A Project Report

on

GAMING APPLICATION FOR ALZHEIMER'S DISEASE DETECTION

Submitted in partial fulfillment of the requirements

for the award of degree of

BACHELOR OF TECHNOLOGY

in

Information Technology

by

K. Sanjana Reddy (19WH1A1219)

M. Deepthi Sharvani (19WH1A1220)

R. Rajani (19WH1A1241)

K. Aarthi (19WH1A1258)

Under the esteemed guidance of

Dr. Aruna Rao S L

Professor & HoD

Department of Information Technology

BVRIT HYDERABAD College of Engineering for Women

Rajiv Gandhi Nagar, Nizampet Road, Bachupally, Hyderabad – 500090

(Affiliated to Jawaharlal Nehru Technological University Hyderabad)

(NAAC 'A' Grade & NBA Accredited- ECE, EEE, CSE & IT)

June, 2023

DECLARATION

We hereby declare that the work presented in this project entitled "**GAMING APPLICATION FOR ALZHEIMER'S DISEASE DETECTION** " submitted towards completion of the project in IV year II sem of B.Tech IT at "BVRIT HYDERABAD College of Engineering for Women", Hyderabad is an authentic record of our original work carried out under the esteemed guidance of **Dr. Aruna Rao S L, Professor & HoD**, Department of IT.

K. Sanjana Reddy (19WH1A1219)

M. Deepthi Sharvani (19WH1A1220)

R. Rajani (19WH1A1241)

K. Aarthi (19WH1A1258)

BVRIT HYDERABAD

College of Engineering for Women

Rajiv Gandhi Nagar, Nizampet Road, Bachupally, Hyderabad – 500090

(Affiliated to Jawaharlal Nehru Technological University, Hyderabad)

(NAAC 'A' Grade & NBA Accredited- ECE, EEE, CSE & IT)

CERTIFICATE

This is to certify that the Major-Project report on **"GAMING APPLICATION FOR ALZHEIMER'S DISEASE DETECTION"** is a bonafide work carried out by **Ms. K. Sanjana Reddy (19WH1A1219), Ms. M. Deepthi Sharvani (19WH1A1220), Ms. R. Rajani (19WH1A1241) , Ms. K. Aarthi (19WH1A1258)** in the partial fulfillment for the award of B.tech degree in **Information Technology, BVRIT HYDERABAD College of Engineering for Women, Bachupally, Hyderabad** affiliated to the Jawaharlal Nehru Technological University Hyderabad under my guidance and supervision. The results embodied in the Major-Project work have not been submitted to any other university or institute for the award of any degree or diploma.

Internal Guide
Dr. Aruna Rao S L
Professor & HoD
Department of IT

Head of the Department
Dr. Aruna Rao S L
Professor & HoD
Department of IT

External Examiner

ACKNOWLEDGEMENT

We would like to express our profound gratitude and thanks to **Dr. K. V. N. Sunitha, Principal, BVRIT HYDERABAD** for providing the working facilities in the college.

Our sincere thanks and gratitude to **Dr. Aruna Rao S L, Professor & Head, Department of Information Technology, BVRIT HYDERABAD** for all the timely support, constant guidance and valuable suggestions during the period of our project.

We are extremely thankful and indebted to our internal guide **Dr. Aruna Rao S L, Professor & HoD, Department of IT, BVRIT HYDERABAD** for her constant guidance, encouragement and moral support throughout our project.

Finally, we would also like to thank our Project Coordinators **Dr. P. Kayal, Associate Professor and Ms. K. S. Niraja, Assistant Professor**, all the faculty and staff of the Department of IT who helped us directly or indirectly, parents and friends for their cooperation in completing the project work.

K. Sanjana Reddy (19WH1A1219)

M. Deepthi Sharvani (19WH1A1220)

R. Rajani (19WH1A1241)

K. Aarthi (19WH1A1258)

ABSTRACT

Alzheimer's Disease is a leading cause for damage or loss of nerve cells and their connection in the brain . Depending on the area of the brain that's damaged, it can affect people differently and cause different symptoms. There is no cure for this disease, although treatments are available that may improve some symptoms. Symptoms of this disease depend on the stage of the disease. Symptoms usually develop slowly and get worse over time, becoming severe enough to interfere with the daily tasks. An android application has been proposed that provides various tests in the form of levels of a game to detect whether a person suffers from Alzheimer's or not and also tells them the degree of the disease i.e. Mild, Moderate, Severe which helps to track the status of the patient also. The main intention of this application is to make the player feel like he/she is not being tested but rather is playing a game full of fun and excitement. At the same time, the application determines the ability to remember everyday things.

LIST OF FIGURES

LIST OF ABBREVIATIONS

Acronym	**Abbreviation**
AD	Alzheimer's Disease
OTP	One-Time Password
MRI	Magnetic Resonance Imaging
CT Scan	Computed Tomography Scan
PET Scan	Positron Emission Tomography Scan
CNN	Convolutional Neural Network
MCI	Mild Cognitive Impairment
VR	Virtual Reality
GPS	Global Positioning System
MARS	Mobile Application Review System
SDK	Software Development Kit
MVC	Model View Controller

TABLE OF CONTENTS

1. INTRODUCTION

Alzheimer's Disease is increasingly becoming an issue of public health concern, given that age is a known risk factor and, accordingly, prevalence rates are likely to rise with more people developing this condition in an ageing population. Neurodegenerative disease that usually starts slowly and progressively worsens. Affected people increasingly rely on others for assistance, often placing a burden on the caregiver.

Alzheimer's disease is the most common type of dementia. It is a progressive disease beginning with mild memory loss and possibly leading to loss of the ability to carry on a conversation and respond to the environment. Alzheimer's disease involves parts of the brain that control thought, memory, and language.

Alzheimer's disease is not a normal part of aging. Memory problems are typically one of the first warning signs of Alzheimer's disease and related dementias. In addition to memory problems, someone with symptoms of Alzheimer's disease may experience Memory loss that disrupts daily life, such as getting lost in a familiar place or repeating questions, Memory loss that disrupts daily life, such as getting lost in a familiar place or repeating questions, Trouble handling money and paying bills, Difficulty completing familiar tasks at home, at work or at leisure, Decreased or poor judgment, Misplacing things and being unable to retrace steps to find them, Changes in mood, personality, or behavior.

Medical management can improve quality of life for individuals living with Alzheimer's disease and for their caregivers.Currently, many people living with Alzheimer's disease are cared for at home by family members. Caregiving can have positive aspects for the caregiver as well as the person being cared for. It may bring personal fulfillment to the caregiver, such as satisfaction from helping a family member or friend, and lead to the development of new skills and improved family relationships.

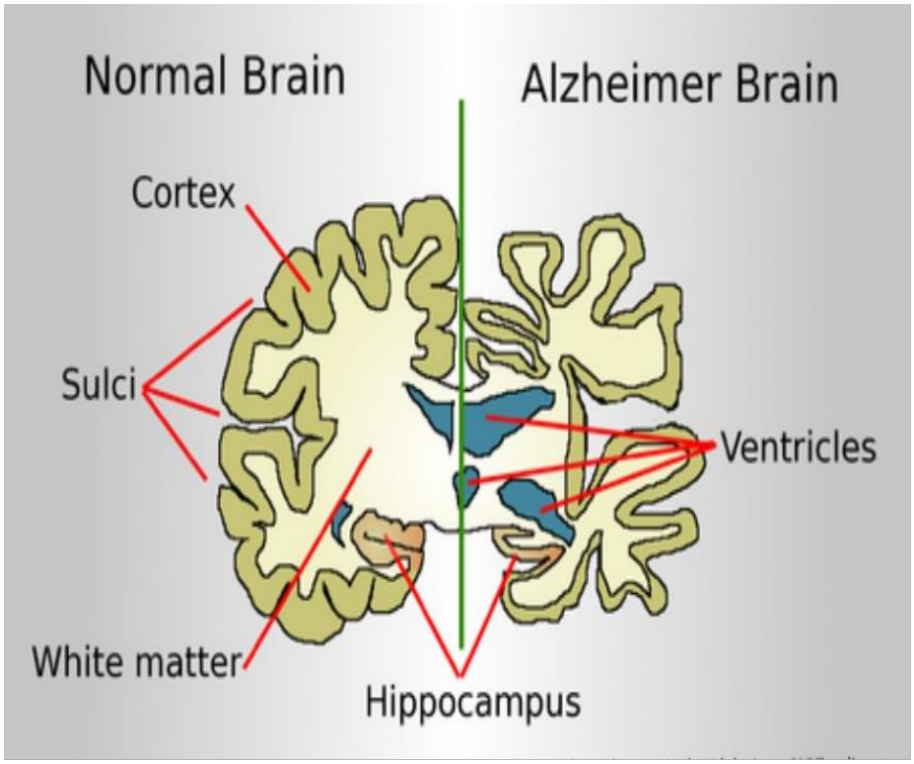


Figure 1 Diagram of a normal brain compared to the brain of a person with Alzheimer's

Alzheimer's disease is thought to be caused by the abnormal build-up of proteins in and around brain cells.One of the proteins involved is called amyloid, deposits of which form plaques around brain cells.Although it's not known exactly what causes this process to begin, scientists now know that it begins many years before symptoms appear.As brain cells become affected, there's also a decrease in chemical messengers called neurotransmitters involved in sending messages, or signals, between brain cells.Levels of one neurotransmitter, acetylcholine, are particularly low in the brains of people with Alzheimer's disease.Over time, different areas of the brain shrink. The first areas usually affected are responsible for memories.The first symptoms may be problems with vision or language rather than memory.

The symptoms of Alzheimer's disease progress slowly over several years. Sometimes these symptoms are confused with other conditions and may initially be put down to old age.The rate at which the symptoms progress is different for each individual.In some cases, other conditions can be responsible for symptoms getting worse.Anyone with Alzheimer's disease whose symptoms are rapidly getting worse should be seen by a doctor so these can be managed.

The most common early symptoms are difficulty in remembering recent events. As the disease advances, symptoms can include problems with language, disorientation (including easily getting lost), mood swings, loss of motivation, self-neglect, and behavioral issues. As a person's condition declines, they often withdraw from family and society. Gradually, bodily functions are lost, ultimately leading to death. Although the speed of progression can vary, the typical life expectancy following diagnosis is three to nine years. The symptoms of Alzheimer's vary for each stage.

As the exact cause of Alzheimer's disease is still unknown, there's no certain way to prevent the condition. But a healthy lifestyle can help reduce your risk.Cardiovascular disease has been linked with an increased risk of Alzheimer's disease and vascular dementia.The latest research suggests that other factors are also important, although this does not mean these factors are directly responsible for causing dementia.

1.1 Early Stage

In the early stages, the main symptom of Alzheimer's disease is memory lapses. Someone with early Alzheimer's disease may forget about recent conversations or events, misplace items, forget the names of places and objects, have trouble thinking of the right word, ask questions repetitively, show poor judgement or find it harder to make decisions, become less flexible and more hesitant to try new things. There are often signs of mood changes, such as increasing anxiety or agitation, or periods of confusion. For People with Alzheimer's Disease, the increasing impairment of learning and memory eventually leads to a definitive diagnosis. Alzheimer's Disease does not affect all memory capabilities equally. Older memories of the person's life, facts learned, and implicit memory are affected to a lesser degree than new facts or memories. Language problems (shrinking vocabulary and decreased word fluency) occur in the early stage.

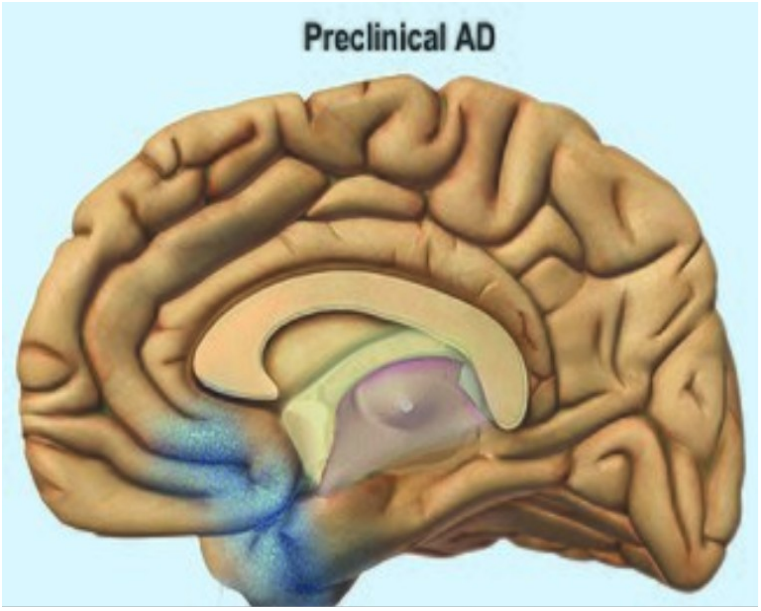


Figure 1.1 Early Stage

1.2 Middle stage

Progressive deterioration eventually hinders independence, with subjects being unable to perform most common activities of daily living. Frequent incorrect word substitutions become evident. Reading and writing skills are progressively lost. The risk of falling increases. During this stage, memory problems worsen, and the person may fail to recognize close relatives. Common manifestations are wandering, irritability and emotional lability, leading to crying, outbursts of unpremeditated aggression, or resistance to caregiving.

