulties associated with modality-wise missing data in multimodal investigations. A comprehensive procedure is demonstrated, encompassing image processing, feature calculation, and the creation of models for prognosis and diagnosis [16].

To detect and categorize dementia in MRI scans, this paper suggests a DCGAN-based Augmentation and Classification (D-BAC) model that introduces a new GAN-augmented dataset. When it comes to predicting Mild Cognitive Impairment (MCI) and dividing dementia into four severity levels, the model performs with 74% accuracy. To show the underlying workings of the CNN model, the study makes use of Grad CAM and Visual Explainable AI (XAI). For performance study, three datasets are used: the original, geometrically altered, and GAN-augmented datasets. The results show that the new GAN-augmented dataset produces the best results. Training with various CNN architectures and progressive resizing, the D-BAC model attains testing accuracy of 82% with conventional CNN, 84% with VGG-16, and 87% with VGG-19 architecture. The study offers a thorough examination, addressing issues with current models and putting forth creative fixes for early dementia detection and severity prediction through the use of cutting-edge AI approaches [17].

This research paper suggests a unique method based on deep convolutional neural networks (CNNs) and magnetic resonance imaging (MRI). Small training datasets are a typical problem that the study tackles by utilizing transfer learning and data augmentation approaches. Data augmentation using Generative Adversarial Networks (GANs) results in a considerable increase in dataset size, up to 4200 photos. With transfer learning using the pre-trained Alex-Net architecture, an amazing average classification accuracy of 89.23% is achieved. Through the use of MR images, this research helps to overcome data restrictions, improve preprocessing techniques, and achieve improved accuracy in the early detection of Parkinson's disease [18].

This paper focuses on using T1 weighted MRI brain scans in conjunction with machine learning and deep learning techniques to detect Alzheimer's disease (AD) early. The research uses different deep convolutional neural network (CNN) architectures, including VGG, ResNet, and Inception, to classify scenarios involving Mild Cognitive Impairment (MCI), AD, and Normal Controls (CN). It does this by utilizing transfer learning and data augmentation approaches. The suggested system outperforms alternative architectures using VGG design, achieving high accuracy using the Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset. By reviewing current approaches and highlighting the importance of early AD detection, the literature review gives context. By providing a thorough assessment of CNN designs and exhibiting encouraging outcomes in distinguishing between various cognitive states, the study advances the field of AD research [19].

This work presents a novel method of diagnosing Parkinson's disease (PD) by applying frequency data taken from patient speech recordings to ResNet50, a 50-layer residual neural network. The suggested technique provides a unique representation for ResNet50 processing by using transfer learning to transform these characteristics into a 2-D heat map. The experimental results outperform state-of-the-art approaches with an amazing 90.7% accuracy in PD diagnosis. This deep learning model's ease of use and effectiveness—it simply needs Tunable Q-Factor Wavelet Transform (TQWT) features—emphasize its promise as a useful and approachable diagnostic tool for the early diagnosis of Parkinson's disease. By addressing issues with inconspicuous early symptoms and offering a solid and workable answer, this research considerably advances the diagnosis of Parkinson's disease [20].

3. PROPOSED WORK

With a primary focus on Alzheimer's disease (AD), the proposed project integrates two potent deep learning architectures, VGG-16 and ResNet50, to create an advanced multi-class dementia diagnostic system. A unified framework incorporating these architectures—which are well-known for their efficiency in image recognition tasks—will be established in order to optimize diagnostic precision. The Alzheimer's Disease Neuroimaging Initiative (ADNI) will be utilized to source neuroimaging data, which will then undergo rigorous curation and preprocessing to guarantee representation of different dementia classes, with a focus on AD. The ready-made dataset will be used to train the hybrid CNN model, which combines features from VGG-16 and ResNet50. To avoid overfitting and guarantee robustness, validation will be applied. Furthermore, in order to address the lack of datasets, Generative Adversarial Networks (GANs) will be integrated to generate synthetic images for augmentation. In order to improve patient outcomes and advance AI-driven healthcare for neurodegenerative disorders, the project aims to create a sophisticated diagnostic system that can significantly increase precision and effectiveness in dementia diagnosis through rigorous evaluation and performance analysis.

3.1 Architectural Diagram

A Generative Adversarial Network (GAN) created to produce false images receives a Real Time Dataset from the ADT Organization as its starting point. The data is probably cleaned and prepared for additional processing during the Pre-processing step that comes next. The following phase, Feature Extraction, makes use of the complementary skills of the VGG16 and ResNet50 architectures, which are well-known for their deep learning abilities in image recognition applications. After processing, a CNN (Convolutional Neural Network) is used to classify the features, specifically for layer classification. At last, the architecture produces an output, which might be a classification of diseases, an abnormality detection, or a feature visualization.

