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NeuroDetect AI: A Deep Learning Framework for Alzheimer's disease Detection using MRI Scan and Clinical Data

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Abstract: Early and accurate detection of Alzheimer's Disease (AD) is critical for slowing cognitive decreasing and allowing for timely clinical intervention, especially as the prevalence of the disease increases among older adults. Traditional diagnostic methods that rely on a single type of data often limit accuracy and do not capture the disease's complex nature. This study introduces a multimodal deep learning framework that combines structural Magnetic Resonance Imaging (MRI) and clinical data to improve classification performance. The method uses a ResNet50 convolutional neural network to identify important spatial features from MRI scans. This helps in recognizing structural brain issues related to Alzheimer's Disease.At the same time, clinical data is processed with different machine learning models, including ensemble of Logistic Regression, Random Forest clssifier, XGBoost classifier, and Gradient Boosting classifier, to uses patient-specific biomarkers and demographic details. The results from these separate paths are assessed to provide additional insights into disease prediction without relying on direct fusion methods. The accuracy of the model using ResNet50 on MRI data is 96% and the accuracy of the model for clinical data is 95%. The dataset used in this project is MRI and clinical data from kaggle. This work aims to be scalable and flexible, which makes it suitable for real-world clinical use. By combining neuroimaging with clinical features, this study helps create strong and more reliable tools for early Alzheimer's detection. This, in turn, supports better patient outcomes and informed choices in healthcare systems.
Keywords: Deep Learning, ResNet50 CNN, Machine Learning, Random Forest classifier, XGBoost classifier, and Gradient Boosting classifier.

I. INTRODUCTION

Alzheimer's Disease (AD) is a progressive brain disorder that leads to cognitive decline, memory loss, and impaired reasoning, primarily affecting older adults. As the global population ages, AD has become a significant public health issue, making it essential to find early and effective diagnostic methods to slow down the disease and improve patient care. Traditional diagnostic methods, like clinical assessments and brain scans, often focus on one type of data. This approach may not capture the complex nature of the disease. In recent years, advancements in artificial intelligence, especially deep learning, have shown promise in automating the detection of Alzheimer's disease using brain imaging data like Magnetic Resonance Imaging (MRI). Convolutional Neural Networks (CNNs) have been commonly used to extract features from MRI scans, allowing for accurate classification of AD and its stages. Transfer learning methods, particularly those using models like ResNet50, have further enhanced performance by employing pre-trained models to identify intricate brain patterns linked to neurodegeneration. Hybrid and multi-stage deep learning models have also been suggested to improve classification accuracy and address differences in disease progression. However, relying only on imaging data may limit diagnostic effectiveness since Alzheimer's Disease is affected by various clinical and biological factors. To tackle this issue, recent studies have looked into multimodal approaches that combine imaging with clinical data, showing better prediction performance and reliability. Ensemble machine learning methods, such as Random Forest, XGBoost, and Gradient Boosting, have been effectively used on clinical datasets to identify patient-specific patterns and biomarkers. The Alzheimer's disease detection is very important to cure it in its early stage. The dataset used in this model is kaggle MRI oasis dataset for alzheimer's disease detection and Alzheimer's clinical dataset for clinical data from kaggle.

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This project aims to enhance prediction accuracy. Inspired by these developments, this study presents a multimodal framework that combines MRI-based deep learning with clinical data-based machine learning models to improve Alzheimer's Disease classification. By merging information from multiple data sources, this approach seeks to provide a more reliable and thorough diagnostic solution.

II. LITERATURE SURVEY

After reviewing the research papers from different journals on the Alzheimer's disease detection I have got to understand that how different models are applied on the same data. Especially MRI scans and clinical data.This tells us how to handle the data how to resample the data. The study proposes a multimodal deep learning combining both MRI data imaging and clinical data for Alzheimer's Disease detection. The authors tried to use different data sources to make the model work perfectly on unseen data. This helps the model to work efectively without making mistakes on unseen data. Training the model on different data sources will make the model more reliable and accurate. I have seen how transfer learning make the model more robust . Transfer learning makes the training time of the model low and this makes the model to work more fast and accurate. But this works only for small datasets. After know all this about transfer learning I choosed ResNet50 for my model because the dataset which I used is areound 80,000 images of brain scans and I used ensemble of classifiers for clinical data.[1][2]