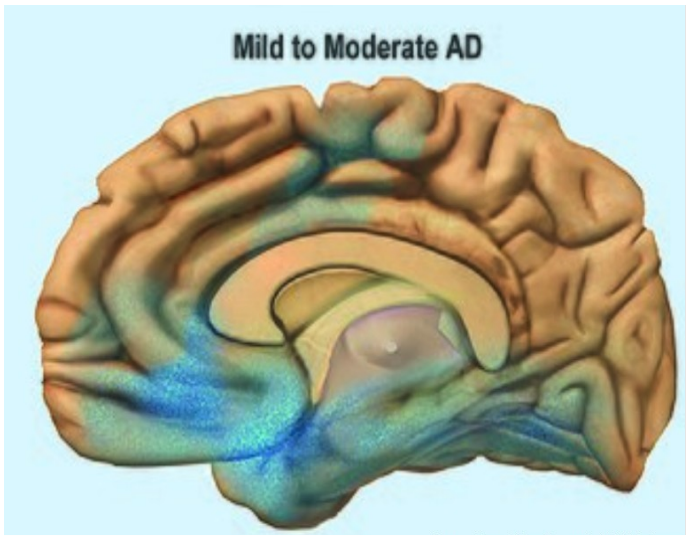


Figure 1.2 Middle Stage

1.3 Later Stage

During the final stage, known as the late-stage or severe stage, there is complete dependence on caregivers or caretakers. Language is reduced to simple phrases or even single words, eventually leading to complete loss of speech. Although aggressiveness can still be present, extreme apathy and exhaustion are more common symptomes.Language is reduced to simple phrases or even single words, eventually leading to complete loss of speech.

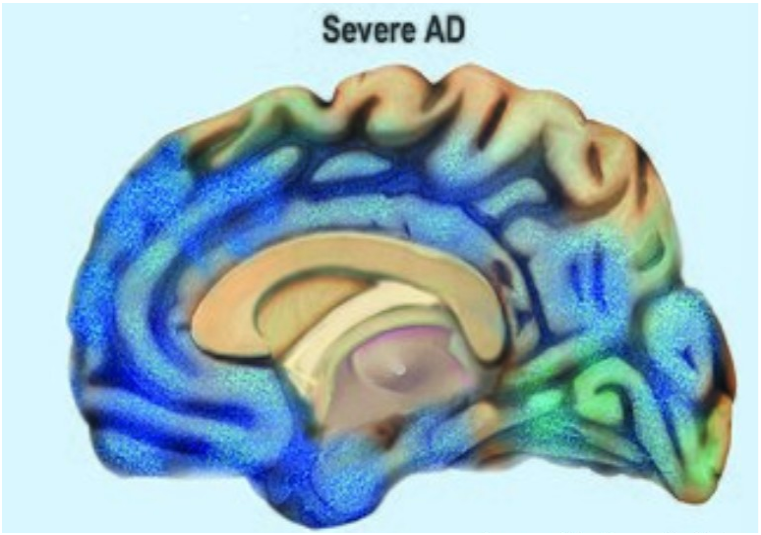


Figure 1.3 Later Stage

As of 2020, there were approximately 50 million people worldwide with Alzheimer's Disease. There are over 10 million new cases of dementia each year worldwide, implying one new case every 3.2 seconds. Alzheimer's Disease is among the most costly diseases for societies worldwide. Costs associated with this disease include direct and indirect medical costs. Direct costs include doctor visits, hospital care, medical treatments, nursing home care, specialized equipment, and household expenses. Indirect costs include the cost of informal care and the loss in productivity of informal caregivers. People whose family members suffer from Alzheimer's may have a higher chance of developing the disease. Also at risk are people who have experienced a head injury, people who have down syndrome or diabetes, or those who have had a low quality education.

1.4 Objective

The goal is to identify the symptoms of Alzheimer's and to keep the mind mentally strong through games, which exercise different parts of the brain in the Games section. Combining brain games, and social interaction, the game can guide its users toward a multifaceted, holistic lifestyle change that may help curtail some of the effects of cognitive decline. This motivates the need to build relatively simple cross-platform mobile applications with interactive GUIs so as to enhance their cognitive abilities.

1.5 Problem Definition

People never prefer to visit a doctor until the symptoms get intensified, which generally happens in later stages of disease. CT scans, MRI scans and PET scans are performed when prescribed by a doctor only. Hence diagnosing the disease and providing the proper medication for the patient in early stages of disease, will help in preventing the serious effects caused by the disease in later stages. One of the possible solutions is to motivate the use of Smartphones by the patient. Smartphones play a crucial role for the family members of the Alzheimer's patients as it helps the patients in carrying out their routine activities by providing time to time notifications about them.

2. LITERATURE SURVEY

In, Sabine Hazan SAGE Journals[1], Rapid improvement in Alzheimer's Disease symptoms following fecal microbiota transplantation: a case report says that Alzheimer's Disease, the most common form of dementia, is a leading cause of death and a major cause of morbidity in older people. The disease is characterized by progressive memory loss, cognitive impairment, and the cerebral accumulation of amyloid-b peptide. Given the health and economic impacts of AD, treatments that target the underlying etiology of AD or modify the course of the disease are of significant interest. The gut microbiome has been increasingly implicated in the pathogenesis of several neurological diseases, including multiple sclerosis and Parkinson's disease. A growing body of experimental and clinical data implicates the gut microbiome in the pathogenesis of several neurological conditions, including autism spectrum disorder, Parkinson's disease and multiple sclerosis. More recently, alterations in gut microbiome composition have been observed in patients with AD, suggesting a potential role for the microbiome in AD pathogenesis. This hypothesis has been supported by animal models.

In Dan Pan, An Zeng, Longfei Jia, Yin Huang, Tory Frizzell and Xiaowei Song, Frontiers[2], Early Detection of Alzheimer's Disease Using Magnetic Resonance Imaging: A Novel Approach Combining Convolutional Neural Networks and Ensemble Learning says that Early detection is critical for effective management of Alzheimer's disease. Among several deep learning techniques that have been applied to assessing structural brain changes on MRI,CNN has gained popularity due to its superb efficiency in automated feature learning with the use of a variety of multi-layer perceptron.Alzheimer's Disease is a chromic, progressive and irreversible neurodegenerative disease clinically manifested by amnesia, cognitive dysfunction, and gradual loss of multiple other brain functions and daily living independency.

In Dr Gil D. Rabinovici, University of California San Francisco Memory and Aging Center[3], Late-onset Alzheimer Disease says that approximately 80% of patients with this disease are older than age 75, with disease incidence increasing from 2 per 1000 at ages 65 to 74 to 37 per 1000 at age 85 and older.The number of patients with alzheimer's in the United States is projected to nearly triple by 2050, with the majority of growth attributed to the 85 and older age group. Prospective population-based studies provide strong evidence that the risk of late-life cognitive impairment and

dementia is modified by medical comorbidities, lifestyle choices, and other environmental factors. The risk of dementia is increased in patients with vascular risk factors, and growing evidence suggests that aggressive treatment of these risk factors as early as midlife can attenuate the risk of developing cognitive impairment in older age.

In Zeinab Breijyeh, Rafik Karaman, Pharmaceutical Sciences Department, Al-Quds University, Comprehensive Review on Alzheimer's Disease: Causes and Treatment. Molecules[4] At present, there are around 50 million alzheimer's patients worldwide and this number is projected to double every 5 years and will increase to reach 152 million by 2050. This burden affects individuals, their families, and the economy, with estimated global costs of US$1 trillion annually. At present, there is no cure for Alzheimer's disease, although there are available treatments that just improve the symptoms. A patient suspected to have Alzheimer's should undergo several tests, including neurological examination, magnetic resonance imaging (MRI) for neurons, laboratory examinations such as vitamin B12, and other tests besides the medical and family history of the patients

In Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., ... Mukadam, N.Dementia prevention, intervention, and care: 2020 report of the Lancet Commission[5] The Lancet. The number of people with dementia is rising. Predictions about future trends in dementia prevalence vary depending on the underlying assumptions and geographical region, but generally suggest substantial increases in overall prevalence related to an aging population. For example, according to the Global Burden of Diseases, Injuries, and Risk Factors Study, the global age-standardized prevalence of dementia between 1990 and 2016 was relatively stable, but with an aging and bigger population, the number of people with dementia has more than doubled since 1990. One large study in China tried to separate cognitive activity in adulthood from activities for those with more education, by considering activities judged to appeal to people of different levels of education. It found people older than 65 years who read, played games, or bet more frequently had reduced risk of dementia.

In Kanwal Yousaf, Zahid Mehmood, Israr Ahmad Awan, Tanzila Saba, Riad Alharbey, Talal Qadah and Mayda Abdullateef Alrige. A comprehensive study of mobile-health-based assistive technology for the healthcare of dementia and Alzheimer's disease[6], authors have carried out work on the comprehensive study of mobile-health-based assistive technology for the healthcare of dementia and Alzheimer's Disease. Assistive technology involvement in therapeutic treatment has provided simple and efficient healthcare solutions to people. Within a short span of time, mobile health (mHealth) has grown rapidly for assisting people living with a chronic disorder. This research paper presents the comprehensive study to identify and review existing mHealth dementia applications (apps), and also synthesize the evidence of using these applications in assisting people with dementia including Alzheimer's disease and their caregivers. Six electronic databases searched with the purpose of finding literature-based evidence. The search yielded 2818 research articles, with 29 meeting quantified inclusion and exclusion criteria. Six groups and their associated sub-groups emerged from the literature. The main groups are (1) activities of daily living based cognitive training, (2) monitoring, (3) dementia screening, (4) reminiscence and socialization, (5) tracking, and (6) caregiver support. Moreover, two commercial mobile application stores i.e., Apple App Store (iOS) and Google Play Store (Android) explored with the intention of identifying the advantages and disadvantages of existing commercially available dementia and Alzheimer's healthcare apps.

In Subetha T, Rashmita Khilar,Sarat Kumar Sahoo. An Early Prediction and Detection of Alzheimer's Disease: A Comparative Analysis on Various Assistive Technologies [7], authors have carried out work on Dementia which involves in the deterioration of cognitive behaviour of a patient. It is observed that the patient's performance slowly deteriorates during the activities like memory loss, language, reasoning, decision making, attention etc., Normally patients with Dementia have sudden change in their behaviour inside and outside their house. This disease leads to Alzheimer's disease and it last for decades with the patient. There is no cure for the disease or a very less and this disease last for decades. There are mainly two causes of dementia disease, they are: reversible and irreversible causes of dementia. Reversible dementias are very rare and this type is curable, if the condition is treated. The condition included for the first type is depression, nutritional deficiencies metabolic and endocrine disorders, normal pressure. The other one is not completely curable and hence require proper treatment.

In Eunhee Kim, Andrius Baskys, Anandi V.Law, Mom R. Rosan, Yan L Don Roosan. Scoping review: The empowerment of Alzheimer's disease caregivers with mHealth Applications[8] , it states that Alzheimer's Disease is one of the most prevalent neurodegenerative chronic diseases. As it progresses, patients become increasingly dependent, and their caregivers are burdened with the increasing demand for managing their care. Mobile health (mHealth) technology, such as smartphone applications, can support the need of these caregivers. This paper examines the published academic literature of mHealth applications that support the caregivers of AD patients. Following the PRISMA for scoping reviews, we searched published literature in five electronic databases between January 2014 and January 2021. Twelve articles were included in the final review. Six themes emerged based on the functionalities provided by the reviewed applications for caregivers. They are tracking, task management, monitoring, caregiver mental support, education, and caregiver communication platform. The review revealed that mHealth applications for AD patients' caregivers are inadequate. There is an opportunity for industry, government, and academia to fill the unmet need of these caregiver.

In Lampros C. Kourtis, Oliver B. Regele, Justin M. Wright Graham B. Jones: Digital Biomarkers for Alzheimer's disease: the mobile or wearable devices opportunity [9], authors states that Alzheimer's Disease (AD) represents a major and rapidly growing burden to the healthcare ecosystem. A growing body of evidence indicates that cognitive, behavioral, sensory, and motor changes may precede clinical manifestations of Alzheimer's by several years. Existing tests designed to diagnose neurodegenerative diseases, while well-validated, are often less effective in detecting deviations from normal cognitive decline trajectory in the earliest stages of the disease. In the quest for gold standards for assessment, there is a growing interest in the identification of readily accessible digital biomarkers, which harness advances in consumer grade mobile and wearable technologies. Topics examined include a review of existing early clinical manifestations and a path to the respective sensor and mobile/wearable device usage to acquire domain-centric data towards objective, high frequency and passive digital phenotyping.

In Thomas Engelsma, Monique W.M. Jaspers, Linda W Peute. Considerate mHealth design for older adults with Alzheimer's disease and related dementias: A scoping review on usability barriers and design suggestions[10], The number of older adults with Alzheimer's disease and related dementias is increasing worldwide. This offers ample opportunities for mobile health (mHealth) apps, for example to support them in performing daily activities or monitoring their health status and how to design these apps taking into consideration this disease related barriers remains a challenge.The identified usability barriers were classified in five categories: cognition, perception, physical ability, frame of mind, and speech- and language. In addition, the design suggestions were categorized as evidence- or expert-based. Evidence-based design suggestions include showing limited information, repeating instructions multiple times and breaking instructions into simple steps given one at a time. This research provides a first step for further collaboration between experts and designers to support the development of effective mHealth apps with high user-friendliness.

