Chapter 7

A Comparison of Machine Learning and Deep Learning Techniques for Predicting Alzheimer's Disease

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ABSTRACT

Alzheimer's disease (AD) is a degenerative condition that can cause anything from a slight loss of memory to total loss of consciousness and speech. Early detection has a critical role in maintaining the patient's quality of life. Despite a wealth of studies on AD diagnosis, early and correct diagnosis is most beneficial to patients. Because machine learning (ML) models may identify abnormalities early on, they have become indispensable in the diagnosis of diseases such as AD. ML and computer-aided diagnostics (CAD) have been combined, and this has enhanced AD detection—especially when integrating with MRI data. ML methods are preferred because they produce results quickly and accurately. The goal of this research is to create an automated AD detection system that is more sophisticated and accurate by integrating data from many modalities. The goal of this strategy is to lower the rate of incorrect diagnoses while offering a more thorough diagnostic, emphasizing accuracy, sensitivity, and specificity.

1. INTRODUCTION

Alzheimer's disease (AD) (Finder, 2010) is a slowly developing illness that starts with minor cognitive deterioration and progresses to the loss of speech and environmental awareness. Being one of the most prevalent illnesses, early detection is essential to stop its growth. The economic impact of mental health disorders on GDP growth, including direct and indirect costs, as well as the statistical value of life, is a noteworthy finding of S. Trautmann et al.. Artificial

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intelligence (AI) and non-invasive brain scans (MRI, for example) can be used to evaluate brain structures and provide insights into mental instability.

With 60–80% of cases, Alzheimer's disease is the most common cause of dementia in older persons. According to the Alzheimer's Association, AD is expected to cost $1.1 trillion by 2050 and rank as the sixth most common cause of mortality in the United States. By 2060, there will be twice as many Americans living with Alzheimer's disease as there are currently (5.8 million). Beyond the age of 65, the prevalence of Alzheimer's doubles roughly every five years. Approximately 3.7 million people over 60 in India have Alzheimer's and associated illnesses. The death rate from Alzheimer's disease is rising, but the death rate from cancer and heart disease is decreasing. Alzheimer's disease and other dementias are frequently underreported on death certificates, which raises the possibility that a far larger number of people may actually be affected.

Three stages can be distinguished in the course of Alzheimer's disease progression. After the age of 60, symptoms may first manifest, and the likelihood increases with age. Changes in the brain, blood, or cerebrospinal fluid (CSF) may start in the preclinical asymptomatic stage before any behavioral problems become apparent. moderate cognitive impairment (MCI), memory problems, and cognitive decline may become noticeable to the patient and close friends in the second stage, impacting day-to-day functioning, albeit symptoms are typically moderate. The severe memory, cognitive, and behavioral symptoms in the final stage of the disease, often known as dementia, have a major influence on patients' everyday life and their capacity to carry out routine tasks.

A serious public health problem has arisen as a result of inadequate diagnostic tools and therapeutic interventions. Alzheimer's patients and their carers may have a higher quality of life with the aid of clinical management. It is currently known that there is no treatment for Alzheimer's. Maintaining mental health, dealing with behavioral problems, and halting or postponing the onset of symptoms are the major goals of treatment. In order to properly treat Alzheimer's disease or stop the condition from progressing, early detection and classification are essential. When compared to text-based methods, the classification of clinical photographs based on their visual content has proven to be beneficial. Currently, methods like image content analysis and categorization show great promise and are rather advanced. The human brain's structural abnormalities can be found using magnetic resonance imaging (MRI) data, especially when it comes to structural MRI measurements that make it easier to monitor the progression of brain atrophy, a sign of Alzheimer's disease (AD). A combination of de-noising, feature extraction, and classification approaches can be used in image processing to identify the Alzheimer's disease-affected area.

1.1 Recent Advances and Trends

The application of advanced machine learning (ML) (Puente-Castro et al., 2020) and ensemble approaches has been the focus of recent developments in the discipline, with the goal of increasing diagnostic accuracy and early detection. Alzheimer's research has showed great potential for ensemble learning, which integrates different models to increase predictive performance. MRI scans and other medical imaging data have been utilized to improve the accuracy of Alzheimer's diagnosis using techniques including Random Forests, Gradient Boosting Machines, and stacking models.

Another important area of advancement is deep learning, which is a branch of machine learning. The analysis of intricate patterns in brain imaging data has proven to be especially beneficial for Convolutional Neural Networks (CNNs) (Murugan et al., 2021), allowing for more precise early-stage Alzheimer's disease detection. Furthermore, even with restricted data availability, transfer learning—which makes use of pre-trained models on big datasets—has been used to increase performance on Alzheimer's datasets.

The integration of multi-modal data, which combines MRI with other data types such genetic information, cerebrospinal fluid biomarkers, and cognitive test results, is another new trend in medical imaging. The goal of this all-encompassing strategy is to increase predicted accuracy and offer a more thorough understanding of the illness.

Federated learning is also becoming increasingly popular; it permits models to be trained across several decentralized datasets without requiring the sharing of patient data. This technique improves model robustness and generalizability by addressing privacy concerns and allowing the use of larger datasets.