Alzheimer’s disease (AD) is a progressive neurodegenerative disorder and the leading cause of dementia worldwide, affecting millions of individuals and posing a significant burden on healthcare systems. Characterized by memory loss, cognitive decline, and impaired daily functioning, AD not only diminishes the quality of life for patients but also places immense emotional and financial strain on caregivers and families. Despite decades of research, the exact etiology of AD remains elusive, though it is widely attributed to a combination of genetic, environmental, and lifestyle factors. Pathologically, AD is marked by the accumulation of amyloid-beta plaques and tau neurofibrillary tangles in the brain, leading to synaptic dysfunction, neuronal death, and irreversible cognitive impairment.

The global prevalence of AD is alarming, with over 55 million people currently living with dementia, a number projected to triple by 2050. This escalating trend underscores the urgent need for early and accurate diagnosis, as timely intervention can slow disease progression and improve patient outcomes. Traditional diagnostic methods, such as clinical evaluations and neuropsychological testing, are often time-consuming, subjective, and prone to human error. Advanced neuroimaging techniques, including magnetic resonance imaging (MRI) and positron emission tomography (PET), have improved diagnostic accuracy but remain costly and inaccessible in many regions.

In recent years, artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), has emerged as a transformative tool in AD research. These technologies enable the analysis of large-scale datasets, such as those from the Alzheimer’s Disease Neuroimaging Initiative (ADNI) and the Open Access Series of Imaging Studies (OASIS), to identify subtle patterns and biomarkers associated with AD. Techniques like support vector machines (SVM), random forests (RF), and convolutional neural networks (CNNs) have demonstrated remarkable accuracy in classifying AD stages, including mild cognitive impairment (MCI) and dementia. For instance, deep learning models like DenseNet-169 and ResNet-50 have achieved training accuracies exceeding 98%, highlighting their potential for real-time AD diagnosis.

Moreover, non-invasive approaches, such as gait analysis using wearable devices, have shown promise as cost-effective diagnostic tools. ML models leveraging these methods have achieved accuracies of up to 92%, offering a scalable solution for early AD detection. Despite these advancements, challenges remain, including the need for explainable AI (XAI) to interpret model decisions and the integration of multimodal data to enhance diagnostic precision.

This paper provides a comprehensive review of the latest advancements in ML and DL for AD diagnosis, focusing on their applications in neuroimaging, gait analysis, and biomarker identification. It also discusses the challenges and limitations of these approaches, offering insights into future research directions. By integrating cutting-edge AI techniques with multimodal data, this work aims to contribute to the development of efficient, real-time diagnostic tools for AD, ultimately improving patient outcomes and reducing the global burden of this devastating disease.