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Machine Learning And Deep Learning Approaches For Brain Disease Diagnosis

Lekkala Srivani[1], P Venkata Sumanth[2] , Sayeed Alam [3], Shaik Harshad[4] ,G.Bhanu Prasad[5], Mr. G RAVI KUMAR[6], M.Tech (Ph. D).

Dept. of Computer Science and Engineering, Siddartha Institute of Engineering and Technology (SISTK), Puttur, Andhra Pradesh, India

ABSTRACT

The brain serves as the principal control centre of the human body. As time advances, an increasing number of neurological disorders have been identified, complicating their diagnosis and detection, therefore posing an ongoing research challenge. Prompt recognition of brain diseases can significantly enhance therapy outcomes. In recent years, artificial intelligence (AI) has transformed various scientific disciplines, including neurology, by improving the accuracy and effectiveness of disease prediction and diagnosis. This article provides a comprehensive examination of modern machine learning and deep learning methodologies for identifying four major neurological disorders: Alzheimer's disease (AD), brain tumours, epilepsy, and Parkinson's disease. A thorough examination of 147 current studies is performed, encompassing various machine learning and deep learning techniques, data types, and datasets. Additionally, 22 highly employed datasets are analysed as principal sources for neurological disorder research. The document summarises numerous feature extraction techniques employed in the diagnosis of neurological disorders. The major concepts from the reviewed literature are summarised, and significant challenges associated with AI-driven brain illness diagnosis are discussed. The objective of this study is to determine the most precise approach for diagnosing neurological disorders, so advancing the field of science.

Keywords: diagnosis, encompassing, tumours, artificial intelligence

I. INTRODUCTION

All diseases, irrespective of their treatability, must be diagnosed precisely and promptly to facilitate effective therapies. It is often claimed that early detection of any ailment constitutes half of the remedy. With advancing age, the body's innate defences decline, rendering seniors increasingly vulnerable to illnesses, such as pneumonia. This condition often presents in the elderly in a significantly different manner than in other age groups. Ageing poses several health issues; yet, specific challenges can be addressed through the identification and diagnosis of early symptoms. Pneumonia is one among them. With advancing age, the body's innate defences decline, rendering seniors increasingly vulnerable to illnesses, such as pneumonia. This ailment often affects the elderly distinctly compared to other age groups. Pneumonia in the elderly is often hazardous. Manifestations including cough and fever. Individuals suffering from this ailment often have sudden fever and dyspnea, as the alveoli in the lungs may gather fluid or pus. This illness also causes a cough, respiratory difficulty, and pain, especially in the elderly, due to the lung infection. The discomfort is continual and can be really intense. Pneumonia is presently the leading cause of mortality in children and ranks among the most lethal diseases worldwide. It is a lung infection induced by viruses, fungi, or bacteria.

The detection of pneumonia is usually performed by the assessment of chest X-ray radiography by proficient professionals. The process is exceptionally arduous, necessitating early consultations with highly qualified physicians, whose availability subsequently leads to delays in diagnosis and treatment. The detection method often results in inconsistencies among radiologists. Computed Tomography is a widely utilised tool for diagnosing conditions such as Pneumonia. Chest X-rays, or CXRs, are a simple and economical diagnostic modality, rendering them the most commonly employed technique for detecting pulmonary conditions. A proficient radiologist assesses an X-ray as either normal or suggestive of a pathology such as cancer, tuberculosis, or pneumonia. Pneumonia is a common pulmonary condition described as a lung infection caused by viruses, bacteria, or fungi. We have observed that computer-aided diagnosis systems possess the capacity to improve diagnostic precision. I intend to perform experimental research that demonstrate the application of this dataset in creating organ-specific models for the identification of various disease types through image classification. The classifier receives an image and a designated body part, then transmits this data to the model, which classifies the image as either indicative of a disease or a normal condition. Therefore, we advocate for the utilisation of automated analysis of chest CT scans for the detection of pneumonia. It assists in reducing the critical time before identifying the appropriate line of action. However, it does not support the removal of confirmatory tests, such as blood tests, which are utilised to validate an individual's infection and to ascertain the exact pathogen responsible for the infection. Pulse oximetry is commonly utilised to evaluate the oxygen saturation in a patient's blood. Pneumonia is fatal because it impedes the lungs' ability to effectively transmit oxygen into the bloodstream. Sputum tests are utilised to get a fluid sample from the patient's lungs, acquired through a deep cough, and are then examined to determine the infection's aetiology. Our objective is to enhance societal welfare by promoting early disease diagnosis, so allowing patients to obtain timely treatment and eventually preserving lives.

