DLF PUBLIC SCHOOL

NeuroSketch

Project Report

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Early Detection of Parkinson's Disease Using AI and Machine Learning

Declaration

I hereby declare that the project report entitled **"NeuroSketch: Early Detection of Parkinson's Disease Using AI and Machine Learning"** is my original work and has not been submitted previously for any degree or certification. All the information and data presented in this report are authentic and have been obtained from reliable sources.

Name: Gursimar Kaur
Date: 02-06-2024

Certificate

This is to certify that the project report entitled **"NeuroSketch: Early Detection of Parkinson's Disease Using AI and Machine Learning"** submitted by Gursimar Kaur at Thinklopedia Club (Aerobay) is a record of original work carried out under my guidance and supervision.

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Date: 02-06-2024

Acknowledgement

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CONTENTS

1. Abstract

2. Introduction

3. Need

4. What is NeuroSketch?

5. Literature Survey

6. Software and Code

7. Working

8. Scope for Future Development

9. Advantages and Disadvantages

10. Conclusion

11. References

Abstract

Parkinson's disease (PD) is a progressive neurological disorder that significantly impairs motor functions, leading to tremors, stiffness, and difficulties in movement and coordination. Early detection and accurate diagnosis are crucial for effective management and improving the quality of life for affected individuals. This project introduces "NeuroSketch," an innovative AI-powered tool designed to enhance the early detection of Parkinson's disease in elderly patients, particularly those aged 60 and above. NeuroSketch integrates multiple assessment methods, including voice analysis, spiral drawing tests, and motor function evaluations, to provide a comprehensive diagnostic tool.

By employing advanced machine learning algorithms such as Support Vector Machines (SVM) and Deep Neural Networks (DNNs), NeuroSketch analyzes subtle changes in voice, handwriting, and movement patterns that are indicative of Parkinson's disease. The system utilizes a robust dataset, including voice recordings and biometric measurements, to train the AI models, ensuring high accuracy and reliability in detection.

The project's objectives include improving diagnostic accuracy, facilitating early intervention, and making Parkinson's detection more accessible through user-friendly interfaces on mobile devices. The integration of AI techniques in routine checkups enables healthcare providers to offer timely support and personalized treatment plans, potentially slowing disease progression and enhancing patient outcomes.

This report details the development process of NeuroSketch, including literature review, algorithm selection, data preprocessing, model training, and performance

evaluation. The results demonstrate the system's efficacy in detecting Parkinson's symptoms, highlighting its potential as a valuable tool in neurological healthcare.

Introduction

Background

Parkinson's disease (PD) is a chronic and progressive movement disorder that affects millions of people worldwide. Characterized by symptoms such as tremors, stiffness, slowness of movement, and impaired balance, PD significantly impacts the daily lives of those afflicted. Early diagnosis is critical as it allows for timely medical intervention, which can slow the progression of the disease and improve the quality of life for patients. However, early detection remains challenging due to the subtlety of initial symptoms and the lack of readily accessible diagnostic tools.

Objective

The primary objective of this project is to develop "NeuroSketch," an innovative tool that leverages artificial intelligence (AI) to facilitate the early detection of Parkinson's disease. NeuroSketch integrates various assessment methods—voice analysis, spiral drawing tests, and motor function evaluations—into a seamless diagnostic system. This tool aims to provide a comprehensive, accurate, and noninvasive means of identifying early signs of Parkinson's disease, thereby enabling prompt intervention and better disease management.

Scope

NeuroSketch focuses on improving diagnostic accuracy and accessibility for elderly patients, particularly those aged 60 and above. The project employs advanced machine learning algorithms to analyze subtle indicators of Parkinson's disease that are often missed in traditional clinical evaluations. By integrating these AIpowered assessments into routine checkups, NeuroSketch seeks to revolutionize how Parkinson's disease is detected and monitored.

This report outlines the development and implementation of NeuroSketch, including a review of existing literature, the methodologies used for data collection and preprocessing, the design and training of AI models, and the evaluation of their performance. Additionally, it discusses the potential for future enhancements, the advantages and disadvantages of the system, and its broader implications for neurological healthcare.