In Rosa Perez-Siguas , Hernan Matta-Solis , Eduardo Matta-Solis. Design and Implementation of a Mobile Application to Help People with Alzheimer‘s[11], Currently, people with Alzheimer‘s require special and full-time care, so they must prevent the person from being in danger. In recent years, the number of people suffering from the disease has increased. In addition, the fact that people who have Alzheimer‘s are characterized as having problems with their cognitive functions, memory loss, and personality changes affects large areas of brain certainty. For this reason, a mobile application was designed that will help stimulate and help people with Alzheimer‘s and responsible people or family members. Because you will be able to monitor where you are and choose the interactive games that you will have to develop your cognitive system, in addition, you will be able to make the application remind you of some people or objects that you have forgotten, for example, the virtual assistant will begin to read the things that you point in the module, as you can also have control of what time to take the medicines. In this work, the Scrum methodology was used for the development and the Figma tool for the design of the prototype. The results obtained from the research will be to have a better follow-up and to be able to help people with Alzheimer‘s in the cognitive system.

In Areej Y. Bayahya , Wadee Alhalabi , Sultan H. AlAmri: Smart Health System to Detect Dementia Disorders Using Virtual Reality[12], Smart health technology includes physical sensors, intelligent sensors, and output advice to help monitor patients' health and adjust their behavior. Virtual reality (VR) plays an increasingly larger role to improve health outcomes, being used in a variety of medical specialties including robotic surgery, diagnosis of some difficult diseases, and virtual reality pain distraction for severe burn patients. Smart VR health technology acts as a decision support system in the diseases diagnostic test of patients as they perform real world tasks in virtual reality (e.g., navigation). In this study, a non-invasive, cognitive computerized test based on 3D virtual environments for detecting the main symptoms of dementia (memory loss, visuospatial defects, and spatial navigation) is proposed. In a recent study, the system was tested on 115 real patients of which thirty had a dementia, sixty-five were cognitively healthy, and twenty had a mild cognitive impairment (MCI). The performance of the VR system was compared with Mini-Cog test, where the latter is used to measure cognitive impaired patients in the traditional diagnosis system at the clinic. It was observed that visuospatial and memory recall scores in both clinical diagnosis and VR system of dementia patients were less than those of MCI patients, and the scores of MCI patients were less than those of the control group.

In Knopman DS, Amieva H, Ronald C. Petersen, Gäel Chételat, David M. Holtzman, Bradley T. Hyman, Ralph A. Nixon, David T. Jones: "Alzheimer disease". Nat Rev Dis Primers[13], Alzheimer disease is biologically defined by the presence of -amyloid-containing plagues and tau-containing neurofibrillary tangles. It is a genetic and sporadic neurodegenerative disease that causes an amnestic cognitive impairment in its prototypical presentation and non-amnestic cognitive impairment in its less common variants. It is a common cause of cognitive impairment acquired in midlife and late-life but its clinical impact is modified by other neurodegenerative and cerebrovascular conditions. This Primer conceives of Alzheimer's disease biology as the brain disorder that results from a complex interplay of loss of synaptic homeostasis and dysfunction in the highly interrelated endosomal/lysosomal clearance pathways in which the precursors, aggregated species and post-translationally modified products of A and tau play important roles. Therapeutic endeavours are still struggling to find targets within this framework that substantially change the clinical course in persons with this disease.

In O. Oyebode, F. Alqahtani, and R. Orji, Using machine learning and thematic analysis methods to evaluate mental health apps based on user reviews[14], The proliferation of smartphones has led to an increase in mobile health (mHealth) apps over the years. Thus, it is imperative to evaluate these apps by identifying shortcomings or barriers hampering effective delivery of intended services. In this paper, we evaluate 104 mental health apps on Google Play and App Store by performing sentiment analysis of 88125 user reviews using machine learning (ML) and then conducting thematic analysis on the reviews. We implement and compare the performance of five classifiers using supervised ML algorithms that are widely used for solving classification problems. The best-performing classifier, with an F1 score of 89.42%, was then used in predicting the sentiment polarity of reviews. Next, we conduct a thematic analysis of positive and negative reviews to identify themes representing various factors affecting the effectiveness of mental health apps positively and negatively. Our results uncover 21 negative themes and 29 positive themes. The negative themes fall under the following categories: usability issues, content issues, ethical issues, customer support issues, and billing issues. Some of the positive themes include an aesthetically pleasing interface, app stability, customizability, high-quality content, content variation/diversity, personalized content, privacy and security, and low subscription cost. Finally, we offer design recommendations on how the identified negative factors can be tackled to improve the effectiveness of mental health apps.

In J. Luis and M. Peña, ICT Innovation Capabilities and Opportunities for Alzheimer's, ICT Innovation Capabilities and Opportunities for Alzheimer's[15], Currently, people with Alzheimer‘s require special and full-time care, so they must prevent the person from being in danger. In recent years, the number of people suffering from the disease has increased. In addition, the fact that people who have Alzheimer‘s are characterized as having problems with their cognitive functions, memory loss, and personality changes affects large areas of brain certainty. For this reason, a mobile application was designed that will help stimulate and help people with Alzheimer‘s and responsible people or family members. Because you will be able to monitor where you are and choose the interactive games that you will have to develop your cognitive system, in addition, you will be able to make the application remind you of some people or objects that you have forgotten, for example, the virtual assistant will begin to read the things that you point in the module, as you can also have control of what time to take the medicines. In this work, the Scrum methodology was used for

the development and the Figma tool for the design of the prototype. The results obtained from the research will be to have a better follow-up and to be able to help people with Alzheimer‘s in the cognitive system.

In N. F. López Yes, A. L. Moscoso Figueroa, M. A. Monzón Girón, K. J. Maldonado Hernández, and M. Toledo Jacobo, Early Prevention Factors in Alzheimer's Disease[16], Cognitive impairment of multiple cognitive functions that people have and that affect memory is more likely to evolve into Alzheimer's disease. However, a percentage of the chronic forms are of discrete alteration that evolves. Among the recommendations he gave was to be ordered. He explained that people with a low level of education, forgetful and distracted, have a greater probability of presenting the disease and presenting it more severely. Positioning system technology that is global allows great changes in societies to occur. Applications that use GPS can constantly grow and become more and more indispensable in our lives because it is very useful for everyone. That is why it takes advantage of the low costs and evolution to be used in favor. In addition, man has created innovations that are advanced in giant steps, allowing a clear disposition to improve the care of people. Alzheimer's disease can produce a progressive disorder of the central nervous system. People directly affected may experience depression, anxiety, psychosis, and sleep disturbances.

In Boyd, K., Bond, R., Ryan, A., Goode, D., and Mulvenna, M. Digital reminiscence app co-created by people living with dementia and carers: Usability and eye gaze analysis[17], This research reports on a pilot study that examined the usability of a reminiscence app called 'InspireD' using eye tracking technology. The InspireD app is a bespoke digital intervention aimed at supporting personalized reminiscence for people living with dementia and their carers. The app was developed and refined in two co-creation workshops and subsequently tested in a third workshop using eye-tracking technology. Eye tracking was used to gain insight into the user's cognition since our previous work showed that the think-aloud protocol can add to the cognitive burden for people living with dementia while also making the test more unnatural.

In Chelberg, G. R., Neuhaus, M., Mothershaw, A., Mahoney, R., and Caffery, L. J. Mobile apps for dementia awareness, support, and prevention - review and evaluation[18], Systematic searches of the Australian-based Google Play Store, Apple App Store, and relevant websites sought apps with dementia or Alzheimer's information, support for caregivers and persons living with dementia, or prevention content. Apps were screened and subsequently appraised via the mobile application review system (MARS). The majority of the final 75 dementia apps were free to download, but were only available on a single platform. Persons involved in caregiving were the primary audience. App content focused on dementia information, practical caregiving, and communication tips. Language options in addition to English were limited and few apps offered ongoing support. MARS appraisal identified few apps with good .Overall Quality"scores. Apps that were more comprehensive trended towards higher MARS scores.

In Eggink, E., Hafdi, M., Hoevenaar-Blom, M. P., Song, M., Andrieu, S., Barnes, L. E., et al. Prevention of dementia using mobile phone applications[19], Profiles of high risk for future dementia are well understood and are likely to concern mostly those in low-income and middle-income countries and people at greater disadvantage in high-income countries. Approximately 30%-40% of dementia cases have been estimated to be attributed to modifiable risk factors, including hypertension, smoking and sedentary lifestyle. Tailored interventions targeting these risk factors can potentially prevent or delay the onset of dementia. Mobile health (mHealth) improves accessibility of such prevention strategies in hard-to-reach populations while at the same time tailoring such approaches. In the current study, we will investigate the effectiveness and implementation of a coach-supported mHealth intervention, targeting dementia risk factors, to reduce dementia risk. The prevention of dementia using mobile phone applications (PRODEMOS) randomised controlled trial will follow an effectiveness-implementation hybrid design, taking place in the UK and China. People are eligible if they are 55-75 years old, of low socioeconomic status (UK) or from the general population (China); have greater than or equal to 2 dementia risk factors; and own a smartphone. 2400 participants will be randomised to either a coach-supported, interactive mHealth platform, facilitating self-management of dementia risk factors, or a static control platform. The intervention and follow-up period will be 18 months. The primary effectiveness outcome is change in the previously validated Cardiovascular Risk Factors, Ageing and Incidence of Dementia dementia risk score. The main secondary outcomes include improvement of individual risk factors and cost-effectiveness.

In Fox, S., Brown, L. J. E., Antrobus, S., Brough, D., Drake, R. J., Jury, F., et al. Co-design of a smartphone app for people living with dementia by applying agile, iterative co-design principles: Development and usability study[20], The benefits of involving those with lived experience in the design and development of health technology are well recognized, and the reporting of co-design best practices has increased over the past decade. However, it is important to recognize that the methods and protocols behind the patient and public involvement and co-design vary depending on the patient population accessed. This is especially important when considering individuals living with cognitive impairments, such as dementia, who are likely to have needs and experiences unique to their cognitive capabilities. We worked alongside individuals living with dementia and their care partners to co-design a mobile health app. This app aimed to address a gap in our knowledge of how cognition fluctuates over short, micro longitudinal timescales. The app requires users to interact with built-in memory tests multiple times per day, meaning that co-designing a platform that is easy to use, accessible, and appealing is particularly important. Here, we discuss our use of Agile methodology to enable those living with dementia and their care partners to be actively involved in the co-design of a mobile health app. The aim of this study is to explore the benefits of co-design in the development of smartphone apps. Here, we share our co-design methodology and reflections on how this benefited the completed product.

In Gustavsson, A., Norton, N., Fast, T., Frölich, L., Georges, J., Holzapfel, D., et al. Global estimates on the number of persons across the Alzheimer's disease continuum[21], Global estimates on numbers of persons in early stages of Alzheimer's disease, including prodromal and preclinical, are lacking, yet are needed to inform policy decisions on preventive measures and planning for future therapies targeting pathology. We synthesized the literature on prevalence across the continuum and derived a model estimating the number of persons, stratified by 5-year age groups, sex, and disease stage.The global number of persons with AD dementia, prodromal, and preclinical Alzheimer's disease were estimated at 32, 69, and 315 million, respectively. Together they constituted 416 million across the continuum, or 22% of all persons aged 50 and above. Considering predementia stages, the number of persons with this is much larger than conveyed in available literature. Our estimates are uncertain, especially for predementia stages in low- and middle-income regions where biomarker studies are missing.

In Hackett, K., Lehman, S., Divers, R., Ambrogi, M., Gomes, L., Tan, C. C., et al.Remind me to remember: A pilot study of a novel smartphone reminder application for older adults with dementia and mild cognitive impairment[22], The SmartPrompt is a smartphone-based reminder application informed by a neuropsychological model of functional disability. This laboratory-based pilot study examined the SmartPrompt feasibility, efficacy, and subjective usability using a within-participant, counterbalanced, cross-over design. Ten participants with mild cognitive impairment or mild dementia completed the Remember to Drink Test, which required preparing a glass of water at four predetermined times, in a SmartPrompt (SP) and Unprompted condition (UP). Written cues and a clock were available in both conditions; however, in the SP, the smartphone presented auditory alarms and visual reminders to obtain the water at specified times and required photo logging. In a separate session, caregivers were trained and tested on configuring the SmartPrompt. Overall, caregivers and participants learned to effectively use the SmartPrompt. Caregivers achieved near-perfect scores on the configuration quiz and responded well to training. Usability ratings were excellent among caregivers and fair among participants. Results indicate that the SmartPrompt holds promise for reducing functional disability in older adults with cognitive difficulties in at-home contexts.

