WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 14, Issue 2, 316-329. Review Article ISSN 2277–7105

A BRIEF REVIEW ON ALZHEIMER'S DISEASE AND UTILIZATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES AS AN AID TO EARLY DIAGNOSIS

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Article Received on
25 Nov. 2024,

Revised on 16 Dec. 2024,
Published on 15 Jan. 2025

DOI: 10.20959/wjpr20252-35221

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ABSTRACT

Alzheimer's disease (AD) is a chronic neurodegenerative disorder characterized by irreversible loss of neurons, majorly affecting the elder population. It is one of the contributing factors to Dementia. According to World Health Organization (WHO), Alzheimer's disease has a significant impact on global population's health. Unfortunately, there is no effective curative treatment to reverse AD at present due to Irreversible brain atrophy. There an early and accurate diagnosis of Alzheimer's disease is crucial for improving measures can be taken in advance to delay the onset time of the disease and retard its progression. Artificial Intelligence is a branch of science that can analyze complex data and allow machines to work efficiently. The role of AI in healthcare service and pharmaceutical research has increased tremendously. In this review, application of different techniques of AI in the diagnosis of AD were discussed, to find out the best technique that could offer better performance. Machine learning and deep learning were the most used AI techniques, playing a key role in solving several medical challenges by providing important technical support for the early detection, diagnosis and treatment of AD. ML has gained attraction in the medical field as a means of determining a person's risk of developing AD in its early stages. One of the most advanced soft computing neural-network (CNN) based deep- learning methodologies has been emerged as the most promising technology. And this work concludes by highlighting the key techniques utilized for the effective diagnosis of AD.

KEYWORDS: Artificial intelligence, Alzheimer's disease, Neurodegenerative disorder, Machine learning, Deep learning, Computing neural network.

INTRODUCTION

Alzheimer's Disease (AD) is a neurodegenerative disease that commences slowly and progressively worsens over time having significant impact.[1] It is the cause of 60% to 70% of dementia cases.[2] Alzheimer's disease is also referred to as Alzheimer's Dementia. It presents with problems in language, disorientation, mood swings, loss of motivation, self-neglect, and behavioural issues.[1] The quality of the day-to-day lives of individuals with Alzheimer's disease declines gradually, affecting both society and family. Alzheimer's disease is a pathological condition that is often poorly understood.[3] Many environmental and genetic risk factors are commonly associated with its development, with the strongest genetic risk factor being the allele of apolipoprotein.[4-5] The prominent risk factors for Alzheimer's disease include high blood pressure, head injury, and clinical depression. In 2020, there were approximately 50 million cases of Alzheimer's disease have been reported worldwide.[6] It affects mostly people over 65, accounting for up to 10% of cases in this age group. Women are more affected than men in Alzheimer's disease.[7-9] Artificial Intelligence (AI) encompasses technologies that mimic human functions. This field includes techniques like machine learning, computer vision, natural language processing and robotics, all of which contribute to potentially innovative patient care and caregiver support. AI-driven robots enhance precision in clinical trials and improve design data and data management.[10-11] The accurate diagnosis of Mild cognitive impairment (MCI) is still a difficult problem in early Alzheimer's disease, since the metabolic rate and structure of the brain change accordingly with the progression of Alzheimer's disease. The positron emission tomography (PET) is usually utilized here to quantify the changes occurring in the brain and is further applied for computer-aided diagnosis (CAD) of Alzheimer's disease.[12-13] It uses two tree-based algorithms to build Machine Learning (ML) Models on a dataset from the European population to predict the risk of Alzheimer's disease then transfer learning the best model on another dataset from the United Kingdom population. They apply technique like Shapley Additive explanations (SHAP) to visualize population-based and individual-level risk factors. A two-layer Random Forest (RF) model approach was proposed for the diagnosis, progression & detection of Alzheimer's disease. The first layer acts as a multi-classification that detect Alzheimer's disease from Normal Control (NC) and Mild Cognitive Impairment (MCI). The Second layer that acts as a prediction tool to forecast the progression from Mild

Cognitive Impairment to Alzheimer's disease. Their model is trained and tested using various biological and clinical attributes of more than 1000 individuals.[14] Deep learning models have emerged as powerful tools in Alzheimer's disease detection, leveraging their ability to learn complex patterns and representations from large-scale imaging datasets. This subsection explores the application of deep learning models in Alzheimer's disease detection, highlighting their architectures, training strategies, and performance evaluation.[15]