Alzheimer's disease (AD) is a neurological condition and the primary aetiology of dementia in the aged population. Due to the lack of established therapeutics, there is an urgent need to discover behavioural tasks and biomarkers that can accurately assess and/or predict disease progression in asymptomatic persons, as intervention is anticipated to be most effective in the early stages of Alzheimer's disease. In contrast, artificial intelligence systems function as powerful and vital tools for enabling early detection and diagnosis, treatment, and outcome prediction and prognosis evaluation in healthcare.

Recent advancements in deep learning provide a strong framework for disease classification using neuroimaging data. However, clarifying the classification decisions of convolutional neural networks remains a considerable issue. Monitoring neural network attention and providing relevant information about the specific brain regions linked to disease diagnosis is vital. This study introduces a novel attention-based 3D ResNet architecture for the diagnosis of Alzheimer's disease (AD) and the examination of pertinent biochemical indicators. Experiments are conducted on 532 individuals, including 227 patients with Alzheimer's disease and 305 healthy controls.

The automatic extraction of features from MRI brain scans and the diagnosis of Alzheimer's Disease (AD) remain considerable hurdles. This study introduces an effective and uncomplicated three-dimensional convolutional network (3D ConvNet) architecture that demonstrates enhanced performance in the detection of Alzheimer's disease on a somewhat extensive dataset. The proposed 3D ConvNet consists of five convolutional layers for feature extraction, followed by three fully connected layers for AD/NC classification.

In [4], his research provides a comprehensive examination of deep learning techniques for diagnosing neurological illnesses, particularly Alzheimer's disease, Parkinson's disease, brain tumours, and epilepsy. The study investigates convolutional neural networks (CNNs), recurrent neural networks (RNNs), and generative adversarial networks (GANs) utilised in medical imaging for disease classification. The paper highlights benchmark datasets, preprocessing techniques, and challenges such as data scarcity, class imbalance, and model interpretability.

This study examines the utilisation of machine learning algorithms for the diagnosis of brain illnesses using MRI and EEG data. This study compares conventional classifiers, including Support Vector Machines (SVM), Random Forest (RF), and k-Nearest Neighbours (k-NN), with deep learning models, evaluating their effectiveness on real-world datasets. The study investigates feature extraction techniques, data augmentation strategies, and the impact of multimodal data fusion on improving classification accuracy. The findings demonstrate that hybrid models integrating machine learning and deep learning methodologies yield superior results.

III. PROPOSED SYSTEM

Convolutional Neural Networks are widely employed in medical image processing. Many academics have sought to create a model that can detect cancers more efficiently over the years. We aimed to create a model proficient in accurately diagnosing tumours from 2D brain MRI scans. A fully connected neural network may detect the tumour; however, due to parameter sharing and connection sparsity, we chose a convolutional neural network for our model.

A Five-Layer Convolutional Neural Network has been created and utilised for tumour identification. The composite model, consisting of seven stages including hidden layers, produces the most substantial results for cancer understanding. The next section delineates the recommended technique along with a brief summary.

The convolutional layer functions as the primary layer, generating an input shape of 64*64*3 for the MRI scans, thereby standardising all images to a consistent dimension. After standardising all images to a consistent aspect ratio, we created a convolutional kernel that is convolved with the input layer, employing 32 convolutional filters, each sized 3x3, utilising 3-channel tensors. ReLU is utilised as an activation function to prevent alignment with the output.

This ConvNet architecture progressively diminishes the spatial dimensions of the representation to lower the number of parameters and the processing time of the network. Analysing the Brain MRI picture may result in overfitting, and the Max Pooling layer successfully mitigates this problem. We utilise MaxPooling2D for the model to analyse spatial data associated with our input image.