The authors used ResNet50-based transfer learning approach for Alzheimer's detection using MRI scans. The model effectively extracts deep spatial features from brain scans, improving classification performance. Its results demonstrate that ResNet50 more reliable and performs well than that of traditional CNN architectures. This work reinforces the importance of deep feature extraction in medical imaging tasks. A hybrid deep learning model is for classifying different stages of Alzheimer's Disease. The model combines multiple architectures to make both local and global image features. It improves stage wise classification accuracy, which is crucial for treatment. This study gives the advantage of hybrid architectures in handling complex medical data.A multi-stage deep learning framework for Alzheimer's classification. It focuses on distinguishing between various disease progression stages not only on simple binary classification. The model improves interpretability and reliabillity by structuring the classification process. This approach improves early-stage detection and clinical applicability.[3][4][5]

The work utilizes the Xception-based deep learning model for Alzheimer's detection using MRI data. The architecture goes depth wise separable convolutions to enhances computational efficiency. The model achieves high accuracy while reducing difficulty. It demonstrates the effectiveness of advanced CNN architectures in medical diagnosis. This provides a comprehensive review of deep learning techniques used for Alzheimer's detection. It takes various models, including CNNs, RNNs, and hybrid approaches. The study discusses challenges such as data unavailability and model generalization. It serves as a strong foundation for understanding current research based trends in this field. The implementation of ResNet-based architecture for Alzheimer's detection using MRI scans. Their approach focuses on improving feature extraction ans selection through residual learning. The model achieves better performance compared to traditional machine

learning methods. This work emphasizes the importance of deep residual networks in medical imaging it makes the model more effective and reliable.[6][7][8]

After reviewing several papers I have seen that the automated Alzheimer's detection using deep learning techniques. It focuses on minimizing manual intervention in feature extraction and classification. The model demonstrates strong performance in identifying disease patterns from MRI data. The work showcases the potential of fully automated diagnostic systems. An ensemble deep learning model for Alzheimer's detection. Several models are combined to upgrade prediction accuracy and reduce overfitting. The ensemble approach enhances robustness across different datasets. This study shows the advantage of combining multiple learners in medical diagnosis. The automated Alzheimer's classification using MRI data and deep neural networks. The model effectively distinguishes between healthy controls, mild cognitive impairment that is MCI in Alzheimer's patients. It demonstrates strong performance on standardized datasets. This work is considered foundational in applying deep learning to AD detection.[9][10][11]

Deep learning techniques to brain MRI analysis for Alzheimer's diagnosis. It focuses on feature learning directly from raw imaging data. The model improves classification accuracy compared to traditional methods. This research highlights early adoption of deep learning in neuroimaging. The CNN-based classification of Alzheimer's Disease using structural MRI data. It demonstrates that deep learning can automatically extract relevant features without manual preprocessing. The results show improved diagnostic accuracy over conventional approaches. It is one of the pioneering works in this domain. The present a machine learning-based approach for Alzheimer's classification using MRI data. Traditional algorithms are used for feature extraction and classification. The study highlights the limitations of classical methods compared to deep learning approaches. It provides a baseline for evaluating newer models.[12][13][14]

Therefore, existing literature shows that deep learning, especially CNNs and multimodal approaches, significantly improves Alzheimer's Disease detection accuracy, though challenges in generalization and real-world implementation remain. After looking into all the references I have gained I got to understand the each approach is different with different data. But all are aiming to uprade the performance of the model with correct predictions. By this I got to know that making the model more accurate on unseen data will make the model more robust and perfect. Major trends are on the performance optimizing and prefect predictions of the model.

III. PROPOSED SYSTEM

The suggested system is an intelligent deep learning system intended to identify and categorize Alzheimer's disease(AD).Within a si ngle web based platform, the system integrates clinical data evaluation and MRI-based evaluation.