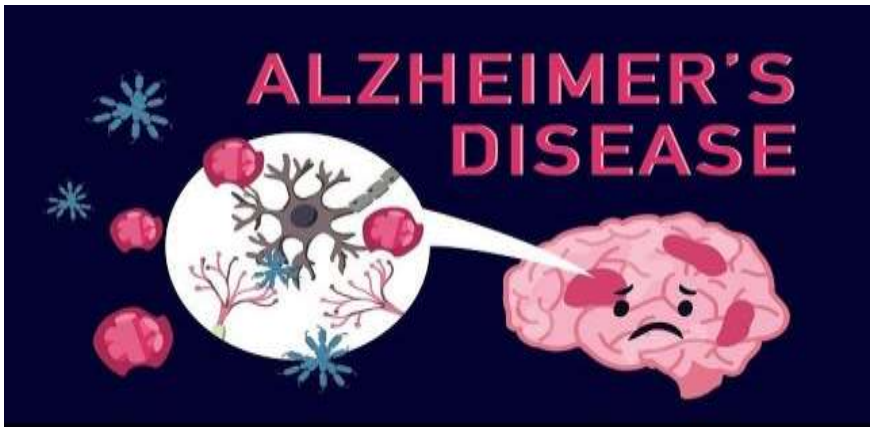

Figure 1: Alzheimer's disease.

History

Auguste D and Alois Alzheimer: In 1907, German psychiatrist and neuropathologist Dr Alois Alzheimer was the first to describe a disorder that would eventually be known as Alzheimer disease (AD). Alois Alzheimer described the case of Auguste D, a 51- years old women with "a peculiar disease of the cerebral cortex" in his seminal year the year of 1906. Auguste had progressive memory loss, language impairment, behavioral symptoms (hallucinations, paranoia and delusions), disorientation and psychosocial impairment.[16] Alzheimer's biopsy of Auguste's brain after his death in 1906 found scattered cortical atrophy," particular changes in cortical cell clusters," and the accumulation of fat bodies in blood vessels, among other conditions. Alzheimer found nerve fibre plaques and tangles, which scientists named beta-amyloid plaques and neurofibrillary tau tangles in the 1980's.[17]

Types

- **Based on signs and symptoms**

1. **Early-Onset Alzheimer's disease (EOAD) / Familial Alzheimer's disease:** Patients between the age group of 40 to 60 are affected by this illness. It only affects 5% of the population. It is characterized by a higher prevalence of plaque development, tangle formation, decrease of brain volume and myoclonus.

2. **Late onset Alzheimer's disease (LOAD) /Sporadic Alzheimer's disease:** It is prevalent in the age groups over 60 and has a slower progression and memory loss. It is characterized by growth of senile plaques, neurofibrillary tangles, increased levels of tau and p-tau.

❖ Based on the severity or state of disease:

1. **Mild Alzheimer's disease**

In the mild stage of Alzheimer's disease dementia, most individuals can to function independently in many areas but are likely to require assistance with some activities to maximize independence and remain safe.

They may still be able to drive, work and participate in their favorite activities But they may need more time to complete them. The symptoms include,

- Mood deviations
- Poor judgement
- Difficulty planning
- Socially inappropriate behavior

2. **Moderate Alzheimer's disease**

In the moderate stage of Alzheimer's disease dementia, which is often the longest stage, individuals experience more problems with memory and language, are more likely to become confused and find it difficult to complete multistep tasks such as bathing and dressing. They may become incontinent at times, begin to have problems recognizing loved ones and start showing personality and behavioral changes, including suspiciousness and agitation. The symptoms are,

- Learning problem
- Dementia
- Aggression
- Dependent on others for daily chores

3. **Severe Alzheimer's disease**

In the severe Alzheimer's disease dementia, individuals' ability to communicate verbally is greatly diminished, and they are likely to require around-the-clock care. Because of damage to areas of the brain involved in movement, individuals find difficulty in walking. As a result, they may spend most of their quality time in a wheelchair or on a bed. This loss of mobility

increases their vulnerability to physical complications including blood clots, skin infections and sepsis (a condition that triggers body-wide inflammations that can result in organ failure). It causes damage to the areas of the brain that control actions like swallowing makes it difficult to eat and drink. This can result in individuals swallowing food into the trachea (windpipe) instead of the esophagus (food pipe). As a result, food particles may get deposited in the lungs and causing an infection called aspiration pneumonia. Aspiration pneumonia is one of the major contributing causes of death among many individuals with Alzheimer's disease. It may cause severity like,

- Motor impairment
- Bedridden.[18-21]