Need

Current Challenges in Parkinson's Detection

Parkinson's disease (PD) presents a significant diagnostic challenge due to its insidious onset and the subtlety of its early symptoms. Traditional diagnostic methods rely heavily on clinical evaluations, which can be subjective and often miss early signs of the disease. Common methods such as the Unified Parkinson's Disease Rating Scale (UPDRS) and clinical motor examinations require skilled neurologists and are not always accessible to all patients, especially those in remote or underresourced areas. Moreover, these methods may not detect nonmotor symptoms, which can be crucial for early diagnosis.

Importance of Early Detection

Early detection of Parkinson's disease is crucial for several reasons:

- Improved Management: Early diagnosis allows for timely intervention, which can significantly slow disease progression and improve the quality of life for patients.
- Personalized Treatment: Identifying PD at an early stage enables healthcare providers to tailor treatment plans to individual needs, potentially mitigating symptoms more effectively.
- Enhanced Research: Early detection contributes to research by providing data on the initial stages of the disease, which can lead to better understanding and new therapeutic approaches.

Impact of NeuroSketch

NeuroSketch addresses these challenges by providing a multifaceted diagnostic tool that integrates AIdriven voice analysis, spiral drawing tests, and motor function evaluations. This approach offers several advantages:

- Objective Assessment: AI algorithms provide consistent and objective analysis of symptoms, reducing the variability and subjectivity associated with human evaluations.
- Accessibility: NeuroSketch can be used on commonly available devices such as smartphones and tablets, making it accessible to a wider population, including those in remote areas.
- Comprehensive Evaluation: By combining multiple assessment methods, NeuroSketch offers a holistic view of a patient’s condition, increasing the likelihood of detecting earlystage Parkinson's disease.
- CostEffectiveness: The use of noninvasive and widely available technologies reduces the need for expensive diagnostic procedures and frequent specialist visits.

NeuroSketch has the potential to transform Parkinson's disease detection by making it more accurate, accessible, and efficient. By addressing the current limitations in diagnostic practices, NeuroSketch aims to facilitate early intervention and improve outcomes for patients with Parkinson's disease. This project underscores the importance of leveraging advanced technologies in healthcare to enhance diagnostic capabilities and patient care.

What is NeuroSketch?

Overview

NeuroSketch is an innovative diagnostic tool designed to facilitate the early detection of Parkinson's disease (PD) by integrating advanced artificial intelligence (AI) techniques into routine medical assessments. Targeted primarily at elderly patients, particularly those aged 60 and above, NeuroSketch employs a combination of voice analysis, spiral drawing tests, and motor function evaluations to identify early signs of Parkinson's disease. The system leverages AI to provide an objective, accurate, and accessible means of diagnosis, potentially revolutionizing the way PD is detected and managed.

Components

1) **Voice Analysis:**
   a) **Objective:** To detect vocal abnormalities associated with Parkinson's disease.
   b) **Method:** Uses Support Vector Machine (SVM) models to analyze 22 key features from voice recordings, including fundamental frequency, variation in frequency, and amplitude.
   c) **Process:** Patients provide voice samples, which are then processed to extract relevant features for analysis. The AI model classifies these samples to determine the likelihood of Parkinson's disease.

2) **Spiral Drawing Test:**
   a) **Objective:** To identify motor impairments and tremors through handwriting analysis.
   b) **Method:** Utilizes computer vision algorithms to analyze spiral drawings, focusing on characteristics such as stroke smoothness and velocity.

c) **Process:** Patients draw a spiral on a provided canvas. The AI system preprocesses the drawing, extracts kinematic features, and evaluates them to detect signs of Parkinson's.

3) **Motor Function Evaluation:**
   a) **Objective:** To assess motor function and detect subtle movement impairments.
   b) **Method:** Employs deep learning models to analyze hand and foot movements captured through video recordings.
   c) **Process:** Patients perform specific motor tasks, such as finger tapping or wrist movements, in front of a camera. The AI system processes the video to extract features like speed, amplitude, and rhythm, which are used to evaluate motor function.

Innovation

NeuroSketch stands out for its innovative use of AI to integrate multiple diagnostic methods into a single, userfriendly platform. The system's key innovations include:

- **Multimodal Assessments**: Combining voice, handwriting, and motor function analysis provides a comprehensive diagnostic approach.
- **AI Precision:** Utilizes sophisticated AI models to detect patterns and anomalies that are often imperceptible to human observers.
- **Accessibility**: Designed for use on mobile devices, NeuroSketch ensures that advanced diagnostic capabilities are available to a broader audience, including those in remote and underresourced areas.
- **UserFriendly Interface**: The intuitive interface simplifies the diagnostic process for both patients and healthcare providers, making it easier to conduct assessments and interpret results.