The proposed system's main goal is to improve early detection accuracy and help clinicians make wise decisions by utilizing trustworthy forecasts that are independent of specific Data sources. The modular architecture used in the system's development allows all of its parts to cooperate in order to process and interpret the given data.Users can submit MRI pictu res or other structured clinical data, like biomarkers, demographic information, or cognitive tests. After processing each type of data separately using various analysis tools, the system gives users classification results for various stages of Alzheimer's disease.

One of the most important parts of the system is the MRI Analysis Module. This module uses a deep learning architecture based on ResNet50 to pull out and sort spatial features from MRI scans. The MRI images are preprocessed before being fed into the network, which lets the model find structural brain abnormalities and atrophy patterns that are linked to Alzheimer's disease. The main goal of this module is to learn how to tell the difference between imaging features that help make accurate predictions about the stage of a disease.Another important module is the Clinical Data Analysis Module, which focuses on well-organized patient data.This module uses ResNet50 and deep learning to find spatial features and sort MRI scan images. This module processes MRI scan images before they are fed into the network.This module processes MRI scan images before they are sent to the network. This helps find structural problems in brain imaging that are linked to Alzheimer's disease. This module extracts imaging features that help tell what stage the disease is in. The Clinical Data Analysis Module is another important part. This module is in charge of looking at structured patient data. This module uses machine learning models like Logistic Regression, Random Forest, XGBoost, and Gradient Boosting to look at clinical and cognitive features like MMSE, CDR, and other traits.

The stage of Alzheimer's disease can be independently predicted by these models. Instead of combining MRI-based and clinical-data-based predictions into a single fused output, the system uses an Independent Output Mechanism. This increases openness and enables medical professionals to independently interpret each prediction, making the system more comprehensible and useful for decision support.

IV. SYSTEM ARCHITECTURE

The system architecture is designed to support multimodal Alzheimer's Disease detection by integrating a user-friendly web application and additional data analysis processes pertaining to MRI and clinical data. It is designed to make it easy for the user, the web application interface, and the data preprocessing and prediction models to work together. The frontend layer is the main way for users to interact with the system. The user can upload pictures of MRI scan results using the web app. The user can also enter structured clinical data. The interface is easy to use, so users can enter both types of data. Users can also see the results of the prediction separately through the interface. The web app lets users upload MRI scan images, which then go through the MRI processing pipeline. The images are preprocessed so that they can be analyzed. The ResNet50 algorithm analyzes the MRI data after it has been preprocessed. It finds important spatial features and sorts them into different stages of Alzheimer's disease. The final output of this pipeline is the result of the classification and the confidence score.

The clinical data processing pipeline begins when a user inputs clinical information into the system. This input is sent to the preprocessing module, which takes care of missing values, scaling, and preparing features. After preprocessing, ensemble machine learning techniques are used to look at clinical data. These techniques make an independent prediction about how to classify Alzheimer's Disease. Pipeline also gives a classification result and a confidence score. The backend layer connects the frontend interface to the analysis modules so they can talk to each other. It is in charge of handling input, processing requests, running the model, and making the results. The backend makes sure that the MRI and clinical data pipelines run separately and that the web application gets the results in the right way. After seeing architecture I can clear say that how data moves from one layer to another this makes the model more clear and more understandable. The outputs should be display to the user after the classification. The User layer that is the frontend should be more friendly to access and make the model reliable. The data will be transformed from one layer to another .This makes the model more robust and effective.