Advantages

In recent years Artificial Intelligence driven Deep Learning (DL) technology has made great strides on the compute vision tasks, for Example: segmentation, classification and detection. Other than the conventional methods mentioned above, deep learning-based methods can automatically find discriminative features from inputs, avoiding complex procession procedures and manually designed feature extraction operators. Inspired by the impressive performance using Deep Learning, a large number of promising studies based on deep learning have been developed for Alzheimer's disease prediction.[22]

Disadvantages

The difficulties of Positron Emission Tomography (PET) image acquisition and the high cost of manual annotation made it infeasible to obtain sufficient training data, which decreased the generalization ability in working data.[23]

PATHOPHYSIOLOGY

Alzheimer disease is characterized pathologically by the accumulation of abnormal, neurotic plaques and neurofibrillary tangles in the brain. These pathological changes are accompanied by a loss of neurons, particularly cholinergic neurons in the basal forebrain and the neocortex.[24] Positive lesions, also known as lesions associated with accumulation, are observed in the brain tissue of Alzheimer's disease patients and are characterized by the accumulation of neurofibrillary tangles, amyloid plaques, neuropil threads, dystrophic neurites and other deposits. Negative lesions are characterized by significant atrophy from synaptic, neuropil and neuronal loss. As a result of neuroinflammation, oxidative stress and damage to cholinergic neurons, inflammation and plasticity (associated to with reactive

process that cause Neurodegeneration) occur.[25-26]

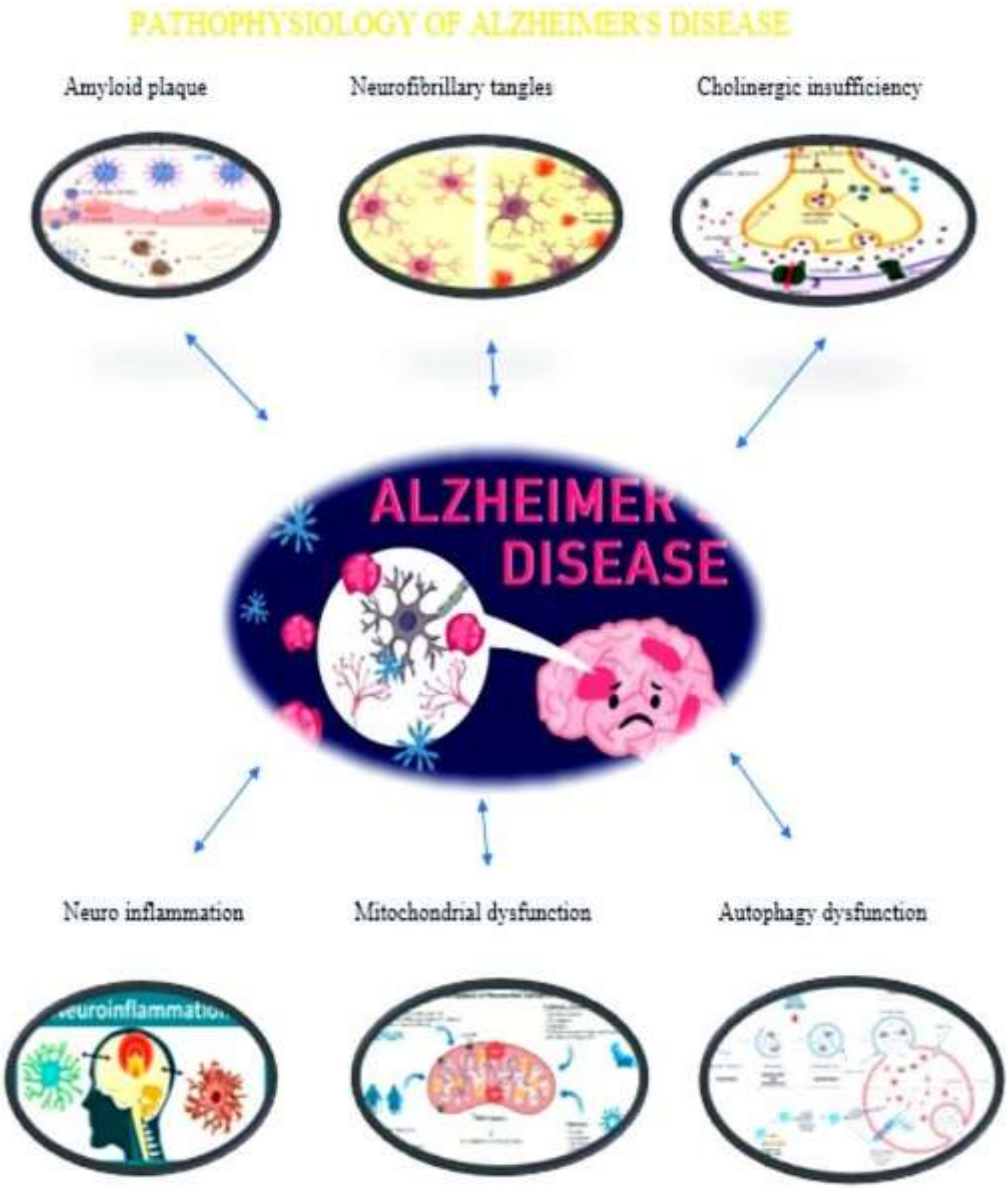

Figure 2: Pathophysiology of Alzheimer.