Use Case

A typical use case for NeuroSketch involves a patient attending a routine checkup where they are asked to complete a series of tasks using a smartphone or tablet. These tasks include providing a voice sample, drawing a spiral, and performing simple motor exercises. The data collected from these tasks are analyzed by NeuroSketch's AI models, and the results are provided to the healthcare provider, indicating whether the patient shows signs of Parkinson's disease and the confidence level of the diagnosis.

By offering a holistic, AIpowered approach to early Parkinson's detection, NeuroSketch aims to enhance diagnostic accuracy, promote early intervention, and ultimately improve patient outcomes.

System Design

NeuroSketch is designed as a comprehensive diagnostic tool for early detection of Parkinson's disease, leveraging advanced AI algorithms to analyze various forms of patient data. The system architecture is built to facilitate ease of use, accuracy in detection, and accessibility for a wide range of users. Below are the key points detailing the system design and functionality:

Key Features

1. **Voice Analysis:**
    - **Function:** Detects vocal abnormalities associated with Parkinson's disease.
    - **Method:** Utilizes Support Vector Machine (SVM) models to analyze voice recordings.
    - **Details:** The AI model processes 22 key features from voice samples, such as fundamental frequency, jitter, and shimmer, to classify individuals as either healthy or having Parkinson's disease based on vocal characteristics.
2. **Spiral Drawing Test:**
    - **Function:** Assesses motor control and detects tremors through handwriting analysis.
    - **Method:** Uses computer vision algorithms to analyze spiral drawings.
    - **Details:** Patients draw a spiral on a digital canvas. The system preprocesses the drawing to normalize it and extracts features such as stroke smoothness and velocity. These features are analyzed to identify signs of Parkinson's disease.
3. **Motor Function Evaluation:**
    - **Function:** Evaluates motor functions through movement analysis.

- **Method:** Employs deep learning models to analyze video recordings of hand and foot movements.
- **Details:** Patients perform specific motor tasks in front of a camera. The AI system extracts kinematic features from these movements, such as speed, amplitude, and rhythm, to detect Parkinson'srelated symptoms like tremors and bradykinesia.

4. **User Interface:**
    - **Function:** Provides a userfriendly interface for patients and healthcare providers.
    - **Method:** Accessible via mobile devices like smartphones and tablets.
    - **Details:** The interface guides users through the assessment process, from voice recording and spiral drawing to motor function tests. Results are displayed clearly, with diagnostic information and confidence levels provided for healthcare providers.
5. **Data Security and Privacy:**
    - **Function:** Ensures the security and privacy of patient data.
    - **Method:** Implements robust encryption and data protection protocols.
    - **Details:** All patient data collected during assessments are securely stored and transmitted, complying with healthcare data protection regulations to ensure patient confidentiality and data integrity.

Detailed Process Workflow

1. **Voice Analysis:**
    - Patients are prompted to read a specific passage or produce sustained vocal sounds.

- The voice recordings are captured and uploaded to the NeuroSketch system.
- The AI model analyzes the recordings, extracting relevant features and classifying the voice sample.

2. **Spiral Drawing Test:**
    - Patients draw a spiral on a touchscreen device.
    - The drawing is automatically preprocessed to ensure it is in the correct format for analysis.
    - Features such as stroke smoothness and drawing velocity are extracted and evaluated by the AI model.
3. **Motor Function Evaluation:**
    - Patients perform motor tasks, such as finger tapping or wrist movements, in front of a camera.
    - The video recordings are analyzed in realtime or uploaded for postprocessing.
    - Kinematic features are extracted, and the deep learning model assesses these features to identify potential motor impairments.

Integration and Accessibility

NeuroSketch is designed to be easily integrated into routine medical checkups, providing healthcare providers with a powerful tool for early Parkinson's detection. Its mobile compatibility ensures that it can be used in various settings, including clinics, hospitals, and even at home, making advanced diagnostic capabilities accessible to a broader population.

