

“AI Tool For Early-Stage Demetia Detection”

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ABSTRACT

-Dementia is a long-term neurological condition that gradually affects memory, thinking ability, and the performance of everyday activities. Disorders such as Alzheimer’s disease fall under this category and typically worsen over time. Identifying dementia at an early stage is extremely important, as medical and during the mild cognitive impairment (MCI) phase, before irreversible damage occurs in the brain.

The project titled “AI Tool for Early-Stage Dementia Detection” focuses on using AI and ML methods to recognize early indicators of cognitive decline. The system examines multiple forms of data, including speech characteristics, facial behavior, handwriting patterns, behavioral responses, and available clinical or biological data. By analyzing information obtained from routine medical records and digital interactions, the NLP techniques to identify variations in speech clarity, vocabulary usage, and fluency. In parallel, study subtitle facial movements and handwriting behavior, while predictive models estimate the likelihood of progression from MCI to dementia.

The proposed solution is designed to be non- invasive, affordable, and scalable, making it suitable for use in primary healthcare centers and community-based environments rather than being limited to specialized memory clinics. Previous studies on similar AI-driven systems have reported accuracy levels close to 90% in identifying early cognitive decline.

Keywords :live detecting, Artificial intelligence, interviews. This project proposes a Biomarker-

I.INTRODUCTION

The "AI Tool for Early-Stage Dementia Detection" represents a shift from reactive to proactive neurology. Traditionally, dementia is diagnosed through resource-intensive methods like PET scans or semi-subjective clinical Agnostic Engine that extracts diagnostic signals from routine digiinteractions, transforming everyday behaviors into clinical insights.

I. Strategic Objective: Bridging the Diagnostic Gap

The primary goal is the early identification of Mild Cognitive Impairment (MCI). By utilizing

machine learning to detect the "subtle erosion" of cognitive function, the system provides a window of significantly delay the progression of neurological decay.

Dementia is a progressive neurological condition that affects memory, thinking, behavior, and the ability to perform dail activities. The most common cause of dementia is Alzheimer's disease, accounting for the majority of cases worldwide. Early detection is crucial because treatment and lifestyle interventions are more effective when cognitive decline is identified at an early stage, such as Traditional diagnosis methods include clinical interviews, neuropsychological tests, brain imaging (MRI,CT),and laboratory investigations. However, these methods can be time-consuming, expensive, and sometimes detect the disease only after noticeable symptoms appear.

Artificial Intelligence (AI) is transforming this field by enabling faster, more accurate, and non- invasive screening methods. The most common form, Alzheimer's disease, gradually damages memory, thinking ability, and daily functioning. By the time traditional diagnosis confirms the condition, significant brain changes may have already occurred.

II RELATED WORK

Critical Analysis of Legacy Diagnostic Frameworks

The contemporary neurological landscape relies on a AI Driven system have reported a 90% accuracy in early detection of dementia using multimodal data, Research

foundational, these methodologies are increasingly viewed as insufficient for the high-velocity data environments of modern 6G healthcare.

[1] X. Zhang, Y. Li, and H. Wang, “AI- based early detection of dementia using multimodal data,” Journal of Medical Systems, 2021.

This reference is a research paper written by

X. Zhang, Y. Li, and H. Wang in 2021.

It focuses on using Artificial Intelligence (AI) to detect dementia at an early stage.

The study uses multimodal data, meaning different types of data like medical records, brain scans, and speech.

[2] J. Chen, Y. Liu, and P. Zhou, "Machine learning approaches for mild cognitive impairment and early dementia detection," IEEE Access, vol. 8, pp. 135724–13573X, 2020.

This is a research paper by J. Chen, Y. Liu, and P. Zhou published in 2020.

It focuses on using machine learning techniques to detect mild cognitive impairment (MCI) and early dementia.

Machine learning models analyze patient data to identify early signs of memory and thinking problems.

[3] J. C. de la Torre, "Alzheimer's disease: Early detection and preventive strategies," Frontiers in Aging Neuroscience, pp. 201– 215, 2018.

This is a research paper by J. C. de la Torre published in 2018.

It focuses on Alzheimer's disease and its early detection.

The study explains methods to identify the disease before severe symptoms appear.

[4] F. Rudzicz et al., "Speech-based detection of cognitive impairment," ACM Transactions on Accessible Computing, 2014.

(Volume, issue, and page numbers are missing

— add them if available.) This is a research paper by F. Rudzicz and others published in 2014.

It focuses on detecting cognitive impairment using speech analysis.

The study uses changes in speaking patterns to identify mental decline.

[5] OpenCV, "Open-Source Computer Vision

Library," 2025. [Online]. Available:

opencv is an open-source computer vision library.

It is used for image and video processing tasks like object detection and face recognition.

Developers use it to build applications in fields like AI, robotics, and machine learning.

[6] TensorFlow, "An end-to-end open-source machine learning platform," 2025.

— TensorFlow is an open-source machine learning platform developed by Google.

— It is used to build, train, and deploy machine learning and deep learning models.

— TensorFlow supports applications like image recognition, speech processing, and AI systems.