CAUSE

The hallmark causes for Alzheimer disease are accumulation of the protein beta-amyloid outside neurons and twisted strands of the protein tau inside neurons. They are accompanied by the death of brain neurons and damage to brain tissue. Inflammation and atrophy of brain tissue are other changes.[27-28]

Figure 3: Causes of Alzheimer's disease.

SYMPTOMS

Difficulty in remembering recent conversions, names or events, apathy; and depression are often early symptoms. Communication problems, confusion, poor judgement and behavioral changes may occur next. Difficulty working, speaking and swallowing are common in the later stages of the disease.[27-28]

Figure 4: Sign and Symptoms of Alzheimer's disease.

ARTIFICIAL INTELLIGENCE (AI) IN THE FIELD OF ALZHEIMER'S DISEASE

Artificial Intelligence (AI) is a field focused on enabling computer systems to possess cognitive capabilities akin to human thinking.[29] The study of Artificial Intelligence extends across diverse domains, predominantly encompassing machine learning (ML) and deep learning (DL).[30] In the last decade, there has been increased interest in advancements in Artificial Intelligence, especially through deep convolutional neural networks, for use in health care delivery.[31] As Artificial Intelligence shows a potential to improve healthcare, its possible benefits for Alzheimer disease patient's and caregivers are increasingly recognized. Artificial Intelligence enables smartphone apps and robots, offering assistance to patients with Alzheimer disease in maintaining attention, enhancing memory training and learning independence.[32-34]

ARTIFICIAL INTELLIGENCE (AI) TOOLS IN THE DIAGNOSIS OF ALZHEIMER'S DISEASE

❖ Machine learning in Alzheimer's disease

The machine learning (ML) techniques has been used in the field of AD to analyze various types of data for the identification of distinguishing patterns associated with the disease. ML have been utilized for the AD detection and diagnosis to identify individuals at risk of developing AD before the onset of significant symptoms.[35-39] ML models provide interpretation of the specific medical decision-making process or diagnostic task they perform in this regard of an explainable Artificial Intelligence (AI).[40] The experimental results demonstrate the capabilities of ML models in the classification of AD patients from those with NC or MCI. Out of the four-model utilized Random Forest (RF), Support Vector Machine (SVM), Neuronal Networks (NN) and K-Nearest Neighbor (KNN) - the RF and SVM models consistently achieved-higher accuracy, precision and recall scores across all tasks.[41]

❖ Deep learning in Alzheimer's disease

Diagnosis using residual network-50-pretrained CNN model which has shown accuracy in recognizing images.[38] Deep learning models have been emerged as one of the powerful tools in Alzheimer's disease detection, leveraging their ability to learn complex patterns and representations from large-scale imaging datasets. This subsection explores the application of deep learning models in Alzheimer's disease detection, highlighting their architectures, training, strategies and performance evaluation.[42] This paper aims to comprehensively

review the current landscape of Alzheimer's disease detection using deep learning techniques. Specifically, our goal is to explore the application of deep learning in both supervised and unsupervised models to gain deeper insight into AD. By examining the latest findings and emerging trends, we examine Alzheimer's disease detection using deep learning.[43] These advances in deep learning and multimodal imaging have improved leveraging CNNs, RNNs and generative modelling techniques. The following sections will explore specific methodologies and findings in deep learning approaches for AD detection.[44]

1. Convolutional Neural Network (CNN)

A CNN is a deep learning method that can take an import matrix and assign importance to different aspects objects while also distinguishing between them. In comparison to other classification methods a CNN requires significantly less pre-processing.[45] Newer machine learning methods based on deep convolutional neural networks (CNN) make it possible to extract features directly from image data in a data-driven fashion.[46-52] In the biomedical field, CNN based methods also have the potential to reveal new imaging biomarkers.[53-54] We propose a deep learning model based on novel CNN architecture that is capable of distinguishing between persons who have normal cognition, MCI, and mild Alzheimer's disease Dementia.[55] To train deep learning models, large amount of annotated datasets are required. The Alzheimer's disease Neuroimaging Initiative (ADNI) and other publicly available datasets, such as the Open Access Series of Imaging Studies (OSASIS) and Australian Imaging, Biomarkers and Lifestyle (AIBL) study, have played crucial roles in facilitating the development and evaluation of deep learning models for Alzheimer's disease detection.[56]