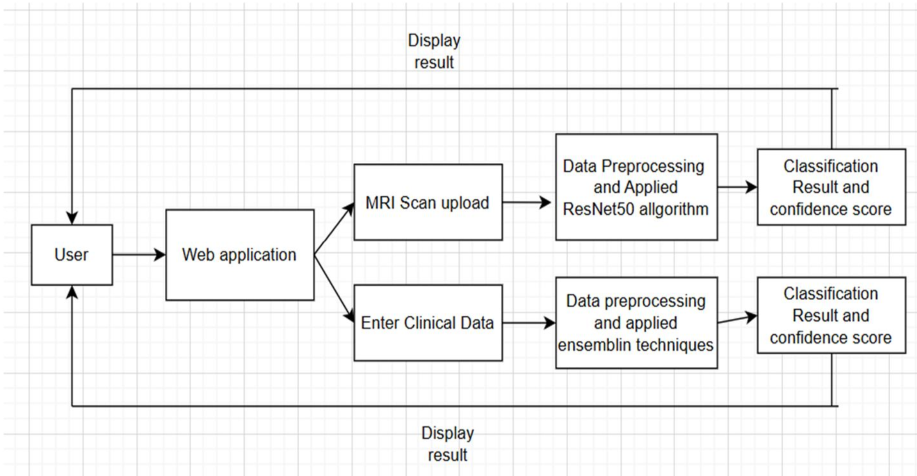

Fig. 1 System Architecture

V. IMPLEMENTATION

The implementation of the proposed system focuses on the development of an intelligent and interactive platform for Alzheimer's Disease detection using MRI scans and clinical data. The system is developed using modern web technologies and machine learning techniques to provide accurate and efficient disease classification. The frontend is implemented using React to create a responsive and user-friendly interface, while the backend is developed using Node.js to handle system logic, data processing requests, and communication between the interface and the prediction models. The overall implementation is divided into multiple functional modules, each designed to perform a specific task within the system. These modules collectively contribute to a unified platform for MRI-based analysis, clinical data evaluation, and result presentation.

A. User Interface Module

This module provides the main point of interaction between the user and the system. Through the web application, users can upload MRI images, enter clinical details, and view the prediction results. The interface is designed to be simple, clear, and accessible so that users can easily navigate through different system functions. It also ensures that MRI-based and clinical-data-based outputs are displayed separately for better understanding.

B. Mri Upload And Analysis Module

The MRI upload and analysis module allows users to submit brain MRI images for automated evaluation. Once uploaded, the images are validated and preprocessed using operations such as resizing, normalization, and formatting to make them suitable for model input. The processed MRI data is then passed to the ResNet50 deep learning model, which extracts meaningful spatial features and identifies structural brain changes associated with Alzheimer's Disease. Based on this analysis, the system generates a classification result and confidence score.

C. Clinical Data Analysis Module

The clinical data analysis module processes structured patient information such as age, MMSE score, CDR value, demographic details, and other relevant medical attributes. The input data is first validated and preprocessed to handle missing values, scaling, and formatting inconsistencies. After preprocessing, the data is analyzed using an ensemble of machine learning models, including Logistic Regression, Random Forest, XGBoost, and Gradient Boosting. These models generate an independent classification result based on clinical attributes.

D. Backend Processing Module

This module acts as the bridge between the frontend interface and the prediction models. It handles input requests from the user, routes MRI and clinical data to their respective preprocessing and analysis pipelines, and manages inference execution. The backend ensures that both pipelines work independently and that results are generated efficiently. It also coordinates the transfer of final outputs back to the web interface for display.

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E. Result Display Module

The result display module presents the output to the user in a clear and understandable format. It shows the classification result and confidence score for the MRI analysis pipeline and the clinical data analysis pipeline separately. This independent display mechanism improves transparency by allowing users and clinicians to compare both outputs directly. Such an approach makes the system more interpretable and practically useful for decision support.

The developed system was evaluated for Alzheimer’s Disease detection using MRI images and clinical data. The system successfully processes user inputs and generates classification results with confidence scores through separate MRI and clinical data pipelines. The independent predictions improve interpretability and provide multiple perspectives for diagnosis.

The MRI analysis module effectively captures structural brain patterns associated with Alzheimer’s Disease, while the clinical data module provides consistent predictions based on patient-specific features. Additionally, the modular architecture ensures efficient data processing and scalability for future enhancements.

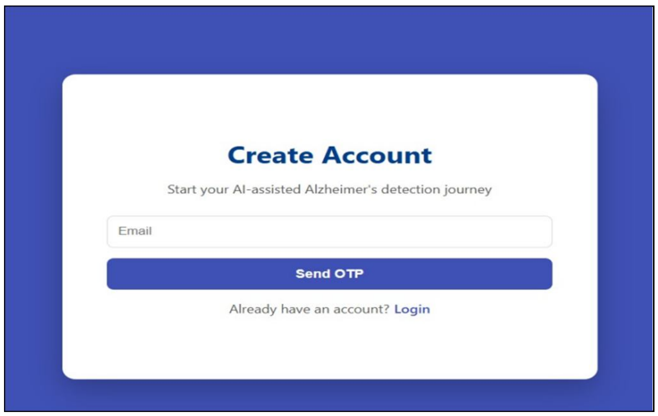

Fig. 2. User Registration and Login Interface

The MRI analysis module was evaluated using sample MRI scans from different Alzheimer’s stages. The system processed the images and accurately classified them into categories such as Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. This helps in early detection and supports clinical decision-making. MRI scans.