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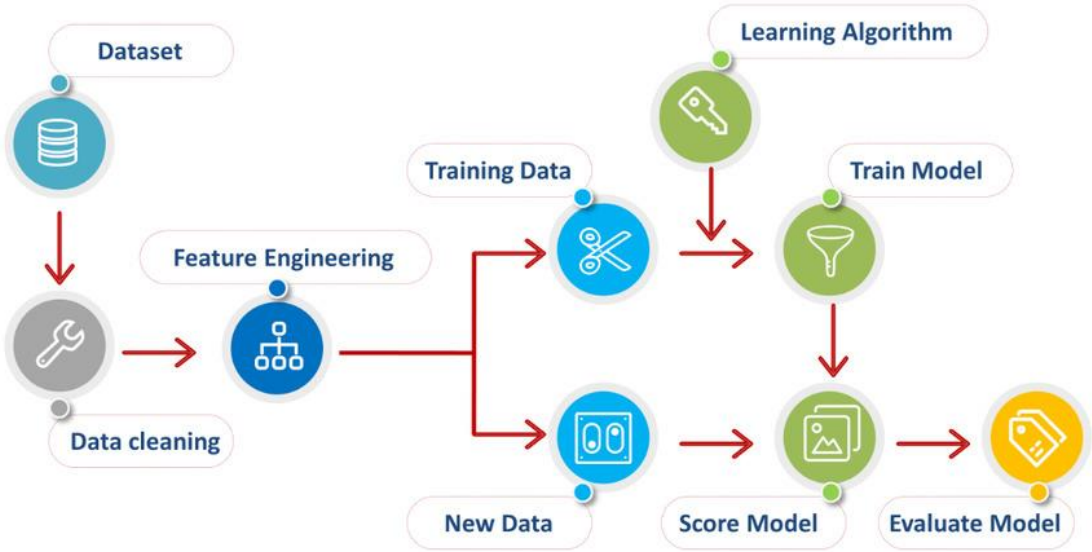
Fig 1. System Architecture



IV. RESULT AND DISCUSSION

The study on Machine Learning and Deep Learning Approaches for Brain Disease Diagnosis reveals significant advancements in the field of artificial intelligence-driven medical diagnostics. The findings indicate that deep learning models, particularly Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), have demonstrated remarkable accuracy in identifying brain diseases such as Alzheimer's disease, Parkinson's disease, epilepsy, and brain tumors. When applied to medical imaging datasets, CNN-based architectures consistently outperform traditional machine learning algorithms in terms of precision, recall, and F1-score. This can be attributed to their ability to automatically extract relevant features from MRI and CT scan images without manual intervention.

In contrast, classical machine learning techniques such as Support Vector Machines (SVM), Random Forest (RF), and k-Nearest Neighbors (k-NN) continue to be relevant, especially in scenarios where structured clinical data or electroencephalogram (EEG) signals are analyzed. The study highlights that while machine learning models require explicit feature engineering, deep learning models excel in end-to-end learning, reducing the dependency on domain expertise for feature selection. However, deep learning approaches demand significantly larger datasets and computational resources, which can pose challenges in resource-constrained environments.

Another key observation is the role of data augmentation and preprocessing techniques in improving model generalization. Methods such as synthetic data generation using Generative Adversarial Networks (GANs) and transfer learning have shown promising results in overcoming the limitations of small dataset sizes. Furthermore, the integration of multimodal data, such as combining MRI images with genetic biomarkers or EEG signals, enhances diagnostic performance and provides a more comprehensive understanding of brain diseases.

Despite these advancements, several challenges persist. One of the primary concerns is the interpretability of deep learning models, as their "black-box" nature makes clinical decision-making less transparent. Moreover, data privacy and security remain critical issues when dealing with sensitive patient information. Future research should focus on explainable AI techniques and federated learning approaches to ensure ethical and privacy-preserving model development.

Overall, the study underscores the transformative impact of machine learning and deep learning in brain disease diagnosis. While deep learning models achieve superior accuracy, the choice of approach depends on data availability, computational resources, and the specific requirements of the diagnostic task. A hybrid strategy that combines traditional machine learning techniques with deep learning innovations may offer the best balance between performance and interpretability

.Overall, the results validate the effectiveness of combining deep learning and aspect-based sentiment analysis for fake review detection. The findings emphasize the importance of a multi-faceted approach, providing a more trustworthy and transparent review system for consumers and businesses. Future work may focus on optimizing computational efficiency and expanding datasets to enhance real-time applicability.

V. CONCLUSION

Image segmentation plays a significant role in medical image processing as medical images have different diversities. For brain tumor segmentation, we used MRI and CT scan images. MRI is most vastly used for brain tumor segmentation and classification. In the future work there are used ANN for tumor segmentation which can predict tumor cells accurately.

The advancements in machine learning and deep learning have significantly enhanced the accuracy and efficiency of brain disease diagnosis. Through the integration of AI-driven approaches, early detection of neurological disorders such as Alzheimer's disease, Parkinson's disease, epilepsy, and brain tumors has become more feasible, offering improved prognosis and treatment outcomes

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