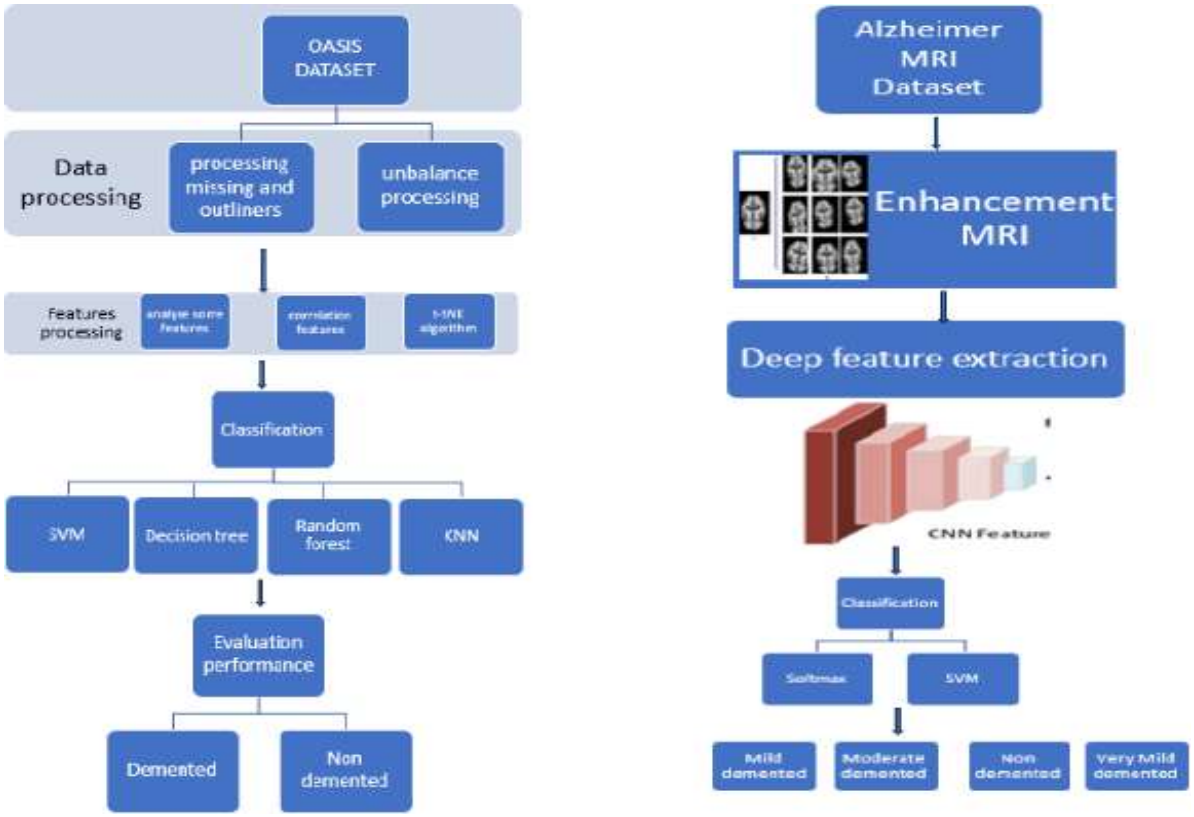

Figure 5: Flowchart for ML and DL.

DRUGS FOR THE TREATMENT OF ALZHEIMER'S DISEASE

A total of eight drugs are currently available for the treatment of Alzheimer's disease. Two of these drugs change the underlying biology of Alzheimer's disease and slow cognitive and functional decline in some individuals. A third of such drug was under review by the Food and Drug Administration (FDA) for potential approval at press time. Six additional drugs have been approved to treat the symptoms of Alzheimer's dementia.[57]

CONCLUSION

Alzheimer's disease is a degenerative neurological condition that leads to both the damage and death of brain cells, causing memory impairment. We proposed a new system for early automatic diagnosis of AD symptoms based on CNN and SVM. "Medical image processing" refers to the process of creating a visual representation of the internal workings of a body by using a variety of imaging technologies to diagnose and treat illnesses using ML and DL. In ML, the SVM-RBF classification offers the highest level of accuracy out of all of the available options for diagnosing Alzheimer's disease. In DL, CNN has gained considerable attention as a form of artificial intelligence. CNN has the best accurate data out of all for diagnosing Alzheimer's disease.

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