In Hort, J., Valis, M., Zhang, B., Kuca, K., and Angelucci, F. An overview of existing publications and most relevant projects/platforms on the use of blockchain in medicine and neurology. Front[23], Blockchain is a new methodology involving a data structure with list of records, called blocks, which are linked using cryptography. The aim of the review is to overview the existing publication, projects, and platforms on the use of blockchain in Medicine and Neurology. The use of the blockchain technology in medicine has been repetitively proposed to solve different problems. In this article, we highlight the possible benefits of this technology, with attention to Neurology. Blockchain use can lead to quantifiable benefits in the treatment of neurodegenerative diseases, especially in clinical trials that can fail because of an incorrect patient recruitment.Among the problems related to medicine, there is the lack of information on the patient's clinical history that could allow accurate diagnosis and treatment.The possibility of having a register based on blockchain technology could help doctors in many ways, including patient management, choosing and monitoring treatments, and standardization of clinical trials.

In Lancaster, C., Koychev, I., Blane, J., Chinner, A., Wolters, L., Hinds, C., et al.Evaluating the feasibility of frequent cognitive assessment using the Mezurio Smartphone App: Observational and interview study in adults with elevated dementia risk[24], By enabling frequent, sensitive, and economic remote assessment, smartphones will facilitate the detection of early cognitive decline at scale. Previous studies have sustained participant engagement with remote cognitive assessment over a week; extending this to a period of 1 month clearly provides a greater opportunity for measurement. However, as study durations are increased, the need to understand how participant burden and scientific value might be optimally balanced also increases.Despite the extended study duration, participants demonstrated high compliance with the schedule of daily learning tasks and were extremely positive about their experiences. Long durations of remote digital interaction are therefore definitely feasible but only when careful attention is paid to the design of the users' experience.

3. SYSTEM ANALYSIS AND DESIGN

3.1 Tools And Technologies

3.1.1 Android Studio

Android Studio is the official integrated development environment (IDE) designed specifically for Android development.It is available for download on Windows, macOS and Linux based operating systems and a replacement for the Eclipse Android Development Tools as the primary IDE for native Android application development.Android Studio supports all the same programming languages of IntelliJ like Java, C++, and more with extensions, such as Go, and Android Studio 3.0 or later supports Kotlin and .[a]ll Java 7 language features and a subset of Java 8 language features that vary by platform version".Once an app has been compiled with Android Studio, it can be published on the Google Play Store.It's features includes requirements for IDE,Android SDK, Android Emulator.

Figure 3.1.1 Android Studio

3.1.2 Firebase

Firebase is a set of hosting services for any type of application. It offers NoSQL and real-time hosting of databases, content, social authentication (Google, Facebook, Twitter and Github), and notifications, or services, such as a real-time communication server.. The Firebase Realtime Database is a cloud-hosted database. Data is stored as JSON and synchronized in realtime to every connected client. Firebase provides detailed documentation and cross-platform SDKs to help you build and ship apps on Android, IOS, web, c++.Google announced that it was acquiring the mobile developer platform LaunchKit,which specialized in app developer marketing, and would be folding it into the Firebase Growth Tools team. Google acquired Fabric and Crashlytics from Twitter to add those services to Firebase.Firebase launched Cloud Firestore, a real-time document database as the successor product to the original Firebase Realtime Database.

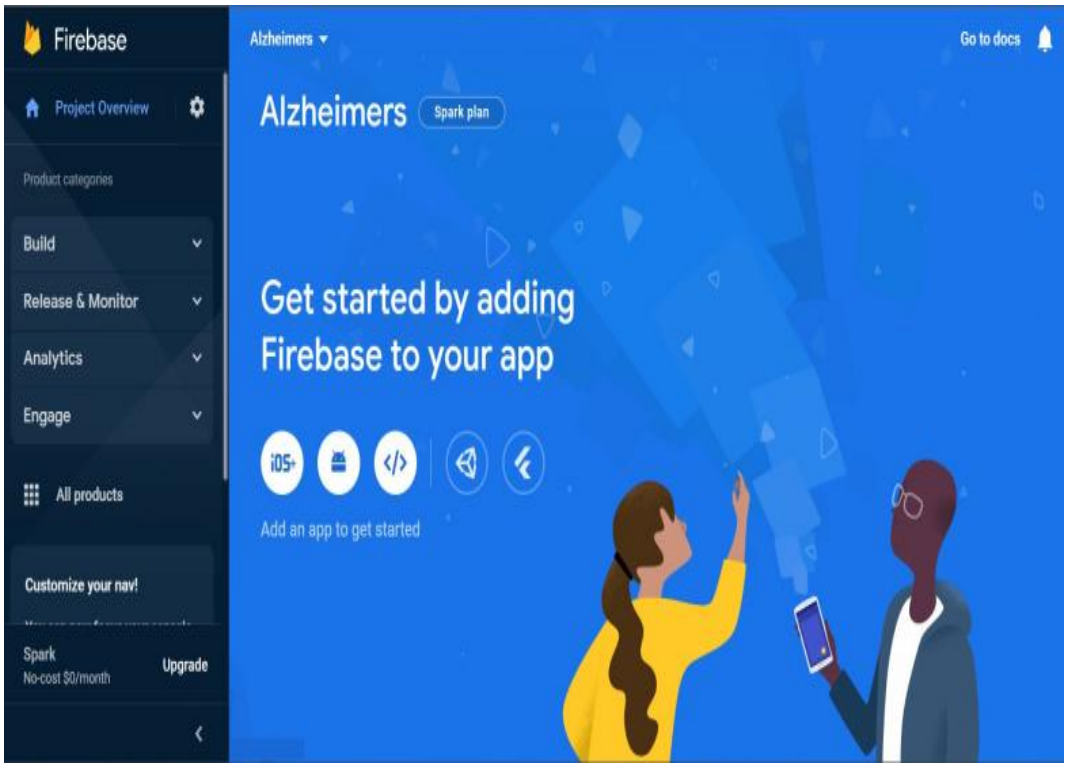


Figure 3.1.2 Firebase

3.1.3 Java

Java is a popular high-level, class-based object oriented programming language.Java is used to develop Mobile apps, Web apps, Desktop apps, Games and much more. It is a general-purpose programming language intended to let programmers write once, run anywhere (WORA), meaning that compiled Java code can run on all platforms that support Java without the need to recompile.Java applications are typically compiled to bytecode that can run on any Java virtual machine (JVM) regardless of the underlying computer architecture. The syntax of Java is similar to C and C++, but has fewer low-level facilities than either of them. There were five primary goals in the creation of the Java language, they are it must be simple, object-oriented, and familiar, robust and secure, architecture-neutral and portable, execute with high performance and interpreted, threaded, and dynamic. It is used for Mobile applications (specially Android apps), Desktop applications, Web applications, Web servers and application servers, Games, Database connection and much more.

Figure 3.1.3 Java

3.1.4 Star UML

StarUML is a software engineering tool for system modeling using the Unified Modeling Language, as well as Systems Modeling Language, and classical modeling notations. In StarUML, a Diagram contains several elements that represent the design iteration. Models contain information of the software design, and Views provides a visual display of the information contained within the models. StarUML offers object oriented modelling capabilities. It supports most of the diagram types specified in UML 2.0. They are Class diagrams, Composite structure diagrams, Component diagrams, Object diagrams, Package diagrams, Use-case diagrams, Activity diagrams, Sequence diagrams, Communication diagrams, Timing diagrams, State diagrams.

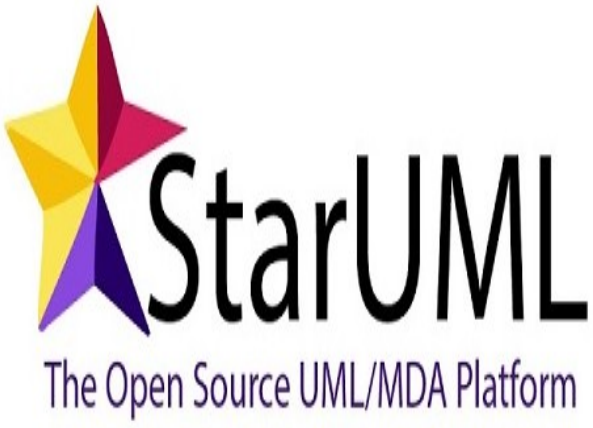
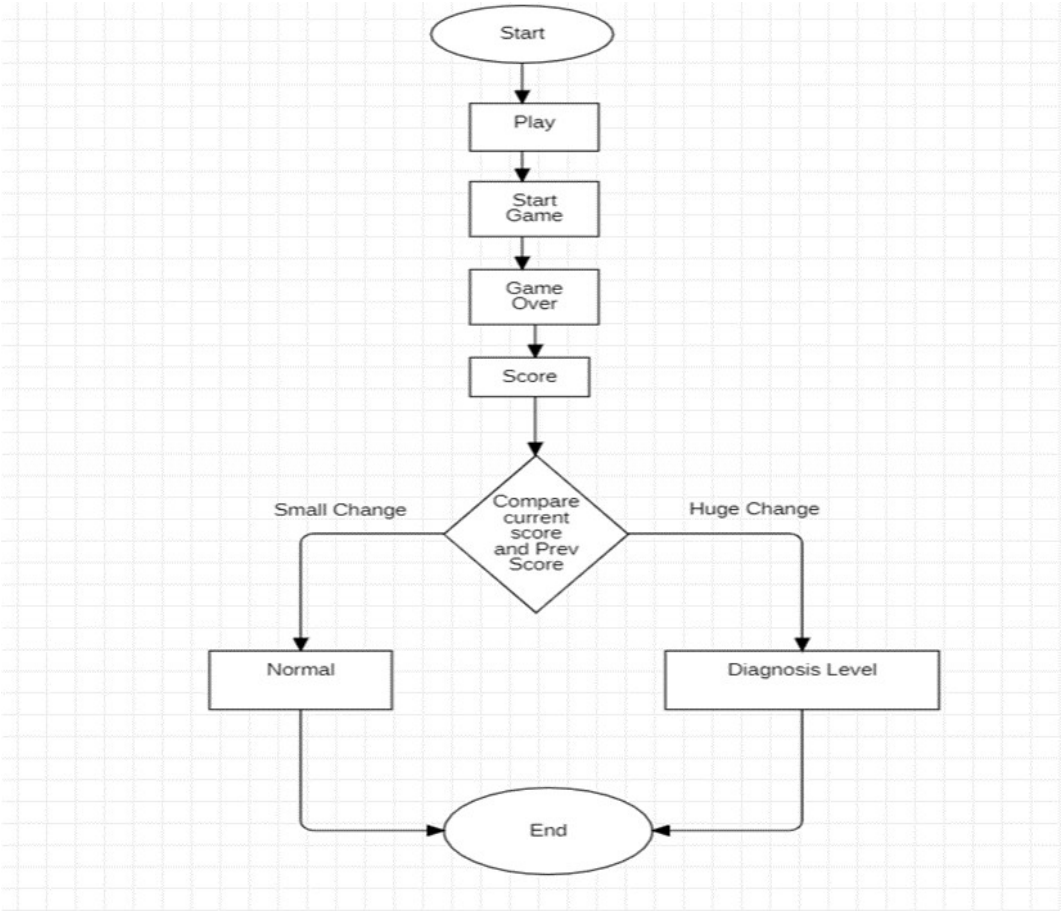


Figure 3.1.4 StarUML

3.2 UML Diagram

UML(Unified Modeling Language) diagram explains the flow of the game.



3.2 UML Diagram for Alzheimer's Disease

The user registers with the email id and plays the game. After the completion of the game the score is displayed. If a player plays for the first time the score is stored. If not, the current score is compared with the scores that are predetermined. If there is a very small difference in current score and the predetermined score then it is Normal. If there is a huge difference in score comparison then the level of disease is diagnosed whether it is Mild , Moderate, Severe.

4. METHODOLOGY

4.1 Modules

There are three modules. They are:

Module 1: Registration with OTP

The user should register via OTP using their mobile number.

Module 2: Designing various games

The game module consists of multiple games. Each game tests the user for different symptoms of Alzheimer's disease. Each game depicts different symptoms. The scores are assigned to the games based on the importance of the games in diagnosing the disease.

Module 3: Analyze the level of disease

The scores of each game are obtained, and based on the score of various levels, the stage of Alzheimer's disease is analyzed.

The level of Alzheimers is represented in three stages

1. Mild
2. Moderate
3. Severe

4.2 MVC Architecture

Model View Controller is a design pattern created for developing applications.

The view of the application deals with UI logic. The controller deals with the Input logic. The model of an application deals business logic.

These MVC Architecture have 3 components:

MODEL: The Model encloses the clean application related data. But the model does not deal with any logic about how to present the data.

VIEW: The View is used for presenting the data of the model to the user. It deals with how to link up with the model's data but doesn't provide any logic regarding what this data all about or how users can use these data.

CONTROLLER: The Controller is in between the model and the view element. It listens to all the incident and actions triggered in the view and performs an appropriate response back to the events.