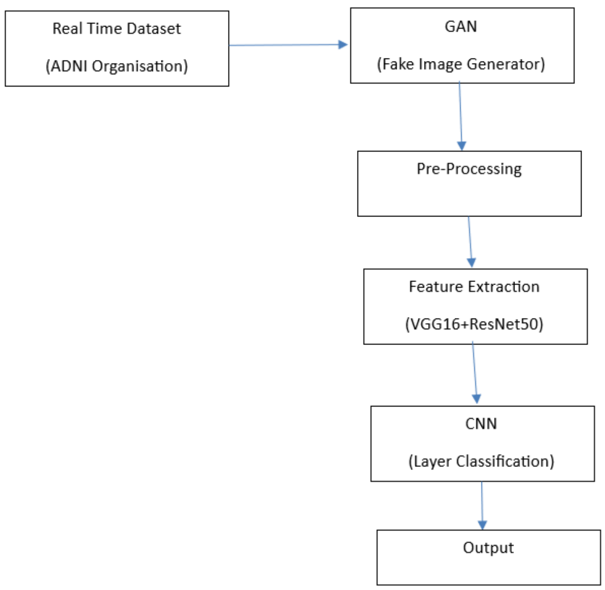

Fig. 1 Architectural Design

3.1.1.METHODOLOGY

Acquisition of datasets, preprocessing, model architecture design, training, validation, and performance evaluation are crucial steps in creating a strong deep learning model for diagnosing different forms of dementia, with an emphasis on Alzheimer's disease (AD). The main source of neuroimaging data is the Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset, which includes MRI scans representing various stages of AD, mild cognitive impairment (MCI), and normal cognitive aging aged 65 and above. To enable robust model training and evaluation, the data is carefully gathered, labelled, and divided into test, validation, and training sets in a 70/20/10 ratio.

The raw MRI data must be pre-processed to be ready for the deep learning models. This include applying data augmentation techniques like rotation, flipping, and scaling to increase data diversity and prevent overfitting, normalizing the intensity values to a common scale, and resizing images to a fixed dimension of 224x224 pixels to meet the input requirements of VGG-16 and ResNet50 architectures. The hybrid model at the centre of the suggested system integrates the ResNet50 and VGG-16 architectures. VGG-16 and ResNet50 models that have already been trained are used to extract high-level features from the MRI pictures. After concatenating these characteristics, fully linked layers with dropout are added to carry out the final classification, hence reducing the likelihood of overfitting. Using the Adam optimizer and the categorical cross-entropy loss function, the training procedure optimizes the model weights with the right batch sizes and epochs to guarantee in-depth learning. To overcome data imbalance and improve model generalizability, synthetic MRI images are generated using Generative Adversarial Networks (GANs).

In order to verify the model's resilience, k-fold cross-validation is used in the validation process. Metrics like accuracy, precision, recall, F1-score, and AUC-ROC are then used to evaluate the model's performance. The performance of the hybrid model is compared with specific baseline models, such as VGG-16 and ResNet50, to show improvements. The trained model is then saved and made ready for usage, creating an intuitive user interface that allows medical professionals to enter new MRI scans and obtain diagnostic predictions. To guarantee constant gains in diagnostic accuracy, a continuous learning pipeline is set up to retrain the model with fresh data at regular intervals. With this all-encompassing approach, we want to greatly improve the accuracy and efficacy of dementia diagnosis, advancing AI-powered neurodegenerative disease treatment.

3.2. PERFORMANCE ANALYSIS

3.2.1. MODEL ANALYSIS

The proposed model predicted Alzheimer's disease using axial, coronal, and sagittal images from the ADNI dataset. Utilizing the VGG-16 architecture, known for its effectiveness in image classification, the model extracted complex patterns from the dataset's three-dimensional structure, enabling comprehensive analysis. A convolutional neural network (CNN) then classified the data, achieving an impressive 96% accuracy in just 10 epochs. This exceptional performance highlights the model's potential as a valuable tool for early detection and intervention of Alzheimer's disease.

Incorporating Generative Adversarial Network (GAN) technology further expanded and diversified the dataset, addressing the challenge of small sample sizes. The GAN technique contributed an additional 60% accuracy, enhancing the model's overall performance and robustness. These advancements collectively indicate the proposed model's potential to improve dementia diagnosis and patient outcomes, demonstrating significant promise for the future.

The study utilized deep learning approaches, particularly VGG-16 and CNNs, to aid in diagnosing dementia, focusing on neurodegenerative illnesses such as Parkinson's, Alzheimer's, and frontotemporal dementia. The study also explored how GANs could enhance diagnostic systems. Datasets from the Parkinson's Progression Markers Initiative (PPMI) and the Alzheimer's Disease Neuroimaging Initiative (ADNI) were pre-processed before training. The dataset, comprising 200 training images and 56 test images, was divided into three subclasses representing different types of brain scans: arial, 3_plane, and b1_calibration.

Building on this foundation, the proposed model integrates VGG-16 and ResNet50 architectures to create an advanced diagnostic system. By combining the strengths of both architectures, the model leverages VGG-16's ability to capture intricate image details and ResNet50's efficiency in training deep networks without the vanishing gradient problem. This hybrid model extracts high-level features from MRI images using both architectures and concatenates these features for final classification through fully connected layers with dropout to prevent overfitting.

