Alzheimer's Disease Detection Using Deep Learning

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***Abstract*—Alzheimer's disease is a progressive brain disorder that damages nerve cells, causing memory loss, impaired thinking, and difficulty performing daily activities. Early detection is crucial for effective treatment and improved patient care, but conventional diagnosis relies on specialists manually analyzing MRI scans and medical reports, which can be time-consuming and subject to interpretation differences. This paper presents an automated system for classifying Alzheimer's disease stages from MRI brain images using a hybrid Convolutional Neural Network (CNN) and Support Vector Machine (SVM) model, where the CNN extracts important image features and the SVM performs the final classification. The system classifies MRI images into four categories: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. To enhance usability, the model is integrated with a Streamlit web application that enables users to upload MRI images and instantly receive the predicted disease stage along with a confidence score. Experimental results demonstrate that the hybrid CNN–SVM model outperforms a standalone CNN, particularly in the early detection of Alzheimer's disease, highlighting the potential of artificial intelligence to provide fast, accurate, and reliable support for clinical diagnosis.**

***Index Terms*—Alzheimer's Disease, Magnetic Resonance Imaging (MRI), Hybrid CNN-SVM Model, Feature Extraction, Non-Demented, Very Mild Demented, Mild Demented, Moderate Demented**

I. INTRODUCTION

Alzheimer’s disease is a brain illness that primarily impacts memory and thinking skills. It is one of the most frequent causes of dementia in older adults. Individuals with Alzheimer’s might begin to forget things, struggle with decision-making, and find it hard to perform daily tasks. Because the disease progresses gradually, early signs are often overlooked or missed. As a result, many patients are diagnosed only after the disease becomes more severe [1].

Doctors look at mri scans to spot brain shrinkage when checking for alzheimers. But going over those scans takes time and a specialist eye for the details.AI steps in as a teammate of sorts. Deep learning lets it check images fast and catch small patterns that get missed sometimes. It feels like a quick second opinion so doctors see things earlier i think [4].

This project is trying to use deep learning on MRI images to find Alzheimer’s disease. It looks at different stages automatically and uses a CNN model for the analysis and predictions. There is also a web app where someone can upload an image and get the result back [2][6].

Some people might see the whole thing differently. Adding text to the source panel seems like a start at least. Once that is done a briefing doc or video could show the models working. It gets a bit messy figuring out the exact next steps though. The main point is to give doctors a quick way to detect it early.

Doctors used to rely on talking to patients and their medical history to figure things out. Memory tests played a big role too. Stuff like the MMSE and CDR checked memory and thinking skills. It seems those worked okay but they depended a lot on the doctor. Maybe that is why early stages were hard to catch, later on scans like MRI became more common since the images show up clear. You can spot brain areas shrinking or spaces getting larger which might mean Alzheimer’s is there. PET and CT scans got used as well but they do not always stand out the same way. Still going through the images takes a long time and needs real experience [8].

II. LITERATURE REVIEW

Doctors traditionally diagnose Alzheimer's disease based on medical checks, patient history, and memory tests. Doctors offer patients questions and administer tests to assess their memory, cognitive aptitude, linguistic skills, and problem-solving abilities. Common tests, such as the MMSE and CDR, are frequently used to assess the patient's mental state and detect signs of dementia [3].

Aside from these tests, doctors use brain imaging techniques including MRI and CT scans. These scans allow doctors to examine the anatomy of the brain and detect alterations that may be linked to Alzheimer's disease. Common changes include the shrinking of certain brain areas and the enlargement of brain spaces. Doctors typically review these photos manually to seek for such signs; nevertheless, while these procedures are frequently utilized, they have certain limitations. The doctor's expertise and experience frequently determine the diagnosis. The results may occasionally be interpreted differently by different medical professionals. Additionally, it can be time-consuming and labour-intensive to manually analyze MRI scans [1], [2].

The inability of conventional techniques to identify the illness in its early stages is another significant drawback. It can be challenging to identify minor brain alterations, and many people receive a diagnosis only when memory loss and other symptoms worsen.

