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Ai Tool for Early-Stage Dementia Detection

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ABSTRACT

In the context of Alzheimer's disease (AD), timely identification is paramount for effective management, acknowledging its chronic and irreversible nature, where medications can only impede its progression. Our study introduces a holistic solution, leveraging the hippocampus and the VGG16 model with transfer learning for early AD detection. The hippocampus, a pivotal early affected region linked to memory, plays a central role in classifying patients into three categories: cognitively normal (CN), representing individuals without cognitive impairment; mild cognitive impairment (MCI), indicative of a subtle decline in cognitive abilities; and AD, denoting Alzheimer's disease. Employing the Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset, our model undergoes training enriched by advanced image preprocessing techniques, achieving outstanding accuracy (testing 98.17 %, validation 97.52 %, training 99.62 %). The strategic use of transfer learning fortifies our competitive edge, incorporating the hippocampus approach and, notably, a progressive data augmentation technique. This innovative augmentation strategy gradually introduces augmentation factors during training, significantly elevating accuracy and enhancing the model's generalization ability. The study emphasizes practical application with a user-friendly website, empowering radiologists to predict class probabilities, track disease progression, and visualize patient images in both 2D and 3D formats, contributing significantly to the advancement of early AD detection.

INTRODUCTION

Increased recognition of a prolonged pre dementia phase in neurocognitive conditions such as Alzheimer's disease (has led to interest in defining diagnostic definitions and biomarkers to allow for earlier recognition and therefore intervention to prevent or postpone dementia. Although there are currently no specific treatments to block the progression of cognitive decline in AD and other neurocognitive dementias, there are important reasons from a patient's social and personal perspective that an early diagnosis is important. Early dementia screening by a primary care physician should be completed as soon as possible once a patient or a knowledgeable informant has noticed decline in memory or difficulty in performing day-today tasks such as paying bills, shopping or managing medications as this enables opportunities for counseling for future care and a chance to arrange financial and legal matters while decision-making capacity remains.

Conversely, there are a number of potential negative aspects of early dementia screening. There is a small risk of false positives inciting anxiety and/or depression in non-demented people. A positive diagnosis can result in depression, loss of status, loss of employment, loss of driver's license, acquisition of a stigmatizing label and diminished quality of life [1]. There is also a risk of misdiagnosis of a range of behaviors as dementia, resulting in under-treatment and misdirection of patients to inappropriate services, especially in a multicultural setting where English might not be the primary language [2]. At the extreme, AD diagnosis has also been linked to suicide [3]. Therefore, it should be up to the patient to decide the amount of information they should receive.

Mild cognitive impairment (MCI) is a syndrome defined by a decline in cognition that is greater than the level expected for an individual's age and education level but that does not interfere notably with activities of daily life It represents an intermediate state between the cognitive changes of normal aging and the earliest clinical manifestations of dementia, the distinction between which can be quite subtle. In comparison to those with MCI, individuals with early dementia are seen to perform poorly in more than one cognitive domain, leading to a more substantial interference in daily function. Although the definition of mild dementia is indicative of a step towards a progressing disease, there are many similarities in the recognition and diagnosis of MCI and early dementia, so these will be discussed together.

PROBLEM DEFINATION

Early-onset dementias are defined by onset of first symptoms before the age of 65. They have specific diagnostic features

which differ from those of elderly patients in terms of their many causes and atypical clinical presentations. MRI is an essential procedure for identifying the underlying cause of the dementia (degenerative, vascular, infectious, inflammatory, metabolic or toxic). Clinical clues and MRI signs are described, and their defining features are related to the young age of the patients concerned. Diagnostic algorithms are proposed from signs which can be seen on the different MRI sequences (T1- weighted volume acquisition, T2-weighted FLAIR sequences, T2-weighted gradient-echo, diffusion-weighted imaging). Once obvious causes have been excluded, MRI can point towards the rarer causes of dementia which are characteristic in young people (particularly metabolic and autoimmune) and which require specific management and genetic counseling.

