PROJECT REPORT

AI-Driven Solution for Early Detection of Neurodegenerative Diseases

Abstract

This project develops an AI-powered system that analyzes brain scans, speech patterns, memory, and movement to detect early signs of neurodegenerative diseases. Through advanced machine learning algorithms, the model identifies subtle changes in cognitive and physical behavior, enabling early intervention by healthcare professionals. Currently, the system does not integrate data from wearable devices or smart home technologies, but future enhancements may include such data sources for a more comprehensive diagnosis. This work highlights the potential of AI and machine learning to revolutionize early disease detection and improve patient outcomes.

Introduction

Neurodegenerative diseases like Alzheimer's and Parkinson's make early diagnosis tough often leading to treatment delays and fewer care options. These conditions have an impact on the nervous system causing a slow decline in function as time passes. Spotting these diseases can boost patient outcomes.

Our project aims to create a computer-based system that uses AI and machine learning to examine key signs, including brain MRI scans how people talk, memory tests, and hand-eye teamwork. By using cutting-edge computer tools, we want to make the diagnosis process more accurate and quick helping doctors to spot early warning signs .

Problem Statement

Current methods to diagnose neurodegenerative diseases rely too much on physical symptoms you can see. Doctors often use these methods when the disease has already gotten worse. This project wants to build a smart system that uses computer tools to spot small changes in how

the brain looks how people move, and how they think. This kind of system could help doctors find these diseases earlier, which means patients might get better results from treatment.

Objectives

- Develop a machine learning-based system for early detection of neurodegenerative diseases.
- Analyse brain MRI images to identify early signs of Alzheimer's disease.
- Evaluate speech patterns and language skills to detect markers for Parkinson's.
- Design and implement engaging cognitive tests, including memory and coordination assessments.
- Create a user-friendly graphical interface (GUI) for seamless interaction with the system.
- Integrate results from multiple diagnostic methods to provide comprehensive insights.

Methodology

This project utilizes a combination of diagnostic approaches to detect early signs of neurodegenerative diseases, such as Alzheimer's and Parkinson's, through the analysis of multiple data types, including MRI scans, speech patterns, coordination tests, and memory-related games. The following methods are employed:
Here's your refined and professional methodology section with clear bullet points:

1. MRI Analysis

Objective: Detect early neurodegenerative changes associated with Alzheimer's disease in brain scans.

Approach:

- **Convolutional Neural Networks (CNNs):** Utilized to classify MRI brain images for identifying neurodegenerative changes.
- **Image Preprocessing:** MRI images are preprocessed to enhance model accuracy, including resizing, normalization, and data augmentation.

- **Model Training:** The CNN model is trained using the preprocessed MRI images. The model consists of several convolutional and pooling layers to extract relevant features.
- **Model Evaluation:** The trained model is tested on unseen data to assess its accuracy and performance, identifying any misclassifications or areas of improvement.

2. Parkinson's Disease Detection

Objective: Identify potential Parkinson's disease based on medical data, including speech patterns and motor functions.

Approach:

- **Random Forest Classifier:** Used to analyze data related to speech, movement, and medical history to identify Parkinson's disease.
- **Data Preprocessing:** The dataset is cleaned and formatted, incorporating features regarding health and Medical History
- **Model Training:** The clean data is fed into the Random Forest model for training, enabling it to learn patterns indicative of Parkinson's disease.
- **Model Evaluation:** K-fold cross-validation is applied to assess the model's performance, with evaluation metrics like accuracy, precision, recall, and F1-score used to ensure its effectiveness.

3. Speech Pattern Analysis

Objective: Detect early signs of Parkinson's disease by analyzing speech patterns.

Approach:

- **Key Features:** Features such as Fundamental Frequency (Fo), Frequency Variations (Fhi, Flo), Jitter (%), Shimmer, and Noise-to-Harmonics Ratio (NHR) are extracted from the audio.
- **Algorithm Selection:** Various machine learning algorithms, including Logistic Regression, Decision Trees, and Random Forests, are tested to identify the best-performing model based on accuracy, precision, and recall.

- **Model Evaluation:** The most suitable model is selected based on its ability to detect early speech anomalies indicative of Parkinson's disease.

4. Coordination Test

Objective: Assess hand-eye coordination to identify early indicators of motor function decline, a symptom of neurodegenerative diseases.