Due to these difficulties, conventional techniques might not always yield quick and reliable results. Automated systems that can more rapidly and precisely analyze MRI images [2] are now required. Consequently, the diagnosis and categorisation of Alzheimer's disease are being supported more and more by machine learning and deep learning approaches.

Deep Learning in Medical Image Analysis.

Machine Learning Methods for Alzheimer's Disease Detection [4].

Neuroimaging Techniques in Alzheimer's Detection.

Hybrid CNN–SVM Models for Alzheimer's Disease Detection [8].

III. PROPOSED METHODOLOGY

The system they came up with can spot Alzheimer disease from MRI brain scans and figure out the stage it is in. It mixes deep learning with machine learning to get better results overall. Collecting the images from a public dataset is where things begin and that dataset has scans from different stages the steps are shown in Fig 1.

Users send their own MRI files through a basic web app so the analysis can run. Image preparation and picking out the main features happen after that and then the stage gets predicted. It seems like the combination of methods helps but I am not totally sure how each part connects in practice.

The image gets resized and normalized with noise cleaned out too so everything ends up in a similar format. This step helps the model run better overall. The CNN then takes that image and picks up patterns from brain areas that could connect to alzheimer's changes the methodology is shown in Fig 2.

Features come out of the CNN and go straight to the SVM for the actual classification into stages like non demented, very mild demented, mild demented or moderate demented. It seems the SVM makes the call more precisely this way instead of relying only on the CNN output in the Fig 3. Some of those brain details are easy to miss without the switch, i think the whole flow works but maybe not every part is needed the same for all cases.

The prediction shows up in the web app with a confidence score next to it. Users can check the outcome pretty quick that way. These features from the deep part go into an SVM classifier after that. It sets up margins in the space to separate the classes better and maybe cut down on mistakes between close alzheimer's stages. The mix of cnn and svm seems useful here since one handles the learning and the other does the deciding part well enough for medical images.

Then streamlit in the Fig 4 shows the mri scan along with the stage it picks like non demented or very mild or mild or moderate. Not everything lines up perfectly though. Demented—and corresponding confidence scores. This integrated framework enables real-time analysis and provides a user-friendly decision-support tool for early and accurate detection of Alzheimer's disease. Alzheimer's disease. Python is used as the main programming language because it supports many useful libraries for machine learning, image processing, and data handling.

Before training the model, MRI images are processed using libraries such as NumPy, OpenCV, and PIL.

These libraries help with tasks like resizing images, normalizing data, and improving.

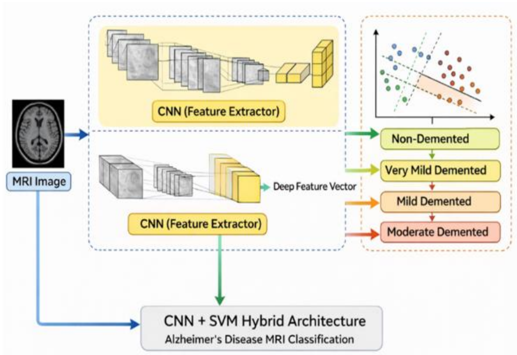

Figure 1: Model Architecture depicting the complete disease detection steps

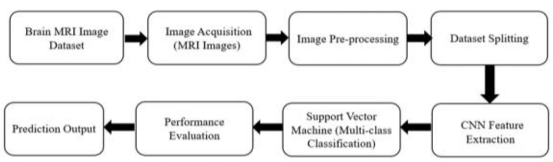

Figure 2: Methodology Workflow of the detection process

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Before training the model, MRI images are processed using libraries such as NumPy, OpenCV, and PIL.

These libraries help with tasks like resizing images, normalizing data, and improving image quality. The model's performance is measured using different evaluation methods, and graphs and charts are created using Matplotlib and scikit-learn.