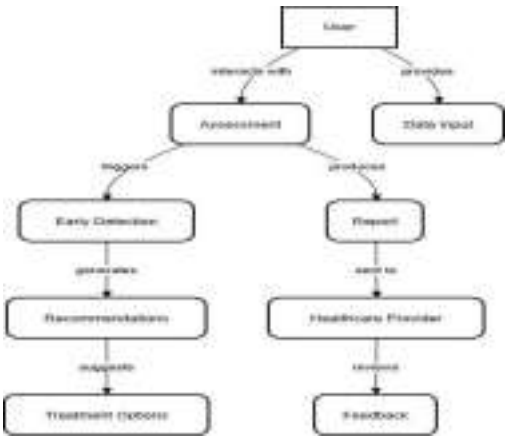
LITRATURE SURWAY

Early-stage dementia detection has become an important research area due to the increasing elderly population and the need for timely medical intervention. Researchers have explored various clinical, cognitive, imaging, and machine-learning-based approaches to identify dementia at its initial stages.

Traditional Clinical and Cognitive Assessment Methods Earlier studies relied mainly on clinical observations and neuropsychological tests such as the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA). These methods assess memory, attention, language, and problem-solving abilities. While they are simple and cost effective, their accuracy is limited due to subjectivity and dependence on the examiner's expertise. Moreover, mild cognitive impairment (MCI), an early indicator of dementia, is often difficult to detect using these tests alone.

Neuroimaging-Based Approaches With advancements in medical imaging, researchers began using Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans to identify structural changes in the brain. Studies have shown that hippocampal atrophy and cortical thinning are strong indicators of early dementia. However, imaging techniques are expensive, require expert interpretation, and are not always accessible in rural or low-resource settings.

Machine Learning-Based Detection To overcome the limitations of traditional methods, machine learning (ML) techniques have been widely adopted. Algorithms such as Support Vector Machine (SVM), Decision Tree, Random Forest, and K-Nearest Neighbors (KNN) have been applied to cognitive scores, demographic data, and brain imaging features. These methods improved detection accuracy compared to manual analysis. However, their performance depends heavily on feature selection and data quality.



PROCEED METHODOLOGY

MODULE DESCRIPTION

AI-based early-stage dementia detection systems have applications in enhanced screening, diagnostic assistance, prognostic modeling, and improved patient management. By analyzing complex and varied data, these systems are more sensitive to the subtle signs of dementia than conventional methods, which are often time-consuming and subjective.

OBJEVTIVE

Early dementia screening is especially important in an age where there is a search for disease modifying therapies, where there is mounting evidence that treatment, if given early, might influence the natural history—hence the need for cost-effective screening measures for early dementia.

APPLICATIONS BENEFITS

A person with dementia may enjoy an outing, even if they do not remember where they have been. What is important is that the moment is enjoyed, even though the experience may be soon forgotten.

Simple and unhurried activities are best. Give the time and space necessary to allow the person to do as much as possible. Focus on one thing at a time. Communicate one instruction at a time. Break down activities into simple, manageable steps.

Prepare a safe working area

People with dementia often have difficulty with visual perception and coordination. Ensure that surfaces are uncluttered, with few distractions and as little noise as possible. Good lighting (without glare), seating preferences and correct work heights are also important. Use plastic containers to help avoid breakages.

Don't allow activities to reinforce inadequacy or increase stress. Levels of ability can change from day to day. Activities can be adapted and tried another time if they were not successful or enjoyable the first time.

Use times that suit the person's best level of functioning

To achieve the most success when carrying out activities, consider the times of the day when the person is at their best. For example, sometimes walking is best done in the morning or the early afternoon. For people who become restless later in the day or who have had a particularly long or meaningless day, a late afternoon walk may be better.

Encourage an emotional connection

For many people with dementia, a sense of movement and rhythm is often retained. Listening to music, dancing, or contact with babies, children or animals provide positive feelings. People with dementia often have excellent memories of past events, and looking through old photos, memorabilia and books can help the person to recall earlier times.

The opportunity to relive treasured moments can be deeply satisfying. If reading skills have deteriorated, make recordings for them. Locate picture books and magazines in the person's areas of interest.