Approach:

- **Hand Tracking:** Real-time hand movement tracking is performed using a webcam and the MediaPipe library.
- **Interactive Task:** An interactive target-based game is created using Pygame, where users must catch moving targets with their hand. The time taken to complete tasks is recorded to evaluate coordination.
- **Performance Logging:** The system logs user performance to evaluate coordination abilities and detect any deficits that may signal early cognitive or motor function decline.

5. Memory Game

Objective: Assess memory retention skills, which may decline with neurodegenerative diseases.

Approach:

- **Memory Quiz:** Participants are shown a series of images and later asked to recall details about them.
- **Response Evaluation:** Responses are analysed to determine the accuracy and speed of memory recall, providing insights into the participant's cognitive abilities.

6. Integration of Diagnostic Approaches

Objective: Combine multiple diagnostic results to form a comprehensive assessment of cognitive health.

Approach:

- **Weighted Test Evaluation:** Different diagnostic tests (MRI analysis, speech patterns, coordination, and memory games) are given varying weights based on their relevance to identifying specific neurodegenerative diseases.
- **Composite Score Calculation:** A final score is derived by averaging the results of all tests, providing a holistic view of the individual's cognitive health.
- **Risk Assessment:** Based on the composite score, the system evaluates the likelihood of neurodegenerative disease and can indicate the need for further clinical consultation.

7. Final Integration & GUI

Objective: Provide an easy-to-use interface for the user to access and interpret results from multiple diagnostic tests.

Approach:

- **Unified Platform:** All diagnostic tests (MRI analysis, speech recognition, memory games, and coordination tests) are integrated into a user-friendly graphical interface developed using the Tkinter library.
- **Data Visualization:** The GUI displays feedback on the user's performance. This ensures a clear and intuitive presentation of complex data.
- **Holistic User Experience:** The system allows users to seamlessly navigate through different tests, receive detailed insights into their cognitive health, and monitor their progress over time, all within the Tkinter interface.

Technology Stack

The following tools, libraries, and frameworks were employed to develop and enhance the system, enabling accurate and efficient analysis for detecting neurodegenerative diseases:

- **Programming Language:** Python
- **Libraries & Frameworks:**

- **TensorFlow/Keras:** For building and training deep learning models, particularly the Convolutional Neural Network (CNN) used for analyzing MRI images.
- **scikit-learn:** For machine learning algorithms, including the Random Forest classifier and K-fold cross-validation, used in Parkinson's detection and speech recognition.
- **Pandas & NumPy:** For efficient data manipulation and handling large datasets, ensuring smooth data processing.
- **Tkinter:** For developing the entire graphical user interface (GUI) in Python, integrating various diagnostic tests such as MRI analysis, speech recognition, and coordination tests into a single user-friendly platform.
- **Librosa:** For extracting audio features from voice samples, crucial for speech pattern analysis and identifying potential signs of Parkinson's disease.
- **MediaPipe:** For real-time tracking of hand movements in coordination tests using webcam input.
- **Pygame:** For building the interactive memory and coordination games, providing an engaging way to assess cognitive function.
- **Matplotlib/Seaborn:** For visualizing data, plotting performance metrics, and displaying test results in an understandable format.

- **Data Handling:**
  - **CSV/JSON:** For handling datasets and ensuring compatibility with the system's input and output requirements.
  - **SQLite/MySQL (for future work):** For future integration to store user data, test results, and provide a more robust backend storage solution.
- **Hardware Requirements:**
  - **Webcam:** For capturing real-time data used in coordination tests.
  - **Wearable Devices (for future work):** To collect real-time health data, such as movement and heart rate, enhancing the accuracy of predictions.