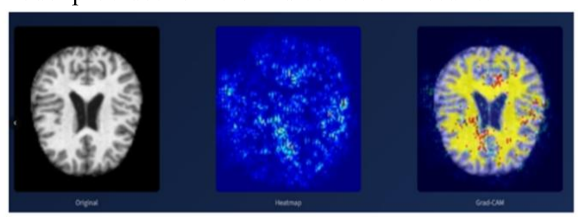
To make the system easy to use, the trained model is connected to a Streamlit web application. Through this application, users can upload MRI brain images and receive prediction results instantly.

IV. RESULTS AND ANALYSIS

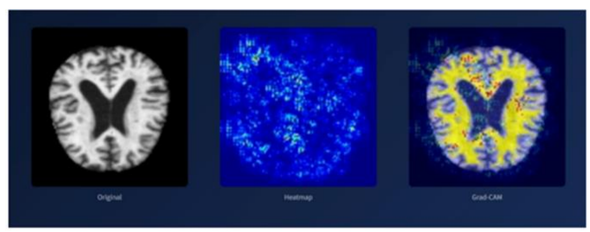
After training the CNN model using the MRI image dataset, the model is tested to check how well it can identify the different stages of Alzheimer's disease. The performance of the model is measured using common evaluation methods such as accuracy, precision, recall, F1-score, and confusion matrix.

The results show that the model can successfully classify MRI images into four categories: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. The training results show that the model learns effectively from the data, with accuracy improving and errors reducing as the training process continues.

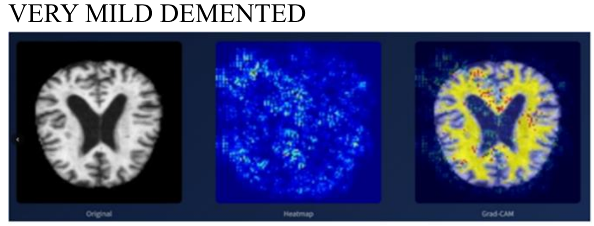
The evaluation results indicate that the model performs well across all disease stages. It is especially effective in identifying Non-Demented and Moderate Demented cases because the differences in brain structure are more noticeable in these stages. Some prediction errors occur between Very Mild Demented and Mild Demented categories because the changes in the brain are very similar during the early stages of the disease show in Fig 3. Even with these challenges, the model provides reliable and consistent results.



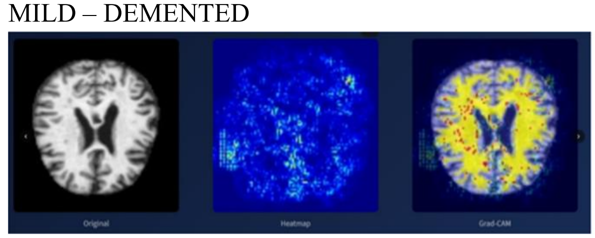
NON-DEMENTED



VERY MILD DEMENTED



MILD – DEMENTED



MODERATE DEMENTED

Figure 3: Different Stages of Classification

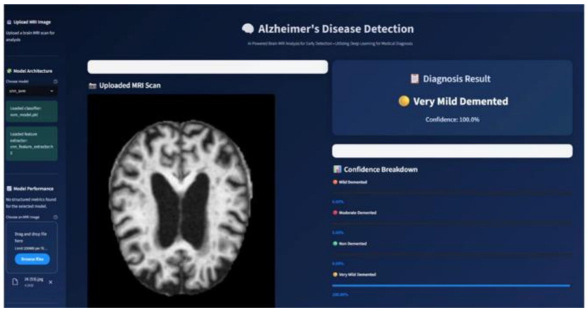


Figure 4: WEB Interface of the Disease Detection.

- Title and System Description: Displays the name and purpose of the application.
- File Upload Button: Allows users to select and upload MRI images.
- Image Preview Panel: Shows the uploaded MRI scan.
- Prediction Result Box: Displays the detected Alzheimer's stage.
- Confidence Score Table / Bar Chart: Shows probability distribution across all classes.