CONCLUSION

arly Treatment: With an early dementia diagnosis, elderly patients can receive timely treatment. Though there is no cure for the disease, early diagnosis will help to gradually slow down the progression of dementia. Doctors recommend medications to manage symptoms like changes in mood, confusion and memory loss.

Dementia is the loss of cognitive functioning — thinking, remembering, and reasoning — to such an extent that it interferes with a person's daily life and activities. Some people with dementia cannot control their emotions, and their personalities may change.

FUTURE SCOPE

1. Improved Diagnostic Accuracy

• Multimodal Data Integration: Future systems will combine MRI/CT scans,
speech patterns, handwriting, gait analysis, and genetic data to detect subtle early changes.

• Explainable AI (XAI): More transparent models will help clinicians trust and understand the AI's reasoning, supporting better clinical decisions.

• Continuous Learning Models: AI can be retrained with new patient data over time to adapt to population changes and improve accuracy.

2. Early and Non-Invasive Screening Tools • Voice and Speech Biomarkers: AI models analyzing speech or conversation could enable screening through smartphones or telemedicine platforms.

• Wearable Devices: Integration with smartwatches or EEG headbands can continuously monitor cognitive and motor signals for early warning signs.

• Home-Based Testing: AI-powered cognitive games or apps can help identify subtle impairments before clinical symptoms become obvious.

3. Integration into Healthcare Systems
• Clinical Decision Support: Integration with hospital EHRs (Electronic Health Records) can alert physicians to early cognitive decline markers.
• Remote Patient Monitoring: Continuous AI-driven monitoring of high-risk patients can improve follow up and reduce hospital visits.
• Population-Level Screening: AI models can assist public health agencies in early identification and intervention programs.

4.Personalized Treatment and Prognosis
• Predictive Analytics: AI can forecast disease progression and personalize treatment plans.
• Treatment Response Monitoring: Tracking changes in patient data post intervention helps assess therapy effectiveness.
• Genomic AI Integration: AI could analyze genetic and molecular data to personalize dementia prevention and therapy strategies.

5.Ethical and Regulatory Advancements • Data Privacy and Security: Future frameworks will focus on secure, federated learning models that protect patient privacy while enabling large scale analysis.
• Regulatory Approvals: AI systems will evolve to meet medical device certification standards (e.g., FDA, CE) for clinical use.
• Bias Reduction: Enhanced datasets representing diverse populations will reduce bias in diagnosis across age, gender, and ethnicity.

6.Collaborative Research and Global Impact
• Cross-Institutional Data Sharing: Secure AI platforms for global data exchange will strengthen model generalization and validation.
• Cost-Effective Screening in Low Resource Settings: AI models running on low-cost devices could help detect dementia early in underdeveloped regions.
• Public Awareness & Preventive Healthcare: Early detection tools can drive awareness and encourage lifestyle interventions before severe decline.

ACKNOWLEDGMENT

Often, AD coexists with other forms of dementia. Sensitivity to early warning signs, interviews with family members, and mental status examinations are essential to early detection of AD, and will prove useful to primary-care physicians who care for older patients.