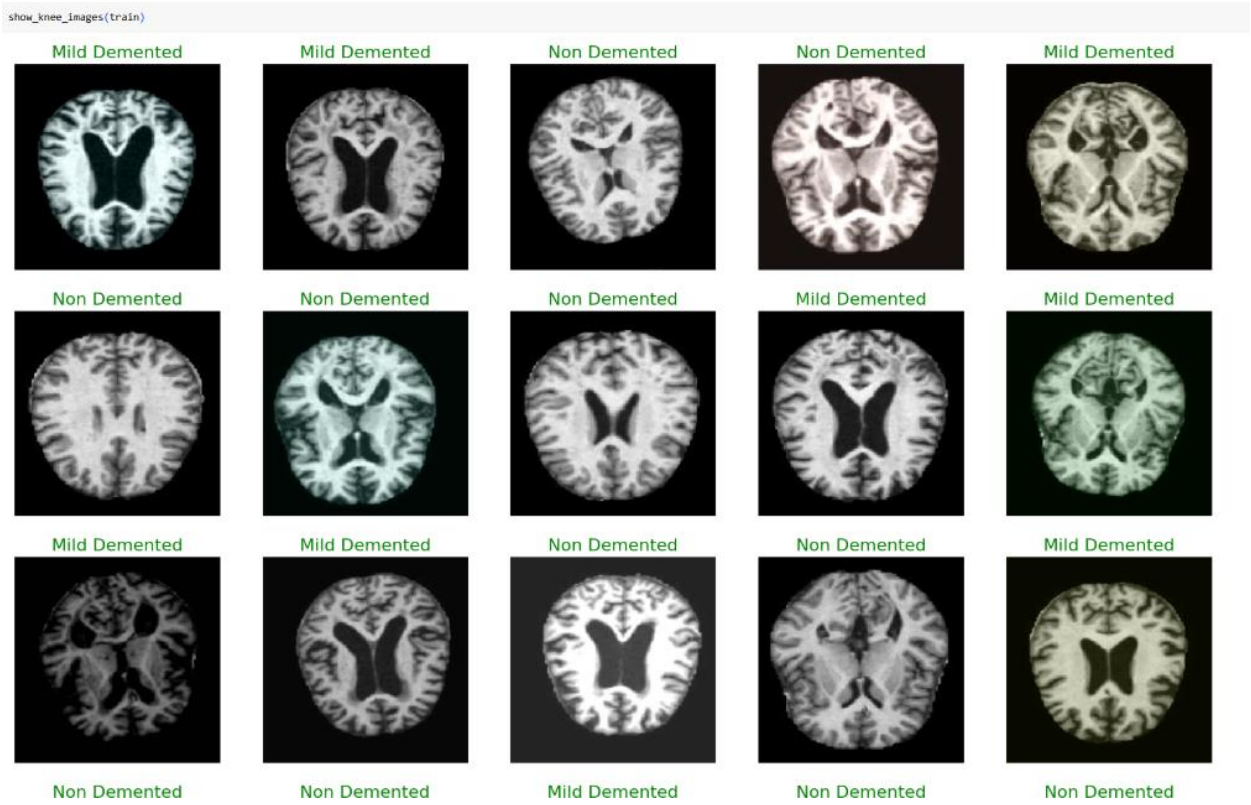
Results

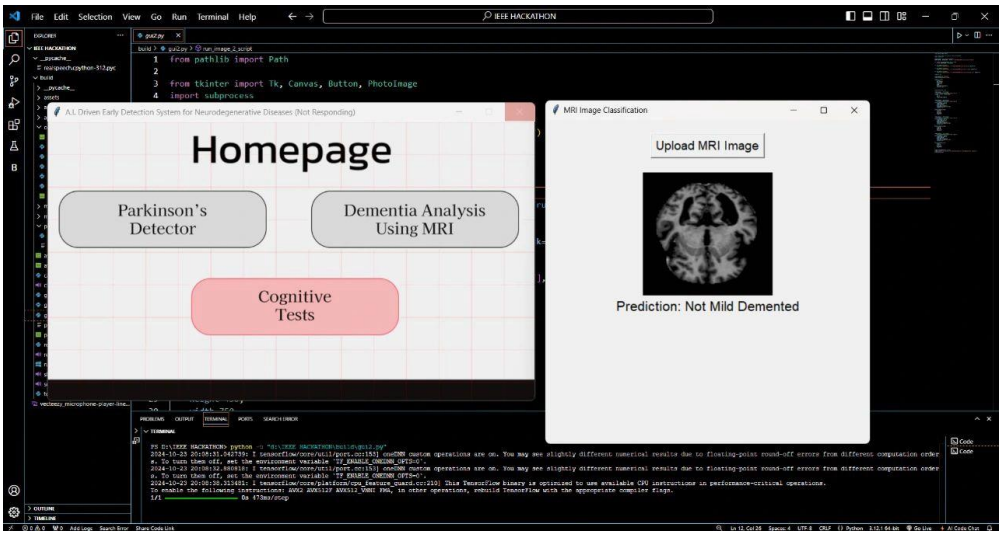
The models showed strong performance in detecting signs of neurodegenerative diseases. Specifically:

- **MRI Image Analysis Model:** Achieved an **88% accuracy** in identifying neurodegenerative changes from brain MRI scans.
- **Parkinson's Disease Detection Model:** The Random Forest Classifier achieved a **92% accuracy** in diagnosing Parkinson's disease from medical data, including speech patterns and motor function metrics.

These results highlight the potential of using AI-driven methods for early detection of neurodegenerative conditions. Further validation and testing are ongoing to refine the models and ensure robustness across various datasets and real-world conditions.

Project overview: slideshow

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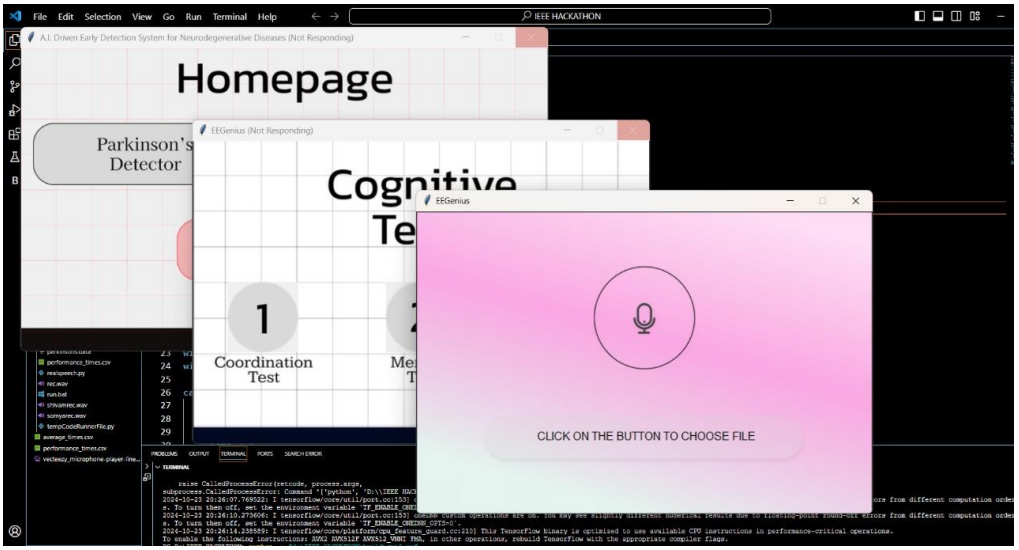
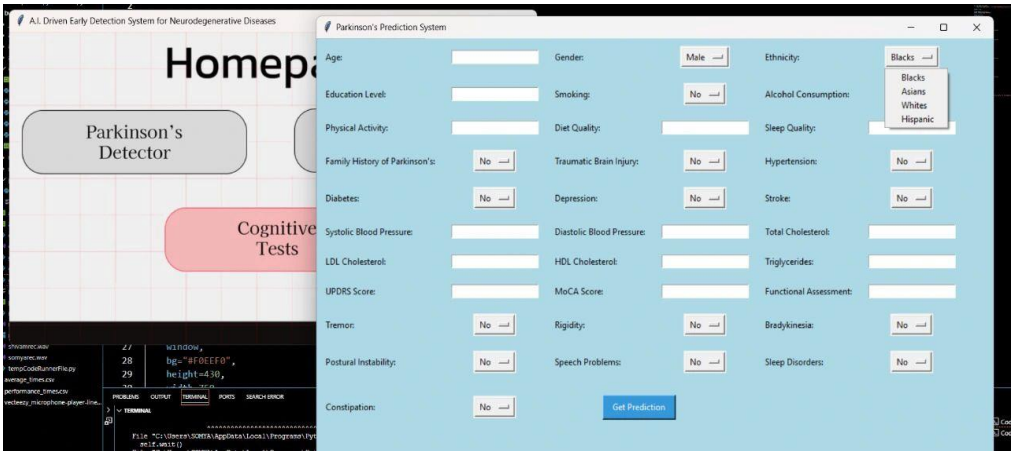
Parkinson's Detector
Dementia Analysis Using MRI
Cognitive Tests
MRI Image Classification
Upload MRI Image
Prediction: Not Mild Demented