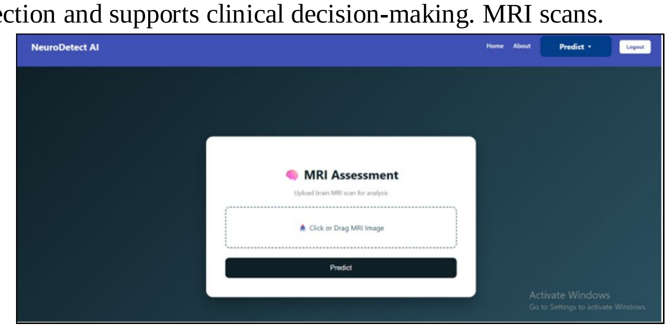

Fig. 3. MRI Scan Upload

The clinical data analysis module evaluates patient information such as age and medical history to identify disease-related patterns. The generated predictions complement MRI-based results, improving system accuracy and enabling better diagnosis.

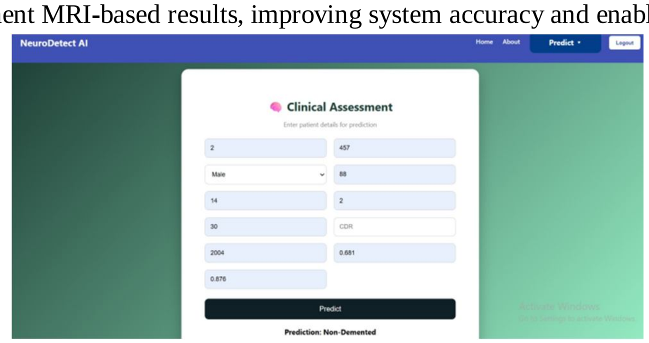

Fig. 4. Clinical Assessment

The decision-level integration module enables the system to combine predictions from both MRI analysis and clinical data evaluation in a unified manner. The system processes outputs from the ResNet50 model and ensemble machine learning models to generate a final diagnosis. During testing, the system produced consistent and reliable predictions by effectively integrating results from both modalities. This approach allows the system to improve overall diagnostic accuracy and supports healthcare professionals in making informed and precise decisions.

This integration ensures that both imaging features and clinical attributes are considered simultaneously, providing a more comprehensive understanding of the patient's condition. By avoiding complex fusion techniques, the system maintains simplicity while still achieving effective performance. As a result, the system supports healthcare professionals in making informed, precise, and timely clinical decisions.

Developed a multimodal AI system integrating ResNet50 for MRI analysis and ensemble machine learning models for clinical data, with decision-level integration to generate accurate Alzheimer's Disease predictions.