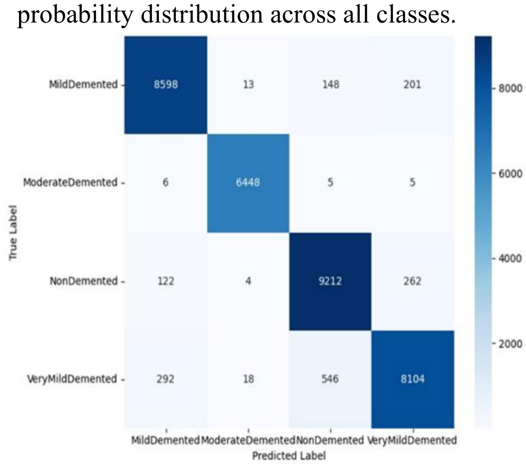


Figure 5: Baseline CNN Confusion Matrix

The confusion matrix thus validates the effectiveness of the proposed system in executing reliable multi-class classification and shows up the robustness of the model in identifying different stages of Alzheimer's disease from brain MRI images, the receiver Operating Characteristic (ROC) curve is used to evaluate the classification performance of the CNN model by analysing the trade-off between sensitivity (true positive rate) and specificity (false positive rate) at different threshold values. For a multi-class problem such as Alzheimer's disease stage classification, ROC curves are generated for each class using a one-versus-rest approach

In this project, ROC curves are plotted for the four classes: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented. The Area Under the Curve (AUC) is computed for each class to quantify the model's ability to distinguish between that class and the others. An AUC value closer to 1 indicates excellent classification performance, while a value closer to 0.5 suggests random guessing.

The obtained ROC curves show high AUC values for all classes, demonstrating that the proposed CNN model has strong discriminative capability. The curves for Non-Demented and Moderate Demented classes are particularly well separated, reflecting the distinct structural differences in MRI scans at these stages. Slightly lower but still significant AUC values are observed for the Very Mild and Mild Demented classes due to the subtle nature of early-stage brain changes.

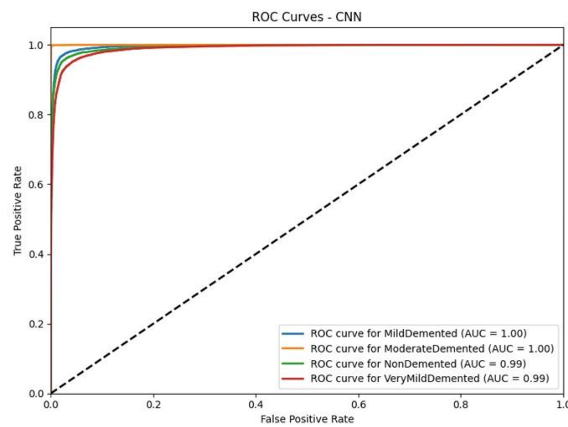


Figure 6: Baseline CNN ROC Curve depicting the Positive and Negative rates

V. CONCLUSION AND FUTURE SCOPE

This project developed an automated system for identifying the different stages of Alzheimer's disease using MRI brain images. The system uses a combination of CNN and SVM models to analyse MRI scans and classify them into four stages: Non-Demented, Very Mild Demented, Mild Demented, and Moderate Demented.

The results show that the combined CNN and SVM approach performs better than using only a CNN model. The system is able to classify MRI images accurately and can effectively identify different stages of the disease. The evaluation results show fewer prediction errors and better classification performance, especially when distinguishing between different Alzheimer's stages.

A web-based application was also developed to make the system easy to use. Users can upload MRI images and quickly receive prediction results along with confidence scores. This makes the system practical and accessible for real-world use.

- Integration of 3D CNN architectures to utilize volumetric MRI data for more comprehensive feature extraction.
- Extension of the system to support multimodal data such as PET scans, clinical records, and cognitive test scores.
- Application of ensemble learning techniques by combining multiple hybrid models to improve robustness.

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