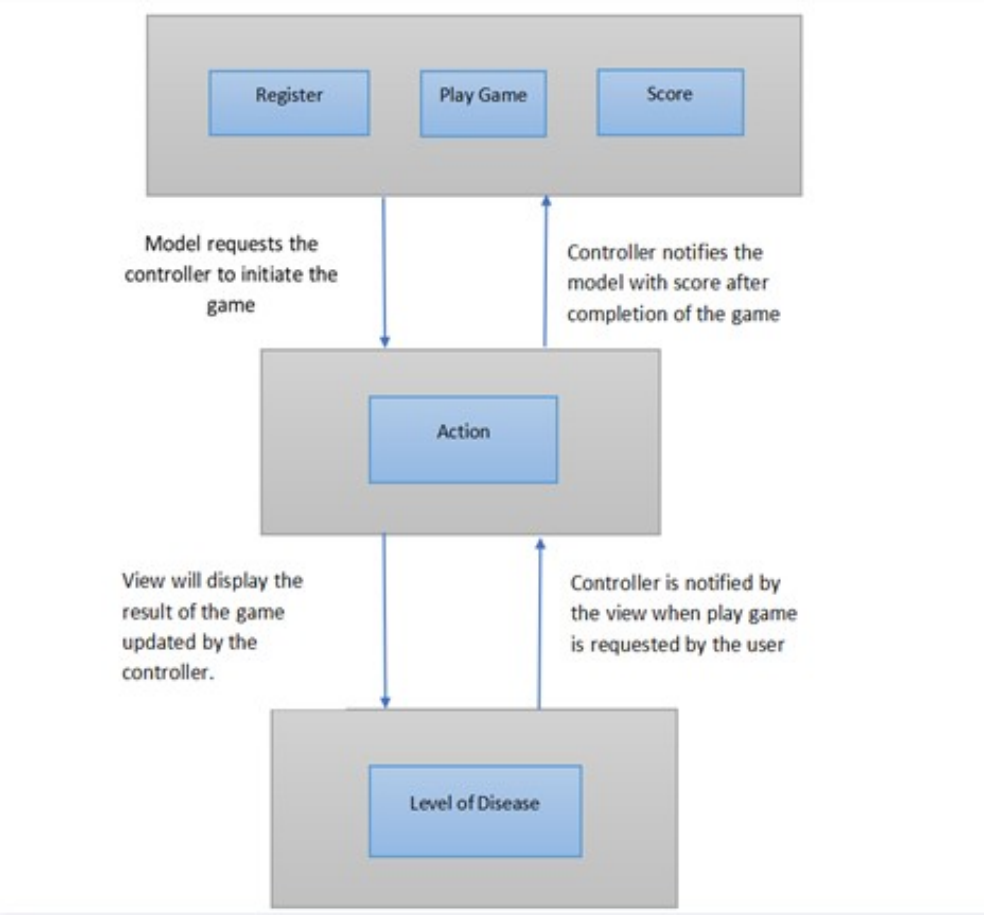


Figure 4.2 MVC Architecture for Alzhiemer's Disease

User clicks/taps on register button on the screen.The controller handles the clicks/taps and converts the event into an appropriate action. The Model requests the controller to initiate the game. Then the view will display the game updated by the controller.

The view will then notify the controller when the user requested for game. Then the controller will notify the model to update and display the score after completion of game.

5. IMPLEMENTATION

```
if(firebaseUser != null)
{
    Intent i = new Intent( packageContext: MainAct.this, Firstscreen.class);

    // on below line we are
    // starting a new activity.
    startActivity(i);

    // on the below line we are finishing
    // our current activity.
    finish();
}
else {
    Intent i = new Intent( packageContext: MainAct.this, OtpSendActivity.class);

    // on below line we are
    // starting a new activity.
    startActivity(i);

    // on the below line we are finishing
    // our current activity.
    finish();
}
```

Figure 5.1 Initial step where we redirect to registration page

```
b.setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View view) {
        if (etd.getText().toString().trim().isEmpty()) {
            Toast.makeText( context: OtpSendActivity.this,  text: "Invalid Phone Number", Toast.LENGTH_SHORT).show();
        } else if (etd.getText().toString().trim().length() != 10) {
            Toast.makeText( context: OtpSendActivity.this,  text: "Type valid Phone Number", Toast.LENGTH_SHORT).show();
        } else {
            otpSend();
        }
    }
});
```

Figure 5.2 Handling the mobile number input field and requesting to send OTP

```
mCallbacks = new PhoneAuthProvider.OnVerificationStateChangedCallbacks() {

    @Override
    public void onVerificationCompleted(PhoneAuthCredential credential) {

    }

    @Override
    public void onVerificationFailed(FirebaseException e) {
      p.setVisibility(View.GONE);
      b.setVisibility(View.VISIBLE);
       Toast.makeText( context: OtpSendActivity.this, text: "Try to verify again", Toast.LENGTH_SHORT).show();
      // Log.d("msg verification.....",e.getLocalizedMessage());
      /* Intent inten = new Intent(OtpSendActivity.this, Login_A.class);
       startActivity(inten);
       finish();

      */
    }
```

Figure 5.3 Handling the successful sending of OTP and failure of OTP sending conditions

```
@Override
public void onCodeSent(@NonNull String verificationId,
                       @NonNull PhoneAuthProvider.ForceResendingToken token) {
    p.setVisibility(View.GONE);
    b.setVisibility(View.VISIBLE);
    Toast.makeText( context: OtpSendActivity.this, text: "OTP is successfully send.", Toast.LENGTH_SHORT).show();
    Intent intent = new Intent( packageContext: OtpSendActivity.this, OtpVerifyActivity.class);
    intent.putExtra( name: "phone", etd.getText().toString().trim());
    intent.putExtra( name: "verificationId", verificationId);
    startActivity(intent);
}
```

Figure 5.4 Handling condition after successfully sending OTP

```
tvMobile=(TextView)findViewById(R.id.tvMobile);
tvResendBtn=(TextView)findViewById(R.id.tvResendBtn);
btnVerify=(Button)findViewById(R.id.btnVerify);
progressBarVerify=(ProgressBar) findViewById(R.id.progressBarVerify);
```

Figure 5.5 OTP verification: storing all required values in variable

```
tvMobile.setText(String.format(
        "+91-%s", getIntent().getStringExtra( name: "phone")
));

verificationId = getIntent().getStringExtra( name: "verificationId");

tvResendBtn.setOnClickListener(new View.OnClickListener() {
    @Override
    public void onClick(View v) {
        Toast.makeText( context: OtpVerifyActivity.this, text: "OTP Send Successfully.", Toast.LENGTH_SHORT).show();
    }
});
```

Figure 5.6 Listener for resend button

```
btnVerify.setVisibility(View.INVISIBLE);
if (etC1.getText().toString().trim().isEmpty() ||
        etC2.getText().toString().trim().isEmpty() ||
        etC3.getText().toString().trim().isEmpty() ||
        etC4.getText().toString().trim().isEmpty() ||
        etC5.getText().toString().trim().isEmpty() ||
        etC6.getText().toString().trim().isEmpty()) {
    Toast.makeText( context: OtpVerifyActivity.this,  text: "OTP is not Valid!", Toast.LENGTH_SHORT).show();
```

Figure 5.7 Checking if any of the otp entering box is empty and failing the verification

```
PhoneAuthCredential credential = PhoneAuthProvider.getCredential(verificationId, code);
FirebaseAuth
        .getInstance()
        .signInWithCredential(credential)
        .addOnCompleteListener(new OnCompleteListener<AuthResult>() {
    @Override
    public void onComplete(@NonNull @NotNull Task<AuthResult> task) {
        if (task.isSuccessful()) {
            progressBarVerify.setVisibility(View.VISIBLE);
            btnVerify.setVisibility(View.INVISIBLE);
            Toast.makeText( context: OtpVerifyActivity.this,  text: "Welcome...", Toast.LENGTH_SHORT).show();
            Intent intent = new Intent( packageContext: OtpVerifyActivity.this, AndroidLauncher.class);
            intent.setFlags(Intent.FLAG_ACTIVITY_CLEAR_TASK | Intent.FLAG_ACTIVITY_NEW_TASK);
            startActivity(intent);
        } else {
            progressBarVerify.setVisibility(View.GONE);
            btnVerify.setVisibility(View.VISIBLE);
            Toast.makeText( context: OtpVerifyActivity.this,  text: "OTP is not Valid!", Toast.LENGTH_SHORT).show();
        }
    }
});
```

Figure 5.8 Verifying the OTP (successful verification)

```
app = new Main( nativePlatform: this);
runOnUiThread(() -> {
    AndroidApplicationConfiguration config = new AndroidApplicationConfiguration();
    config.useImmersiveMode = true;
    ((ViewGroup) findViewById(R.id.app)).addView(initializeForView(app, config));
});

pref = Gdx.app.getPreferences( name: "preferences");
i = pref.getInteger( key: "scoresec");
if (score > 0)
    saveScore(score);
v = String.valueOf(score);
Log.d( tag: "The result issssssss", v);
// signed
if (getResources().getBoolean(R.bool.connect_games) && GoogleSignIn.hasPermissions(GoogleSignIn.getLastSignedInAccount( context: this),
        GoogleSignInOptions.DEFAULT_GAMES_SIGN_IN.getScopeArray()))
    onSignIn();

// AdMob
adMob();
```

Figure 5.9 Rendering game-1 and storing the results

```
// buttons animation
Vector2 point = stage
        .screenToStageCoordinates(new Vector2( x: Gdx.graphics.getWidth() / 2,  y: Gdx.graphics.getHeight() / 2));
float animSpeed = 0.3f; // animation speed
int n = 0;
for (int i = 0; i < buttons.size; i++) {
    buttons.get(i).setAlpha(0);
    buttons.get(i).setRotation((float) (Math.random() * 360));
    buttons.get(i).setScale(0.5f);
    buttons.get(i)
            .addAction(
                    Actions.sequence(Actions.moveTo( x: point.x - buttons.get(i).getWidth() / 2,  y: point.y
                            - buttons.get(i).getHeight() / 2), Actions.delay( duration: n * animSpeed * 0.5f), Actions.parallel(
                            Actions.alpha( a: 1, animSpeed), Actions.rotateTo( rotation: 0, animSpeed), Actions.scaleTo( x: 1,  y: 1,
                                    animSpeed), Actions.moveTo(buttons.get(i).getX(), buttons.get(i).getY(),
                                    animSpeed, Interpolation.swingOut))));
```

Figure 5.10 Displaying the buttons in game 1

```
// current screen render
if (screen.equals("game"))
    renderGame();
else if (!screen.isEmpty()) {
    // world render
    world.step( timeStep: 1 / 30f,  velocityIterations: 8,  positionIterations: 3);

    // camera position
    stage.getRoot().setPosition( x: (SCREEN_WIDTH - mapWidth) * 0.5f,  y: (SCREEN_HEIGHT - mapHeight) * 0.5f);
    cam.position.set( x: (SCREEN_WIDTH * 0.5f - stage.getRoot().getX()) / PPM,
            y: (SCREEN_HEIGHT * 0.5f - stage.getRoot().getY()) / PPM,  z: 0);
    cam.update();

    // stage render
    stage.act(Math.min(Gdx.graphics.getDeltaTime(), 0.02f));
    stage.draw();
}
```

Figure 5.11 Giving timer and waiting for user input after showing numbers

```
// saveScore
public boolean saveScore(int score) {
    if (!pref.contains("score") || score > pref.getInteger( key: "score")) {
        pref.putInteger( key: "score", score);
        pref.flush();
        return true;
    }

    return false;
}
```

Figure 5.12 Conditions to be checked after the game is over, if the user gave a wrong answer or right answer

```
// gameOver
void gameOver() {
    // hide elements
//    btnPause.enabled = false;
//    btnPause.removeListener(controlListener);
//    btnPause.addAction(Actions.alpha(0, 0.2f));
    progressBg.addAction(Actions.alpha( a: 0,  duration: 0.2f));
    progressLine.addAction(Actions.alpha( a: 0,  duration: 0.2f));
    progressOver.addAction(Actions.alpha( a: 0,  duration: 0.2f));
    TIMER.cancel();

    // hide items
    for (int i = 0; i < items.size; i++) {
        items.get(i).enabled = false;
        items.get(i).addAction(Actions.alpha( a: 0, ANIMATION_TIME));
    }

    // sound
    if (!pref.getBoolean( key: "mute",  defValue: false) && isForeground)
        assetManager.get( fileName: "sndGameOver.mp3", Sound.class).play( volume: 1f);

    showGroup(groupGameOver);
}
```

Figure 5.13 Conditions to be checked after the game is over, if the user gave a wrong answer or right answer

```
int numNumbers;
if (level >= 18)
    numNumbers = 7;
else if (level >= 12)
    numNumbers = 6;
else if (level >= 7)
    numNumbers = 5;
else if (level >= 3)
    numNumbers = 4;
else
    numNumbers = 3;
```

Figure 5.14 No. of numbers to be displayed

```
// remove unneeded numbers
for (int i = numNumbers; i < items.size; i++)
    items.get(i).remove();
items.truncate(numNumbers);

// random array
List<Integer> rand_array = new ArrayList<>();
for (int i = 1; i <= 9; i++)
    rand_array.add(i);
Collections.shuffle(rand_array);
```