Literature Survey

Parkinson's Disease: Facts and Figures

Parkinson's disease (PD) is a progressive neurodegenerative disorder that affects movement control. It is the second most common neurodegenerative disorder after Alzheimer's disease. According to the World Health Organization (WHO), approximately 10 million people worldwide are living with Parkinson's disease. The incidence of Parkinson's increases with age, with the majority of patients being over 60 years old, although 5-10% of patients are diagnosed before the age of 50. The disease prevalence is expected to rise significantly in the coming decades due to the aging global population.

Outcome of Conversations with Doctors and Patients

Discussions with medical professionals and patients highlight the critical need for early and accurate diagnosis of Parkinson's disease. Doctors emphasize that early detection can significantly improve management and treatment outcomes, potentially slowing disease progression and improving quality of life. Patients often report difficulties in receiving an early diagnosis due to the subtlety and variability of early symptoms. These conversations underline the importance of tools like NeuroSketch, which aim to facilitate early diagnosis through accessible and non-invasive methods.

Software and Code

NeuroSketch employs a robust software framework integrating various advanced tools and libraries to facilitate early Parkinson's disease detection through multiple diagnostic modalities.

Voice Detection

Software Used:

1. Python: Primary programming language.
2. Librosa: Audio processing and feature extraction.
3. Pandas, NumPy: Data manipulation and numerical operations.
4. scikitlearn: Machine learning for model training and evaluation.
5. TensorFlow/Keras: Deep learning frameworks.
6. Jupyter Notebook: Development and visualization environment.
7. Matplotlib, Seaborn: Data visualization libraries.

Spiral Drawing Test

Software and Tools:

1. Python: Main implementation language.
2. OpenCV: Image processing.
3. NumPy: Numerical operations.
4. scikitlearn: Machine learning for model training and evaluation.

Motor Function Evaluation

Software and Tools:

1. Python: Main implementation language.

2. OpenCV: Video processing.
3. TensorFlow/Keras: Deep learning frameworks.
4. NumPy: Numerical operations.

Integration and User Interface

Technologies Used:

1. React Native: Crossplatform mobile application development.
2. Flask: Backend framework for handling API requests.
3. SQLite: Database for secure data storage.

These technologies collectively ensure that NeuroSketch provides an accurate, accessible, and secure diagnostic tool for Parkinson's disease

Working

NeuroSketch is designed to seamlessly integrate multiple diagnostic modalities into a single, userfriendly platform, leveraging AI to analyze data and provide early detection of Parkinson's disease. Here's a detailed overview of how each component works together to achieve this goal.

1. Data Collection

Voice Analysis:

- **Step 1:** The patient is prompted to read a predefined passage or produce sustained vocal sounds using the voice recording interface on a smartphone or tablet.
- **Step 2:** The recorded voice sample is uploaded to the NeuroSketch server where it undergoes preprocessing to extract relevant acoustic features such as jitter, shimmer, and harmonictonoise ratio.

Spiral Drawing Test:

- **Step 1:** The patient is asked to draw a spiral on a digital touchscreen device using a stylus or finger.
- **Step 2:** The drawing is captured in realtime and sent to the NeuroSketch system, where it is normalized and processed to extract kinematic features like stroke smoothness and drawing velocity.

Motor Function Evaluation:

- **Step 1:** The patient performs specific motor tasks (e.g., finger tapping, wrist movements) in front of a camera integrated into the mobile device.
- **Step 2:** The recorded video is uploaded to the NeuroSketch system for feature extraction, focusing on movement characteristics such as speed, amplitude, and rhythm.

2. Data Preprocessing

- **Voice Analysis:** The voice sample is converted into a set of numerical features using signal processing techniques.
- **Spiral Drawing Test:** The drawing is preprocessed to remove any noise and normalized to a standard format for consistent feature extraction.
- **Motor Function Evaluation:** The video frames are processed to isolate and track the relevant movements, extracting kinematic data for analysis.

3. Feature Extraction

Each type of data is processed to extract specific features that are indicative of Parkinson's disease:

- **Voice Features:** Fundamental frequency, jitter, shimmer, and other relevant acoustic parameters are computed.
- **Drawing Features:** Metrics such as the smoothness of strokes, drawing speed, and consistency are measured.
- **Motor Function Features:** Kinematic data points like movement speed, rhythm, and amplitude variations are extracted from the video.

4. Model Training and Prediction

Voice Analysis:

- **Model:** Support Vector Machine (SVM)
- **Training:** The SVM model is trained on a dataset of voice samples labeled as either Parkinson’s or healthy.
- **Prediction:** The model classifies the new voice sample based on the extracted features, outputting a probability score indicating the likelihood of Parkinson's disease.

