Chapter 16
Real-World Applications and Case Studies of Deep Generative Models in Alzheimer's Disease Research

Rachna Behl
Manav Rachna International Institute of Research and Studies, India

Indu Kashyap
Manav Rachna International Institute of Research and Studies, India

Bhanu Dwivedi
Manav Rachna International Institute of Research and Studies, India

ABSTRACT

Alzheimer's Disease (AD) is an irreversible neurodegenerative condition that causes a gradual decline in cognitive functions. Early AD detection is essential for efficient management. Traditional methods of detection utilizing magnetic resonance imaging (MRI) and other neuropsychological testing have been successful in past decades. However, lack of clinical experts, expensive tests, poor diagnosis require interventions. ML is effective in AD research; however, they fail to handle complex data. Convolution Neural Networks also trigger early prediction of AD but fail due to insufficient data. Deep Generative Models (DGMs) have attracted a lot of attention in recent years. However, the use of Deep Generative Models in Alzheimer research still needs to be validated. Applying DGMs across various disciplines have been promising. This chapter provides an overview of DGMs and their applications

DOI: 10.4018/979-8-3693-6442-0.ch016

in Alzheimer's Research. Real-world applications and case studies are presented by the authors. The chapter discusses the challenges of DGMs and strategies to address challenges.

INTRODUCTION

Alzheimer's Disease named after Dr. Alois Alzheimer is a brain neuro-disorder caused due to abnormal protein deposits specially beta-amyloid and aggregations of tau protein known as neurofibrillary tangles or paired helical filaments (PHF). It is a progressive disorder characterized by degeneration of the brain. Further, patients affected by AD have memory loss, gradual decrease in cognitive function, and are not able to do daily chores impacting the quality of life. Neural transmission in patients is affected that give rise to brain atrophy and cell death. Further, the hippocampus, the major region of the brain that controls memory formation, gets affected triggering the early-onset dementia (Beheshti et al., 2019). The hippocampus, which is important for memory formation, is one of the first regions to define the earliest symptoms of memory loss (Cui & Lui, 2019).

The symptoms of AD progress through several stages, beginning with memory loss, particularly concerning recent events and new information. They also face difficulties in planning or solving problems, confusion with time or place, and changes in mood and personality, such as increased anxiety. As the disease progresses to the middle stage, symptoms escalate to increased memory loss and confusion, difficulty recognizing family and friends, inability to learn new information, problems with language and organizing thoughts, and behavioral changes, including agitation, aggression, and wandering. In the advanced stages, patients lose the ability to communicate coherently, require full-time assistance with daily activities, and lose physical abilities such as walking, sitting, and eventually swallowing. They also become vulnerable to infections, particularly pneumonia. Several risk factors contribute to the development of AD. The risk increases significantly with age, especially after 65. Genetics play a role, with family history and specific genetic mutations (e.g., APOE ε4 allele) linked to a higher risk. Lifestyle and heart health factors, such as hypertension, diabetes, obesity, and a sedentary lifestyle, can also increase the risk. Severe or repeated head trauma, lower levels of formal education, and reduced cognitive engagement may elevate the likelihood of developing AD. Diagnosing AD involves a combination of methods. Clinical evaluation includes a detailed medical history and an assessment of cognitive and functional abilities.

Neurological examinations assess balance, sensory functions, and reflexes. Neuropsychological tests evaluate memory, problem-solving, attention, and language skills. Imaging techniques, such as MRI and CT scans, detect brain atrophy and

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