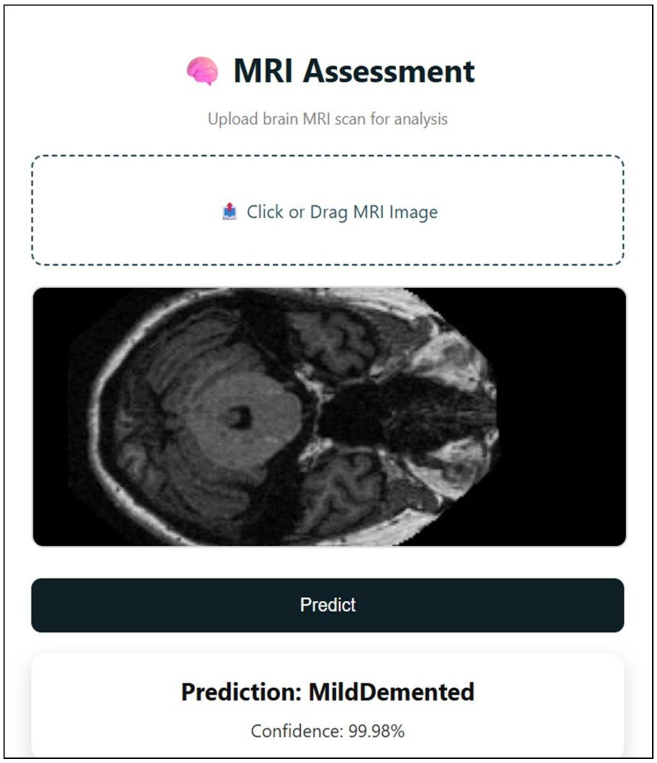

Fig. 5. MRI Assessment

The system also includes a result and report generation module, which provides detailed diagnostic outputs based on the analysis of MRI images and clinical data. This module retrieves prediction results from both the MRI and clinical models and presents them to the user in a clear and structured format. This feature helps healthcare professionals focus on patient-specific conditions and improves confidence in making informed clinical decisions.

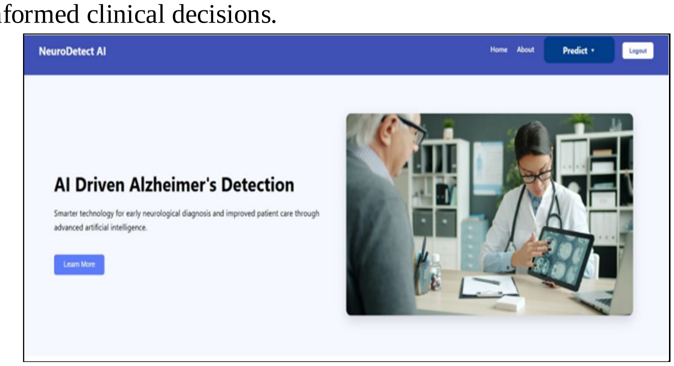

Fig. 6. Home page

VI. CONCLUSION

This paper presents NeuroDetect AI, an AI-based diagnostic system .The main objective of this system is to assist in the early detection of Alzheimer’s Disease using MRI images and clinical data. The system integrates several components such as MRI-based deep learning, clinical data evaluation using ensemble models, and decision-level integration within a single platformThe system uses advanced machine learning and medical data analysis to make reliable predictions and structured insights that help find the best way to track disease progression. The MRI analysis allows users to upload their MRI Scans and module correctly sorts brain images into different stages of Alzheimer's Disease.This really helps users identify their condition accurately. The clinical data analysis module, on the other hand, looks at patient-specific information to make predictions more accurate. The system also gives clear outputs that help healthcare workers understand the results. After completing this project I got to know about the data preprocessing and how to handle large data.

This system aims to support early diagnosis of the disease by offering fast, efficient and intelligent predictions . By providing accurate predictions and analysis, NeuroDetect AI can help in identifying Alzheimer’s Disease at earlier stages and give needfulsuggestions to the users based on their condition.

VII. FUTURE WORK

The current implementation of NeuroDetect AI provides works effectively for prediction of Alzheimer’s Disease by providing detailed insights based on MRI Scans and clinical data, but we can further modify the current system for further enhancement in future versions of the system. One way of making it better is to use advanced explainable AI techniques, such as Grad-CAM, to make the disease easier to understand. Another way of making the system better is to add more types of information, such as genetic information and lifestyle information, to make the predictions more accurate and reliable. Another way of making this system more reliable is to add more medical information to the dataset and utilize real-time clinical decision support systems. Since now this model contains only MRI scan and clinical data we try to add speech module too and fusion all the inputs in one model for more precise accuracy related to the Alzheimer’s disease detection

The reliability of the platform can be enhanced by adding more medical data to the dataset and utilizing real-time clinical decision support systems. The future studies may also explore the application of advanced deep learning techniques and hybrid models to enhance the classification and detection accuracy. The NeuroDetect AI system can be made more efficient and an all-in-one healthcare platform that assists physicians in decision-making and early detection by incorporating these features.

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