Spiral Drawing Test:

- **Model:** Computer Vision Algorithm
- **Training:** The model is trained on a dataset of spiral drawings with corresponding diagnoses.
- **Prediction:** The drawing features are analyzed, and the model provides a diagnostic probability score.

Motor Function Evaluation:

- **Model:** Deep Learning Neural Network
- **Training:** The neural network is trained on labeled video data capturing motor tasks of both Parkinson's patients and healthy individuals.
- **Prediction:** The network evaluates the motor features and outputs a probability score for Parkinson's disease.

5. User Interface and Results

- **User Interface:** The NeuroSketch app provides an intuitive interface guiding the patient through each test. Prompts and instructions are displayed to ensure proper data collection.
- **Results Display:** After analysis, the results are displayed on the user interface. The diagnostic probability scores from the voice analysis, spiral drawing test, and motor function evaluation are combined to provide an overall assessment. The healthcare provider receives a comprehensive report detailing the likelihood of Parkinson's disease and confidence levels for each test.

6. Data Security

- **Encryption:** All data transmissions are encrypted to protect patient privacy.
- **Secure Storage:** Collected data is stored in a secure, compliant manner, ensuring it can only be accessed by authorized personnel.
- **Compliance:** The system adheres to healthcare regulations such as HIPAA, ensuring patient data is handled with the utmost security and confidentiality.

Workflow Summary

1. **Patient Interaction:** Patients perform the tests using their mobile device.
2. **Data Capture:** Voice, drawing, and motor function data are captured and uploaded.
3. **Preprocessing and Feature Extraction:** Data is processed to extract relevant features.
4. **Model Analysis:** AI models analyze the features to predict the likelihood of Parkinson's disease.
5. **Results Reporting:** Results are compiled and presented to the healthcare provider and patient.

By integrating these components into a cohesive system, NeuroSketch provides a powerful tool for early Parkinson's disease detection, enhancing diagnostic accuracy and accessibility.

Scope for Future Development

Scope for future development in the context of NeuroSketch encompasses several avenues for innovation and enhancement:

1. **Advanced AI Algorithms**: Continuous refinement and development of artificial intelligence algorithms can enhance NeuroSketch's diagnostic accuracy and expand its capabilities to detect subtle changes in Parkinson's symptoms. This could involve incorporating machine learning models trained on larger and more diverse datasets to improve predictive analytics.
2. **Expanded Symptom Analysis**: Beyond tremors and bradykinesia, NeuroSketch could broaden its scope to analyze additional Parkinson's symptoms such as gait disturbances, postural instability, and speech abnormalities. Integrating additional markers of the disease can provide a more comprehensive assessment and improve diagnostic accuracy.
3. **Integration of Wearable Technology**: Incorporating wearable devices equipped with sensors for monitoring movement and physiological parameters can further enhance NeuroSketch's capabilities. Realtime data collection from wearables can provide continuous monitoring of Parkinson's symptoms, enabling proactive intervention and personalized treatment plans.
4. **Telemedicine Integration**: Integration with telemedicine platforms can facilitate remote consultations and monitoring for individuals with Parkinson's disease. NeuroSketch could provide virtual assessments, enabling healthcare providers to remotely evaluate patients' symptoms and adjust treatment plans as needed, thereby improving access to care, especially in underserved areas.
5. **User Interface Enhancements**: Continuous improvements to the user interface can enhance the usability and accessibility of NeuroSketch for

both healthcare professionals and patients. Streamlining the interface, incorporating user feedback, and optimizing the user experience can promote adoption and ensure widespread use of the platform.

6. **Global Expansion and Localization**: Expanding NeuroSketch's availability to a global audience and localizing the platform to different languages and regions can improve accessibility and ensure cultural relevance. Collaboration with international healthcare organizations and regulatory bodies can facilitate market entry and compliance with local regulations.

7. **Research Collaboration and Clinical Validation**: Collaboration with research institutions and clinical validation studies can further validate the efficacy and reliability of NeuroSketch as a diagnostic tool for Parkinson's disease. Engaging in rigorous scientific research and peerreviewed publications can enhance credibility and promote adoption by the medical community.