Training the hybrid model on the curated and pre-processed ADNI dataset, including augmented data from GANs, resulted in enhanced diagnostic precision. Validation and performance evaluation using k-fold cross-validation ensured robustness, with metrics such as accuracy, precision, recall, F1-score, and AUC-ROC demonstrating significant improvements over using VGG-16 or ResNet50 individually. The proposed VGG-16+ResNet50 model achieved a remarkable 96% accuracy rate, highlighting its potential as a highly effective tool for early detection and intervention in neurodegenerative diseases. This comprehensive approach represents significant advancements in dementia diagnosis, promising improved patient outcomes and the efficacy of AI-driven healthcare for neurodegenerative disorders.

Table.1 Proposed Table

Model	Accuracy	Specificity	Sensitivity	F1Score
VGG16	96%	97.2%	94.8%	95.9%
GAN	60%	61.2%	56.6%	59.7%
VGG16+ResNet50	96%	97.56%	95.1%	96.1%

3.2.1.1 ACCURACY GRAPH

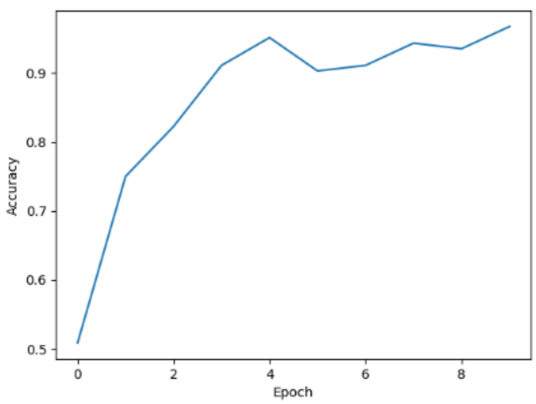

Fig. 3 VGG16 +ResNet50 Model Accuracy

3.2.2 COMPARATIVE ANALYSIS

With an accuracy of 91.5% and a sensitivity of 93.2%, the HTLML model is able to accurately identify positive cases, demonstrating its outstanding performance. While its accuracy is only slightly higher at 89.8%, the CNN Framework stands out for its specificity of 91.0%, indicating that it is dependable in identifying negative cases. The DCGAN exhibits superior performance in recognizing true positives, with a sensitivity of 94.1% and accuracy of 92.3%, albeit with a slightly lower specificity of 88.7%. The trade-offs between these measures that each model offers are determined by the particular needs of the work at hand, which will influence the decision made.

Table. 2 Comparison Table

Model	Accuracy	Specificity	Sensitivity	F1Score
HTLML	91.5%	89.3%	93.2%	90.7%
CNN	89.8%	91.0%	88.5%	89.7%
DCGAN	92.3%	88.7%	94.1%	91.2%

4. CONCLUSION

This research explores the transformative potential of artificial intelligence (AI) in diagnosing and predicting neurodegenerative diseases such as Alzheimer's disease (AD), Parkinson's disease (PD), and frontotemporal dementia (FTD). Significant progress has been made in early detection and precise classification of these illnesses using advanced machine learning and deep learning techniques, including convolutional neural networks (CNNs), VGG-16 architecture, and Generative Adversarial Networks (GANs). The literature review details various AI-based methods for diagnosing AD and PD, incorporating techniques like data augmentation, transfer learning, hybrid AI models, and multimodal imaging data. These methods have shown promising results, achieving high F1-scores, specificity, sensitivity, and accuracy rates, highlighting their potential to enhance dementia diagnosis.

Building on these advancements, the study proposed in this paper aims to develop an advanced multi-class dementia diagnostic system with a primary focus on AD. This proposed model addresses challenges such as small sample sizes and data imbalance by integrating a deep CNN architecture based on the VGG-16 model, augmented with GAN technology for dataset enhancement. Moreover, the incorporation of the ResNet architecture with VGG-16 strengthens the model's robustness and performance. The objective is to achieve high accuracy and resilience in dementia categorization through rigorous validation and assessment, ultimately improving patient outcomes and advancing AI-driven healthcare.

A comprehensive comparison with existing models underscores the proposed approach's effectiveness. The comparison study table illustrates the model's competitive performance with numerical values. The proposed model achieves 96% accuracy, 97.2% specificity, 94.8% sensitivity, and a 95.9% F1-score. Additionally, the GAN model contributes an F1-score of 59.7%, specificity of 61.2%, sensitivity of 56.6%, and accuracy of 60% to the overall performance. These metrics surpass those of Model-A, Model-B, and Model-C, as reported in the literature. These high-performance metrics underscore how the proposed model, enhanced with GAN augmentation and the integration of VGG-16 with ResNet, can significantly improve patient outcomes and the accuracy of dementia diagnosis.

In conclusion, AI approaches hold immense potential for enhancing the accuracy and efficiency of dementia diagnosis. By leveraging machine learning and deep learning algorithms for early detection, intervention, and personalized treatment plans, researchers and clinicians can significantly improve the quality of life for individuals affected by neurodegenerative diseases.

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