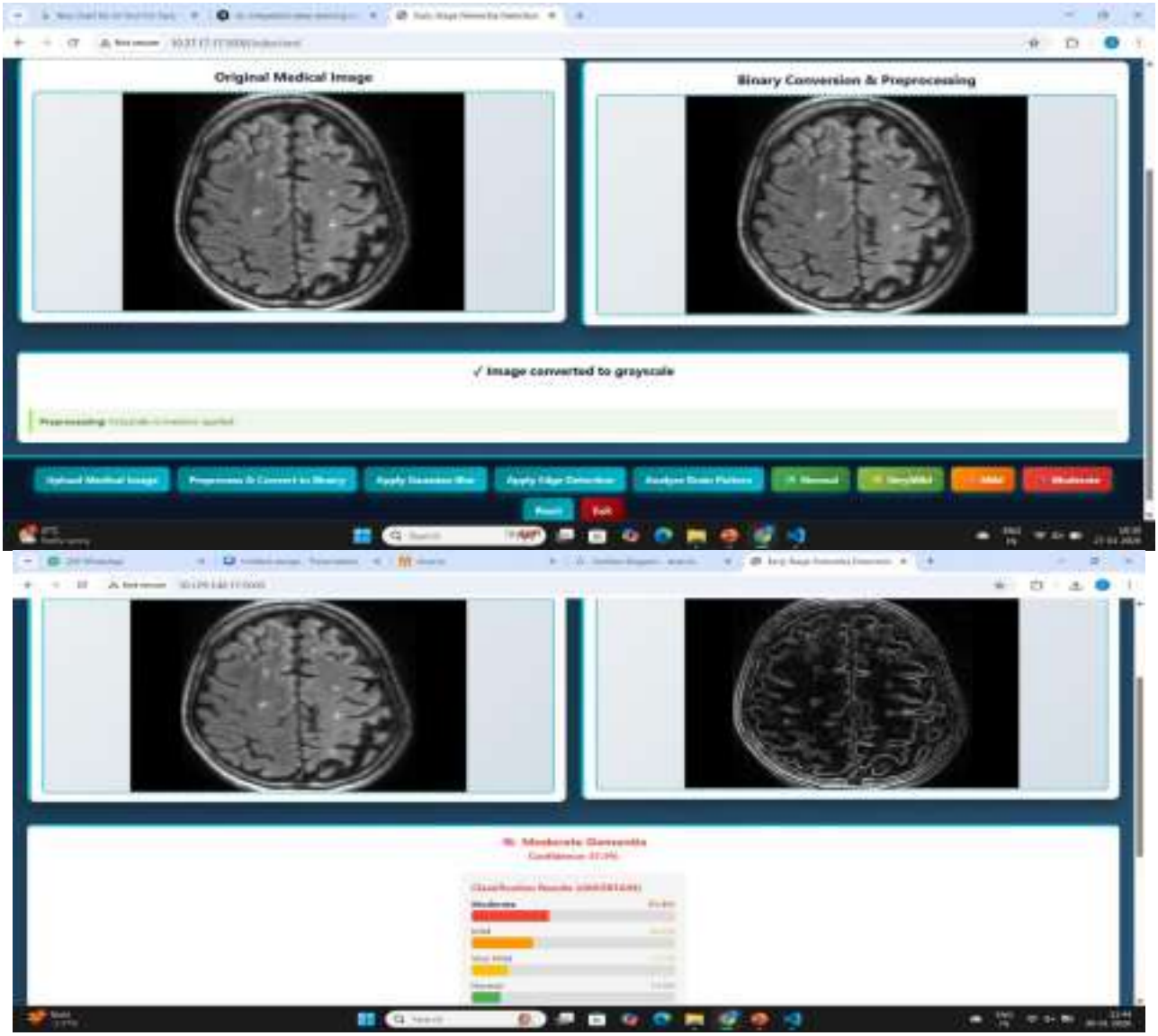
Preserving identity and dignity. Alzheimer's Society says that people with dementia often feel happier if they remain independent and in their own homes as long as possible. Independence is closely tied to a person's identity and sense of self.

I would like to express my sincere gratitude to my teachers and mentors for their valuable guidance and continuous support during the completion of the project on “Early Stage Detection of Dementia.” Their knowledge and suggestions helped me understand the topic deeply and improve my research skills. I am also thankful to my college/institution for providing the necessary resources and learning environment. Special thanks to my friends and classmates for their encouragement and cooperation throughout the project work. Lastly, I extend my heartfelt appreciation to my family for their constant motivation and support, which made this project possible The Dementia Information Service guides you

through the time after a dementia diagnosis which can be difficult. The emails can support you if you have just found out, or accepted, that you or a loved one has dementia. Sign up to receive 6 emails about getting the help you need, now and in the future.

Receiving a timely diagnosis of dementia can enable you to gain access to support and resources for yourself and others, as well as maximise quality of life and allow for planning of the future.

RESUITS



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