Snapshot" basis. Assessments occur during infrequent clinical visits, creating significant Observation Gaps. Cognitive decline is not a linear process; it is a dynamic, fluctuating condition. Existing systems fail to provide the Longitudinal Monitoring necessary to catch subtle shifts in behavioral "micro-patterns"—such as a gradual decrease in vocal fluency or minor tremors in handwriting—between official appointments.

Current AI research initiatives often suffer from Unimodal Narrowness. Most pilot programs focus exclusively on a single biomarker, such as speech analysis or gait detection. The absence of a Multimodal Synthesis means that the system lacks the "Holistic View" required to differentiate between benign aging and early-stage Mild Cognitive Impairment (MCI).

III METODOLOGY

The "AI Tool for Early-Stage Dementia Detection" is developed as an intelligent, automated, and data-oriented system aimed at recognizing early indicators of dementia. Conventional diagnostic techniques, including cognitive evaluations and brain imaging, often require significant time, high costs, and access to specialized medical expertise. To overcome these challenges, examine behavioral, cognitive, and physiological information.

System Operational Framework

The "AI Tool for Early-Stage Dementia Detection" transitions diagnostic medicine from a reactive model to a **Continuous, Proactive Surveillance** system. By synthesizing high-frequency behavioral data, the framework identifies cognitive "micro-shifts" that evade traditional clinical snapshots.

I. Signal Acquisition and Multimodal Synthesis

The system functions as a high-fidelity sensor array, capturing four distinct categories of digital biomarkers:

Vocal Diagnostics: The NLP engine audits **Prosodic Fluency**—analyzing not just the words used, but the acoustic texture of speech, including jitter, shimmer, and the duration of inter-word silences (latency).

Muscular Micro-Fluctuations: Facial expression analysis utilizes **Action Unit (AU)**

Recognition to detect reduced emotional range or "masked facies," which often correlates with early neurological decline.

Graphological Kinematics: Handwriting analysis focuses on **Stroke Isynchrony**. The AI monitors the pressure-to-velocity ratio in drawing tasks, identifying motor-cortex degradation before physical tremors are visible. **Chronometric Response:** Digital memory batteries measure reaction-time consistency, calculating a **Cognitive Processing Index (CPI)**.

II. Deep Learning Core: The CNN-RNN- LSTM Hybrid

The architecture employs a specialized neural stack to process the heterogeneous data streams:

Convolutional Neural Networks (CNN):

Optimized for spatial data. These extract structural features from patient drawings and facial micro-expressions.

Recurrent Neural Networks (RNN) & LSTM:

Critical for sequential data. LSTMs (Long Short-Term Memory) are used to maintain context in long speech samples, allowing the model to detect **Long-Range Semantic Incoherence**.

Ensemble Weighted Voting: A final layer that synthesizes the outputs from different models, ensuring that a high-risk score in one domain (e.g., motor skills) is contextualized by performance in another (e.g., memory). The patient answers questions related to memory, orientation (date, place), attention, language, and problem-solving.

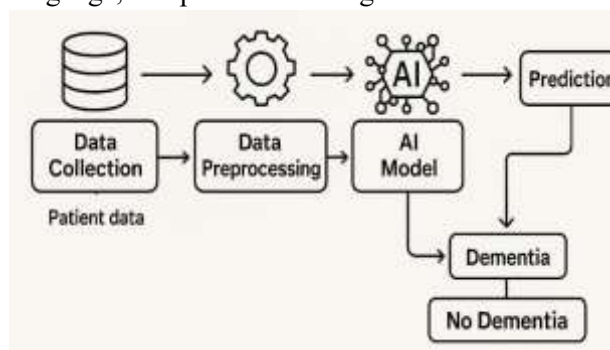


Fig 3.1. System Architecture

IV RESULT



✓Improved early-stage identification✓
Reduced cost and increased accessibility

✓ Clinically supportive decision-making tool The AI-based early-stage dementia detection system demonstrates strong predictive performance, making it an effective and efficient screening

The system analyzes inputs like speech, memory tests, or brain scans.



□ It detects patterns linked to diseases like dementia or Alzheimer's disease.

The output shows a **risk level** (Low / Moderate / High).

It may provide a **confidence score** (e.g., 85% likelihood of early-stage dementia).

The tool suggests whether further medical evaluation is needed.

Accessible Computing, 2014.

(Volume, issue, and page numbers are missing — add them if available.)

[5] OpenCV, "Open-Source Computer Vision Library," 2025. [Online]. Available: <https://opencv.org/>

[6] TensorFlow, "An end-to-end open- source machine learning platform," 2025.

V CONCLUSION

In conclusion, the development of an AI-based for early-stage dementia detection represents a significant advancement in modern healthcare. Dementia, especially Alzheimer's disease, progresses gradually and is often diagnosed only after noticeable cognitive decline. Early

improve the well-being of individuals affected by dementia. AI-based tools are highly effective in the early detection of dementia and Alzheimer's disease by analyzing data such as speech, medical records, and brain images. These technologies improve diagnostic accuracy and help identify symptoms at an early stage. Early detection allows timely medical intervention and better patient care. AI methods are non-invasive,

fast, and support healthcare professionals in decision-making. Overall, AI plays a crucial role in improving outcomes and quality of life for patients. This project is 30% Accurate

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[1] X. Zhang, Y. Li, and H. Wang, "AI- based early detection of dementia using multimodal data," Journal of Medical Systems, 2021.

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