Figure 5.15 Random generation of required numbers

```
// make numbers
for (int i = 0; i < items.size; i++) {
    items.get(i).enabled = false;
    items.get(i).num = rand_array.get(i);
    items.get(i).tex = itemsTextures.findRegion(String.valueOf(items.get(i).num));
    items.get(i).setAlpha(0);
    items.get(i).setZIndex(txtReady.getZIndex());

    if (i == items.size - 1)
        items.get(i).addAction(
                Actions.sequence(Actions.alpha( a: 1, ANIMATION_TIME), Actions.delay(DELAY_SHOW), (Action) (delta) -> {
                        // enabled items
                        for (int i = 0; i < items.size; i++) {
                            items.get(i).enabled = true;
                            items.get(i).tex = new TextureRegion(assetManager.get( fileName: "itemEmpty.png", Texture.class));
                        }

                        numOpened = 0;
                        currentTime = TIME;
                        Timer.schedule(TIMER,  delaySeconds: 1,  intervalSeconds: 1);
                        return true;
                }));
    else
        items.get(i).addAction(Actions.alpha( a: 1, ANIMATION_TIME));
}
```

Figure 5.16 Displaying of items

```
// hideItems
void hideItems() {
    for (int i = 0; i < items.size; i++) {
        if (i == items.size - 1) // last item
            items.get(i).addAction(
                    Actions.sequence(Actions.alpha( a: 0, ANIMATION_TIME), Actions.delay(DELAY_LEVEL), (Action) (delta) -> {
                        level++;
                        showItems();
                        return true;
                    }));
        else
            items.get(i).addAction(Actions.alpha( a: 0, ANIMATION_TIME));
    }
}
```

Figure 5.17 Hiding the numbers in the circles

```
// check item
boolean isTrue = true;
for (int i = 0; i < items.size; i++)
    if (items.get(i).enabled && items.get(i).num < ((Act) event.getTarget()).num) {
        isTrue = false;
        break;
    }

// disable item
((Act) event.getTarget()).enabled = false;
((Act) event.getTarget()).tex = itemsTextures.findRegion(String.valueOf(((Act) event.getTarget()).num));
```

Figure 5.18 Checking if the correct item is clicked or not, if yes disable the item else end the game

```
if (isTrue) {
    // true
    numOpened++;
    score += 5;
    // save score
    if (saveScore(score))
        nativePlatform.saveScore(score);
    System.out.println("Save scoreee issssss+555555");
    System.out.println(score);
    // sound
    if (!pref.getBoolean( key: "mute",  defValue: false) && isForeground)
        assetManager.get( fileName: "sndYes.mp3", Sound.class).play( volume: 1f);
    // all opened
    if (numOpened == items.size) {
        TIMER.cancel();
        currentTime = 0;
        hideItems();
    }
} else {
    // wrong
    if (!pref.getBoolean( key: "mute",  defValue: false) && isForeground)
        assetManager.get( fileName: "sndNo.mp3", Sound.class).play( volume: 1f);

    gameOver();
}

return true;
```

Figure 5.19 Adding the score and continuing if the correct option is selected, exit if the wrong option is selected, moving to the next step if all are selected correctly

```
// card position
card_size = (int) (screen_height - DpToPx(margin * 4) - findViewById(R.id.txt_ask).getHeight() - DpToPx(10));
findViewById(R.id.card).getLayoutParams().width = findViewById(R.id.card).getLayoutParams().height = card_size;
findViewById(R.id.card).setX((screen_width - card_size) / 2f);
findViewById(R.id.card).setY(DpToPx(margin * 2) + findViewById(R.id.txt_ask).getHeight());

// txt_no & txt_yes
findViewById(R.id.txt_no).getLayoutParams().width = findViewById(R.id.txt_yes).getLayoutParams().width = (int) ((screen_width - card_size) / 2f);

// current_card
current_card = (int) Math.round(Math.random() * num_cards);
((ImageView) findViewById(R.id.card)).setImageResource(getResources().getIdentifier( name: "card" + current_card,  defType: "drawable",
        getPackageName()));

h.postDelayed(hide_card,  delayMillis: 2000);
```

Figure 5.20 Card, yes or no button positioning

```
public void run() {
    // animate
    anim = new AnimatorSet();
    anim.playTogether(ObjectAnimator.ofFloat(findViewById(R.id.card), propertyName: "x", -card_size));
    anim.setDuration(200);
    anim.addListener(new AnimatorListener() {
        @Override
        public void onAnimationStart(Animator animation) {
        }

        @Override
        public void onAnimationRepeat(Animator animation) {
        }

        @Override
        public void onAnimationCancel(Animator animation) {
        }

        @Override
        public void onAnimationEnd(Animator animation) { h.post(show_card); }
    });
    anim.start();
}
```

Figure 5.21 Animation of moving the previous card out of the screen and rendering the current card

```
public void run() {
    ((ProgressBar) findViewById(R.id.progress))
            .setProgress(((ProgressBar) findViewById(R.id.progress)).getProgress() - 1);

    // time is up
    if (((ProgressBar) findViewById(R.id.progress)).getProgress() == 0) {
        findViewById(R.id.game).setEnabled(false);
        findViewById(R.id.mess).setVisibility(View.VISIBLE);

        // animation
        if (anim != null) {
            anim.removeAllListeners();
            anim.cancel();
        }

        // sound
        if (!sp.getBoolean( key: "mute", defValue: false) && isForeground)
            sndpool.play(snd_info, leftVolume: 1f, rightVolume: 1f, priority: 0, loop: 0, rate: 1);

        h.postDelayed(STOP, delayMillis: 3000);
        return;
    }

    h.postDelayed(TIMER, delayMillis: 1000);
}
```

Figure 5.22 Running the timer for the game

```
// STOP
Runnable STOP = new Runnable() {
    @Override
    public void run() {
        // show result
        show_section(R.id.result);

        saveScore(score);

        // show score
        ((TextView) findViewById(R.id.txt_result)).setText("Score:" + " " + score);
        ((TextView) findViewById(R.id.txt_high_result)).setText("Your Score:" + " " + sp.getInt( key: "scoresec",  defValue: 0));

        // sound
        if (!sp.getBoolean( key: "mute",  defValue: false) && isForeground)
            sndpool.play(snd_result,  leftVolume: 0.5f,  rightVolume: 0.5f,  priority: 0,  loop: 0,  rate: 1);// AdMob Interstitial
        // load
    }
};
```

Figure 5.23 Stopping conditions for game 2 after the timer ends

```
case R.id.btn_start:
    START();
    break;
case R.id.btn_start2:
    Intent in=new Intent( packageContext: Mainsec.this, Mainthird.class);
    startActivity(in);
    finish();
    break;
```

Figure 5.24 Game starting and ending (moving to next game) conditions

```
// saveScore
void saveScore(int score) {
    // save score local
    // if (score > sp.getInt("scoresec", 0))
        sp.edit().putInt("scoresec", score).commit();
    System.out.println("Saving the score which isssss:"+score);

    // save score in leaderboard
    if (getResources().getBoolean(R.bool.connect_games) && isSigned)
        Games.getLeaderboardsClient( activity: this, GoogleSignIn.getLastSignedInAccount( context: this)).submitScore("CgkI5-eSGOgEAIQBw", score);
}
```

Figure 5.25 Saving the score

```
// check answer
if (prev_card == current_card) {
    if (event.getX() >= screen_width / 2f) {
        // true
        score += 10;
        if (!sp.getBoolean( key: "mute",  defValue: false) && isForeground)
            sndpool.play(snd_yes,  leftVolume: 1f,  rightVolume: 1f,  priority: 0,  loop: 0,  rate: 1);
    } else {
        // wrong
        score = Math.max(score - 10, 0);
        if (!sp.getBoolean( key: "mute",  defValue: false) && isForeground)
            sndpool.play(snd_no,  leftVolume: 1f,  rightVolume: 1f,  priority: 0,  loop: 0,  rate: 1);
    }
} else {
    if (event.getX() < screen_width / 2f) {
        // true
        score += 10;
        if (!sp.getBoolean( key: "mute",  defValue: false) && isForeground)
            sndpool.play(snd_yes,  leftVolume: 1f,  rightVolume: 1f,  priority: 0,  loop: 0,  rate: 1);
    } else {
        // wrong
        score = Math.max(score - 10, 0);
        if (!sp.getBoolean( key: "mute",  defValue: false) && isForeground)
            sndpool.play(snd_no,  leftVolume: 1f,  rightVolume: 1f,  priority: 0,  loop: 0,  rate: 1);
    }
}
```

Figure 5.26 Editing the score for second game based on the user answer

```
// first run
if (bitmap_items == null) {
    // item_size
    item_size = (int) ((findViewById(R.id.oll).getWidth() - (NUM_ITEMS + 1) * DpToPx(MARGIN)) / NUM_ITEMS);

    // items container size
    findViewById(R.id.items).getLayoutParams().width = findViewById(R.id.items).getLayoutParams().height = (int) Math.ceil(item_size * NUM_ITEMS

    bitmap_items = new ArrayList<Bitmap>();

    // bitmap_place
    bitmap_place = bitmapFromAssets( src: "place.png", item_size, item_size);

    // bitmap_items
    for (int i = 0; i < NUM_ITEMS * NUM_ITEMS / 2; i++)
        bitmap_items.add(bitmapFromAssets( src: "item" + i + ".png", item_size, item_size));
    bitmap_items.addAll(bitmap_items);
}

// shuffle items
Collections.shuffle(bitmap_items);
```

Figure 5.27 Storing all required images in array and shuffling it

```
// add items
int x_pos = 0;
int y_pos = 0;
List<Animator> anim_list = new ArrayList<>();
for (int i = 0; i < NUM_ITEMS * NUM_ITEMS; i++) {
    ImageView item = new ImageView( context: Mainthird.this);
    ((ViewGroup) findViewById(R.id.items)).addView(item);
    item.setClickable(true);
    item.setImageBitmap(bitmap_place);
    item.getLayoutParams().width = item.getLayoutParams().height = item_size;
    item.setX(x_pos * item_size + x_pos * DpToPx(MARGIN));
    item.setY(y_pos * item_size + y_pos * DpToPx(MARGIN));
    item.setAlpha(0f);
    item.setTag(i);
    anim_list.add(ObjectAnimator.ofFloat(item, propertyName: "alpha", ...values: 1f)); // animation

    // next item position
    x_pos++;
    if (x_pos == NUM_ITEMS) {
        x_pos = 0;
        y_pos++;
    }
```

Figure 5.28 Adding items onto screen

```
// touch listener
item.setOnTouchListener(new OnTouchListener() {
    @SuppressLint("ClickableViewAccessibility")
    @Override
    public boolean onTouch(View v, MotionEvent event) {
        // item touch
        if (findViewById(R.id.items).isEnabled() && (current_items.size() == 0 || current_items.indexOf(v) == -1) && event.getAction() == MotionEvent.
            // score
            score++;
            ((TextView) findViewById(R.id.txt_score)).setText("Score:" + score);

            current_items.add(v);
            findViewById(R.id.items).setEnabled(false); // disable items
            hide_place();
        }

        return false;
    }
});
```

Figure 5.29 Touch listener for items

```
// compare_items
void compare_items() {
    if (current_items.size() == 2) {
        if (bitmap_items.get((int) current_items.get(0).getTag()).equals(bitmap_items.get((int) current_items.get(1).getTag())))
            hide_two_items(); // hide two opened items
        else
            hide_first_item(); // hide first opened item
    } else
        findViewById(R.id.items).setEnabled(true); // enable items
}
```

Figure 5.30 Comparing the two cards and hiding cards based on the cards selected

```
// animate
anim.removeAllListeners();
anim = null;
anim = new AnimatorSet();
anim.playTogether(ObjectAnimator.ofFloat(current_items.get(0), propertyName: "scaleX", ...values: 0.5f), ObjectAnimator.ofFloat(current_items.get(0)
anim.setDuration(ANIM_SPEED);
```

Figure 5.31 Hiding 1st opened card when cards are not matched

```
// hide_two_items
void hide_two_items() {
    anim.removeAllListeners();
    anim = null;
    anim = new AnimatorSet();
    anim.playTogether(ObjectAnimator.ofFloat(current_items.get(0), propertyName: "scaleX", ...values: 0.5f), ObjectAnimator.ofFloat(current_items.get(0)
    anim.setDuration(ANIM_SPEED);
    anim.addListener(new AnimatorListener() {
        @Override
        public void onAnimationEnd(Animator animation) {
            num_opened += 2;

            // remove opened items
            ((ViewGroup) findViewById(R.id.items)).removeView(current_items.get(0));
            ((ViewGroup) findViewById(R.id.items)).removeView(current_items.get(1));
            current_items.clear();

            // check complete
            if (num_opened == NUM_ITEMS * NUM_ITEMS)
                game_over();
            else
                findViewById(R.id.items).setEnabled(true); // enable items
        }
```

Figure 5.32 Hiding both cards when cards are matched

```
if(percentg<35)
{
    //severe
    stag="Severe";
    Log.d( tag: "Condition",  msg: "severe");
    sp.edit().putString("stage","Severe").commit();

}
else if(percentg>35 && percentg<65)
{

    stag="Moderate";
    Log.d( tag: "Condition",  msg: "moderate");
    sp.edit().putString("stage","Moderate").commit();
    //moderate
}
```

Figure 5.33 Analysis

```
else if(percentg>65 && percentg<80)
{
    stag="Mild";
    Log.d( tag: "Condition",  msg: "Mild");
    sp.edit().putString("stage","Mild").commit();
    //Mild
}
else
{
    stag="No Alzheimers";
    Log.d( tag: "Condition",  msg: "No alzheimers");
    sp.edit().putString("stage","No alzheimers").commit();

    // No alzheimers
}
```