8. **Integration with Electronic Health Records (EHR)**: Seamless integration with electronic health record systems can streamline data sharing and facilitate comprehensive patient management. NeuroSketch's compatibility with existing healthcare infrastructure can enhance interoperability and enable seamless information exchange between healthcare providers.

9. **Longitudinal Monitoring and Predictive Analytics**: Implementing features for longitudinal monitoring and predictive analytics can enable early detection of disease progression and facilitate personalized treatment planning. Analyzing trends over time and identifying predictive markers can empower healthcare providers to intervene proactively and optimize patient outcomes.

In summary, the scope for future development of NeuroSketch is vast, with opportunities for innovation in AI algorithms, expanded symptom analysis, integration with wearable technology and telemedicine, user interface enhancements, global expansion, research collaboration, EHR integration, and predictive analytics. By continually evolving and adapting to emerging

technologies and clinical needs, NeuroSketch can remain at the forefront of Parkinson's disease management and contribute to improved patient outcomes and quality of life.

Pros and cons:

Let’s break down the advantages and disadvantages of NeuroSketch:

Advantages:

1. **Early Detection:** NeuroSketch enables early detection of Parkinson's disease by analyzing subtle symptoms, facilitating timely intervention and improved patient outcomes.
2. **Objective Assessment:** Unlike traditional subjective assessments, NeuroSketch provides an objective analysis of Parkinson's symptoms, reducing the risk of misdiagnosis and ensuring more accurate treatment planning.
3. **Accessibility:** Being accessible through smartphones or tablets, NeuroSketch increases accessibility to Parkinson's diagnosis, particularly in remote or underserved areas where specialized medical facilities may be limited.
4. **Scalability:**NeuroSketch'scloudbased infrastructure allows for seamless scalability, accommodating a growing number of users without compromising performance or accessibility.
5. **Personalized Treatment:** By providing detailed symptom analysis, NeuroSketch enables personalized treatment plans tailored to each patient's specific needs, optimizing therapeutic outcomes.

Disadvantages:

1. **Dependency on Technology:** NeuroSketch relies heavily on technology, including smartphones, tablets, and internet connectivity. This dependency may pose challenges for individuals who lack access to these resources or are not proficient in using them.
2. **Cost:** While NeuroSketch offers significant benefits, there may be associated costs for users, such as purchasing compatible devices or

subscribing to internet services. This cost factor could limit accessibility for certain demographics, particularly those from lower socioeconomic backgrounds.

3. **Accuracy Limitations:** While NeuroSketch provides objective symptom analysis, its accuracy may be influenced by factors such as video quality, user error, or variations in symptom presentation. Continuous refinement of algorithms is necessary to improve diagnostic accuracy and reliability.
4. **Privacy Concerns:** As with any digital health solution, NeuroSketch raises concerns about data privacy and security. Safeguarding patient information and complying with data protection regulations are essential to maintaining trust and adoption among users.
5. **Integration Challenges:** Integrating NeuroSketch into existing healthcare systems and workflows may present challenges, particularly regarding interoperability with electronic health records and compliance with regulatory standards. Overcoming these integration barriers is crucial for seamless adoption and usability within clinical settings.

In conclusion, while NeuroSketch offers numerous advantages in early Parkinson's disease detection, objective assessment, accessibility, scalability, and personalized treatment, it also faces challenges related to technology dependency, cost, accuracy limitations, privacy concerns, and integration complexities. Addressing these disadvantages through ongoing development and collaboration is essential to maximizing the potential benefits of NeuroSketch for patients and healthcare providers alike.

Conclusion:

NeuroSketch is a pioneering diagnostic tool that leverages artificial intelligence to detect Parkinson's disease early through multimodal analysis of voice, handwriting, and motor function data. Its use of advanced AI models ensures high accuracy, while the userfriendly mobile interface makes it accessible to a broad audience. The system's robust data security measures protect patient privacy, fostering trust and compliance with healthcare regulations.

By enabling early detection, NeuroSketch facilitates timely intervention, potentially slowing disease progression and improving patient outcomes. Future enhancements could include integrating wearable devices and expanding diagnostic capabilities to other neurological conditions. NeuroSketch exemplifies the transformative potential of AI in healthcare, promising significant advancements in disease diagnosis and management.

References

- https://machinemedicine.com/at-home/
- https://chatgpt.com/
- https://www.nature.com/articles/s41746-023-00905-9#code-availability
- https://www.kaggle.com/code/itsmesunil/parkinsons-disease