A.I. Driven Early Detection System for Neurodegenerative Diseases (Not Responding)
Homepage
Parkinson's Detector
EEGenius (Not Responding)
Coordination Test
EEGenius
CLICK ON THE BUTTON TO CHOOSE FILE


A.I. Driven Early Detection System for Neurodegenerative Diseases
Parkinson's Detector
Cognitive Tests
Parkinson's Prediction System
Age:
Gender:
Male
Ethnicity:
Blacks
Asians
Whites
Hispanic
Education Level:
Smoking:
No
Alcohol Consumption:
Physical Activity:
Diet Quality:
Sleep Quality:
Family History of Parkinson's:
Traumatic Brain Injury:
Hypertension:
Diabetes:
Depression:
Stroke:
Systolic Blood Pressure:
Diastolic Blood Pressure:
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HDL Cholesterol:
Triglycerides:
UPDRS Score:
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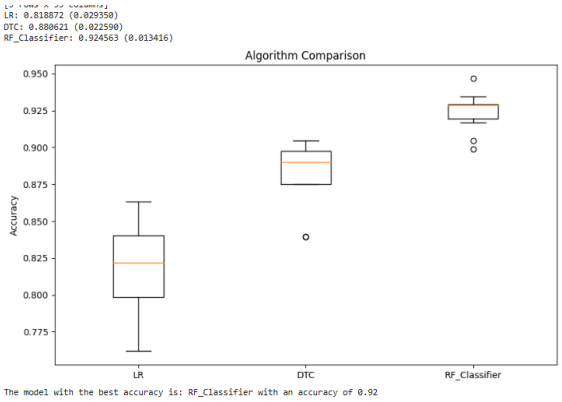
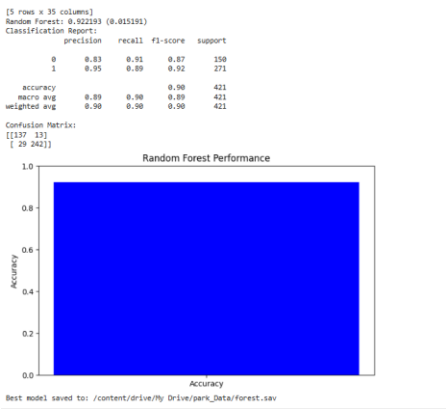
Get Prediction





Conclusion

This project illustrates the promising role of AI in revolutionizing the early detection of neurodegenerative diseases like Alzheimer's and Parkinson's. By analyzing data from everyday devices—such as smartphones, wearables, and webcams—the platform offers a non-invasive, cost-effective, and accessible approach to improving patient outcomes. This can significantly enhance the quality of life for individuals by enabling early intervention and personalized care strategies.

Future Work

Future developments will focus on enhancing the system's accuracy and real-time applicability. Key areas of future work include:

- **AR/VR Integration:** Implementing augmented reality (AR) or virtual reality (VR) technologies in devices like spectacles to detect hallucinations or changes in cognitive behavior, commonly seen in neurodegenerative diseases.

- **Wearable Devices:** Expanding the use of wearable technology, such as smartwatches and glasses, to continuously monitor vital health data and detect any dangerous symptoms or sudden changes in health status.
- **Assistance Devices:** Incorporating sensors into mobility aids like walking sticks for the elderly, which could monitor falls, movement patterns, or alert caregivers in case of emergencies.
- **Dataset Expansion:** Collecting more diverse and comprehensive datasets to enhance the model's generalization ability and improve its performance in real-world applications.
- **Model Deployment:** Refining the models for seamless integration into healthcare environments, enabling practical, real-time monitoring and diagnosis.
- **Collaboration with Healthcare Providers:** Establishing partnerships with medical professionals and healthcare institutions to ensure that the system is clinically validated and ready for deployment in real-world scenarios.

This platform has the potential to not only detect neurodegenerative diseases early but also improve the overall healthcare experience for patients, caregivers, and healthcare providers.

Project Repository

Link: [Github]

Report Title:
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