Figure 5.34 Analysis

6. RESULTS

Figure 6.1 Registration with OTP

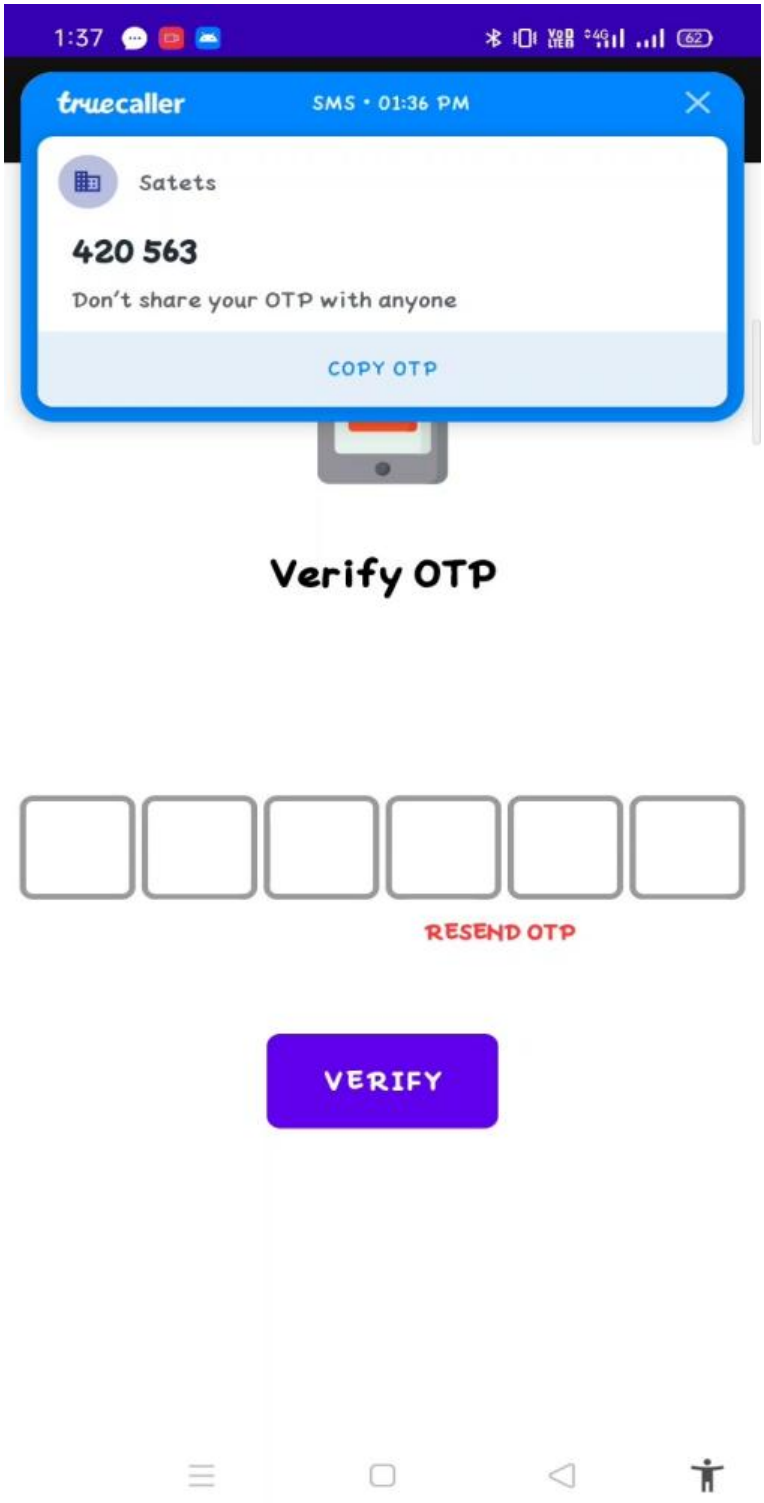


Figure 6.2 OTP Received

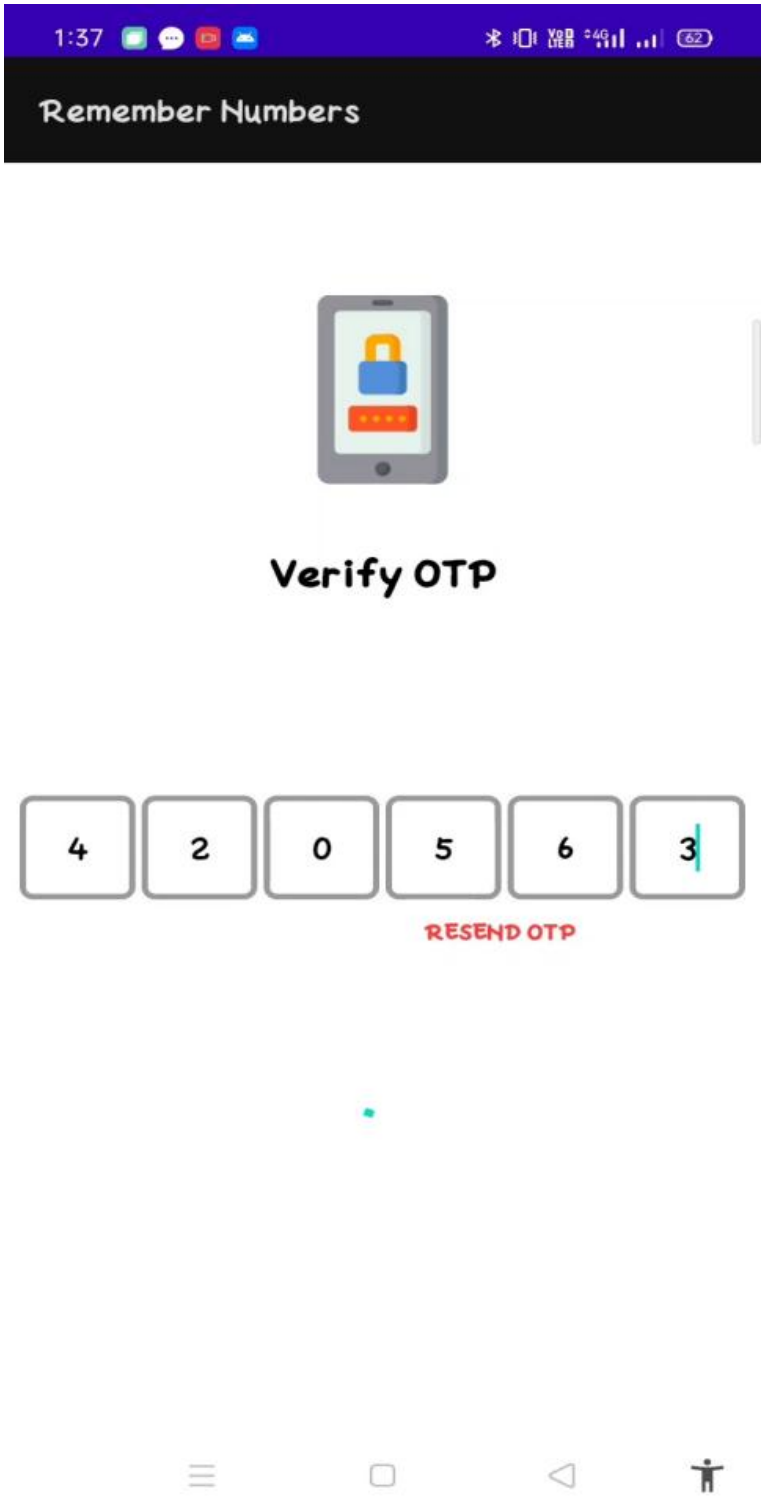


Figure 6.3 OTP verified

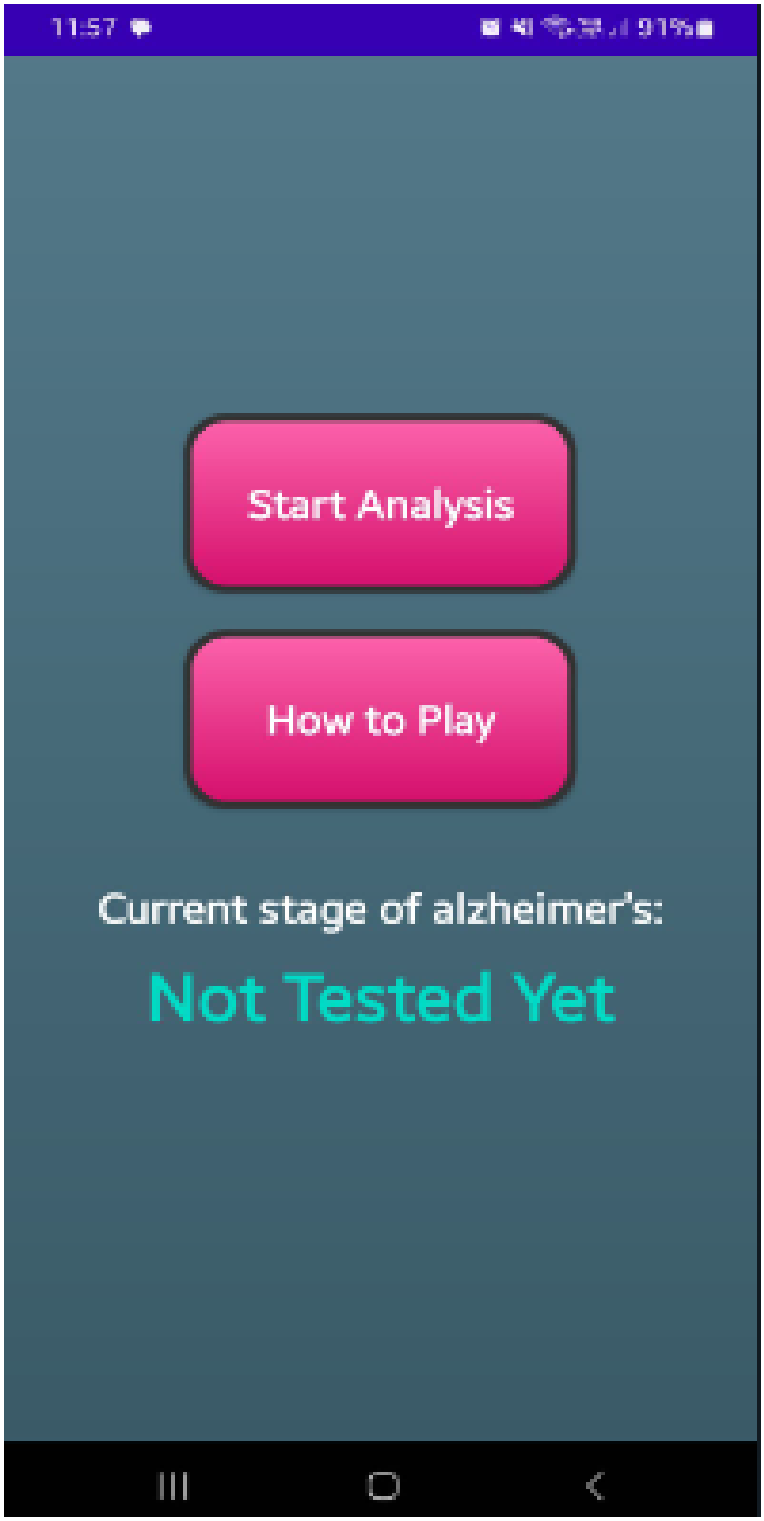


Figure 6.4 Not yet tested

Figure 6.5 Mild Stage

Figure 6.6 Moderate Stage

Figure 6.7 Severe Stage

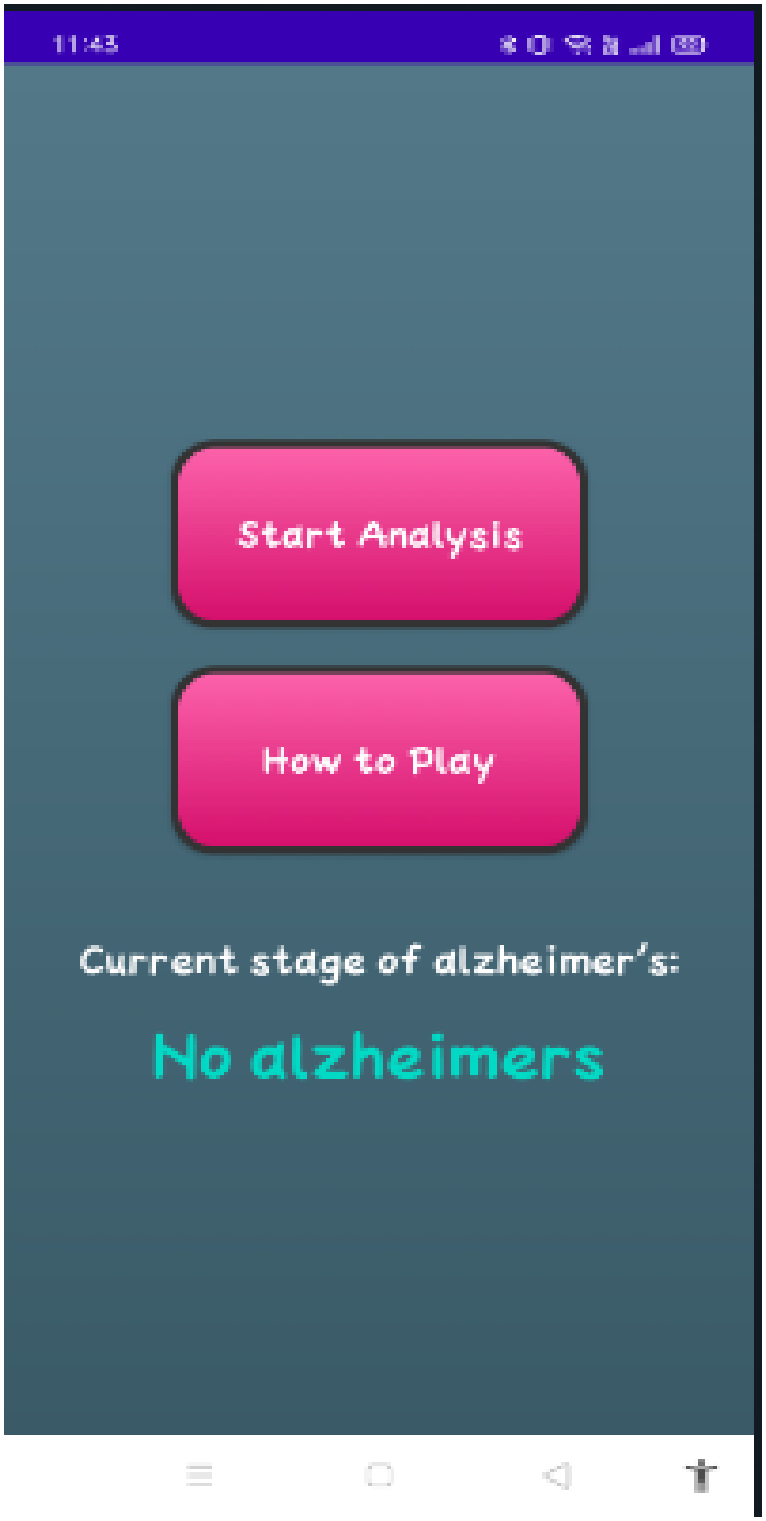


Figure 6.8 No Alzheimers

7. CONCLUSION AND FUTURE SCOPE

People never prefer to visit a doctor until the symptoms get intensified, which generally happens in the later stages of the disease. CT scans, MRI scans, and PET scans are performed when prescribed by the doctor only. Hence diagnosing the disease and providing the proper medication for the patient in the early stages of disease, will help in preventing the serious effects caused by the disease in later stages. The mobile application developed will help to diagnose the disease in the early stage by playing the games.

Along with diagonizing of disease, we can provide games to improve the patient's thinking skills and memory power. We can extend the application by providing the medication for the disease, and by helping the patient to get doctor appointments in the required situations.

REFERENCES

[1] Sabine Hazan SAGE Journals (2020, Jun). Rapid improvement in Alzheimer's Disease symptoms following fecal microbiota transplantation: a case report.National Library of Medicine.

[2] Dan Pan, An Zeng, Longfei Jia, Yin Huang, Tory Frizzell and Xiowei song (2020 May) "Early Detection of Alzheimer's Disease Using Magnetic Resonance Imaging: A Novel Approach Combining Convolutional Neural Networks and Ensemble Learning" frontiersin.org/articles/10.3389/fnins.2020.00259/full.

[3] Dr Gil D. Rabinovici, University of California San Francisco Memory and Aging Center (2019, Feb). Late-onset Alzheimer Disease. National Library of Medicine.

[4] Zeinab Breijyeh, Rafik Karaman, Pharmaceutical Sciences Department, Al-Quds University (2020, Dec) Comprehensive Review on Alzheimer's Disease: Causes and Treatment. National Library of Medicine.

[5] Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., Mukadam, N.Dementia prevention, intervention, and care (2020 Aug). Report of the Lancet Commission.

[6] Kanwal Yousaf ,Zahid Mehmood ,Israr Ahmad Awan ,Tanzila Saba ,Riad Alharbey , Talal Qadah and Mayda Abdullateef Alrige,(2019) "A comprehensive study of mobile-health based assistive technology for the healthcare of dementia and Alzheimer's disease (AD) ", Healthcare management science , https://doi.org/10.1007/s10729-019-09486-0,Springer Science+Business Media, LLC, part of Springer Nature .

[7] Subetha T, Rashmita Khilar,Sarat Kumar Sahoo (2020) "An Early Prediction and Detection of Alzheimer's Disease: A Comparative Analysis on Various Assistive Technologies" IEEE. .

[8] Eunhee Kim, Andrius Baskys, Anandi V.Law, Mom R. Rosan, Yan L Don Roosan (2021, Sep). Scoping review: The empowerment of Alzheimer's disease caregivers with mHealth Applications, National Library of Medicine.

[9] Lampros C. Kourtis, Oliver B. Regele, Justin M. Wright Graham B. Jones(2019, Feb): Digital Biomarkers for Alzheimer's disease: the mobile or wearable devices opportunity, National Library of Medicine.

[10] Thomas Engelsma, Monique W.M. Jaspers, Linda W Peute(2021 Aug). Considerate mHealth design for older adults with Alzheimer's disease and related dementias (ADRD): A scoping review on usability barriers and design suggestions

[11] Rosa Perez-Siguas , Hernan Matta-Solis , Eduardo Matta-Solis(2022). Design and Implementation of a Mobile Application to Help People with Alzheimer's.

[12] Areej Y. Bayahya, Wadee Alhalabi, Sultan H. AlAmri(2021), "Smart Health System to Detect Dementia Disorders Using Virtual Reality", National Library of Medicine.

[13] Knopman DS, Amieva H, Ronald C. Petersen, Gäel Chételat, David M. Holtzman, Bradley T. Hyman, Ralph A. Nixon, David T. Jones (2021, May) "Alzheimer disease". Nat Rev Dis Primers.doi:10.1038/s41572-021-00269-y.

[14] O. Oyebode, F. Alqahtani, and R. Orji(2020), Üsing machine learning and thematic analysis methods to evaluate mental health apps based on user reviews",IEEE.

[15] J. Luis and M. Peña, ICT (2021) Ïnnovation Capabilities and Opportunities for Alzheimer's, ICT Innovation Capabilities and Opportunities for Alzheimer's". Doi:10.4321/repisalud.5436

[16] N. F. López Yes, A. L. Moscoso Figueroa, M. A. Monzón Girón, K. J. Maldonado Hernández, and M. Toledo Jacobo (2021), Early Prevention Factors in Alzheimer's Disease, Academic Journal CUNZAC. 4(2) 31–37. Doi: 10.46780/cunzac.v4i2.41.

[17] Boyd, K., Bond, R., Ryan, A., Goode, D., and Mulvenna, M. (2021). Digital reminiscence app co-created by people living with dementia and carers: Usability and eye gaze analysis. Health Expect. 24, 1207–1219. doi: 10.1111/hex.13251.

[18] Chelberg, G. R., Neuhaus, M., Mothershaw, A., Mahoney, R., and Caffery, L. J. (2022). Mobile apps for dementia awareness, support, and prevention - review and evaluation. Disabil. Rehabil. 44, 4909–4920. doi: 10.1080/09638288.2021.1914755.

[19] Eggink, E., Hafdi, M., Hoevenaar-Blom, M. P., Song, M., Andrieu, S., Barnes, L. E., et al. (2021). Prevention of dementia using mobile phone applications (PRODEMOS): Protocol for an international randomised controlled trial. Br. Med. J Open 11, e049762. doi: 10.1136/bmjopen-2021-049762.

[20] Fox, S., Brown, L. J. E., Antrobus, S., Brough, D., Drake, R. J., Jury, F., et al. (2022). Co-design of a smartphone app for people living with dementia by applying agile, iterative co-design principles: Development and usability study. JMIR Mhealth Uhealth 10, e24483. doi: 10.2196/24483.

[21] Gustavsson, A., Norton, N., Fast, T., Frölich, L., Georges, J., Holzapfel, D., et al. (2022). Global estimates on the number of persons across the Alzheimer's disease continuum. Alzheimer's Dement. 2022, 13694. doi: 10.1002/alz.12694.

[22] Hackett, K., Lehman, S., Divers, R., Ambrogi, M., Gomes, L., Tan, C. C., et al. (2022). Remind me to remember: A pilot study of a novel smartphone reminder application for older adults with dementia and mild cognitive impairment. Neuropsychol. Rehabil. 32, 22–50. doi: 10.1080/09602011.2020.1794909.

[23] Hort, J., Valis, M., Zhang, B., Kuca, K., and Angelucci, F. (2021). An overview of existing publications and most relevant projects/platforms on the use of blockchain in medicine and neurology. Front. Blockchain 2021, 580227. doi: 10.3389/fbloc.2021.580227.

[24] Lancaster, C., Koychev, I., Blane, J., Chinner, A., Wolters, L., Hinds, C., et al. (2020). Evaluating the feasibility of frequent cognitive assessment using the Mezurio Smartphone App: Observational and interview study in adults with elevated dementia risk. JMIR Mhealth Uhealth 8, e16142. doi: 10.2196/16142.

[25] Leorin, C., Stella, E., Nugent, C., Cleland, I., and Paggetti, C. (2019). The value of including people with dementia in the co-design of personalized eHealth technologies. Dement. Geriatr. Cogn. Disord. 47, 164–175. doi: 10.1159/000497804.

[26] Lucas, J. W., and Villarroel, M. A. (2022). Telemedicine Use Among Adults: United States, 2021. NCHS Data Brief, No 445. Hyattsville, MD: National Center for Health Statistics.

[27] Minen, M. T., Gopal, A., Sahyoun, G., Stieglitz, E., and Torous, J. (2021). The functionality, evidence, and privacy issues around smartphone apps for the top neuropsychiatric conditions. J. Neuropsychiatr. Clin. Neurosci. 33, 72–79. doi: 10.1176/appi.neuropsych.19120353.

[28] Paddick, S. M., Yoseph, M., Gray, W. K., et al. (2021). Effectiveness of app-based cognitive screening for dementia by lay health workers in low resource settings. A validation and feasibility study in rural Tanzania. J. Geriatr. Psychiatry Neurol. 34, 613–621. doi: 10.1177/0891988720957105.

[29] Rangseekajee, P., Aphisitphinyo, S., Paholpak, P., Piyavhatkul, N., Vadhanavikkit, P., Kaenampornpan, M., et al. (2021). Mobile application for monitoring behavioral and psychological symptoms of dementia in patients with moderate to severe dementia. Geriatr. Gerontol. Int. 21, 472–477. doi: 10.1111/ggi.14164.

[30] Rosenblum, S., Richardson, A., Meyer, S., Nevo, T., Sinai, M., Hassin-Baer, S., et al. (2021). DailyCog: A real-world functional cognitive mobile application for evaluating mild cognitive impairment (MCI) in Parkinson's disease. Sensors 21, 1788. doi: 10.3390/s21051788.

[31] Sabermahani, F., Almasi-Dooghaee, M., and Sheikhtaheri, A. (2022). Alzheimer's disease and mild cognitive impairment serious games: A systematic analysis in smartphone application markets. Stud. Health Technol. Inform. 293, 179–186. doi: 10.3233/SHTI220366.

[32] Tak, S. H. (2021). In quest of tablet apps for elders with Alzheimer's disease: A descriptive review. Comput. Inform. Nurs. 39, 347–354. doi: 10.1097/CIN.0000000000000718.

[33] Werner, N. E., Brown, J. C., Loganathar, P., and Holden, R. J. (2022). Quality of mobile apps for care partners of people with Alzheimer disease and related dementias: Mobile app rating scale evaluation. JMIR Mhealth Uhealth 10, e33863. doi: 10.2196/33863.

[34] Mayoclinic Org (2019) "Patient care and Health Information: Diagnosis and Treatment".

[35] Dementia(2020). In: World Health Organization. Geneva: World Health Organization; .

[36]El-Hayek YH, Wiley RE, Khoury CP, et al, (2019)"Tip of the Iceberg: Assessing the Global Socioeconomic Costs of Alzheimer's Disease and Related Dementias and Strategic Implications for Stakeholders". J Alzheimers Dis. 70 (2): 323–341. doi:10.3233/JAD-190426.

[37]Wong W (2020, Aug), "Economic burden of Alzheimer disease and managed care considerations". Am J Manag Care. 26 (8 Suppl): S177–S183. doi:10.37765/ajmc.2020.88482.

[38] Deardorff WJ, Grossberg GT(2019), "Behavioral and psychological symptoms in Alzheimer's dementia and vascular dementia". Handbook of Clinical Neurology. 165: 5–32. doi:10.1016/B978-0-444-64012-3.00002-2.

[39] Celesti, A., Ruggeri, A., Fazio, M., Galletta, A., Villari, M., and Romano, A. (2020). Blockchain-based healthcare workflow for tele-medical laboratory in federated hospital IoT clouds. Sensors 20:2590. doi: 10.3390/s20092590.

[40] Chang, M. C., Hsiao, M.-Y., and Boudier-Revéret, M. (2020). Blockchain technology: efficiently managing medical information in the pain management field. Pain Med. 21, 1512–1513. doi: 10.1093/pm/pnz26.