COGNITIVE REHABILITATION BASED PERSONALIZED SOLUTION FOR DEMENTIA PATIENTS USING REINFORCEMENT LEARNING

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DECLARATION

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ABSTRACT

Dementia is a wide-ranging term which used to describe, several symptoms cognitive failure, which is mainly causes loss of brain functionalities due to brain injury or brain diseases. Further explain, Dementia is not just a single disease, but it is kind of collection of huge categories of brain disorders, which can be deteriorated human's memory, their language and decision making and problem-solving skills etc. As a human, none of people would like to damage or loss memory at any cost, this theory is applicable for people who named as Dementia patients. Since there is no way to prevent from Dementia, additionally to medicine that's why doctors are advised patients to go through mind games or some of people called those brain games, in order to diminish the influence of Dementia.

Though, there are lots of brain games or mind, memory games were introduced, this research study area is mainly focused on develop a gaming application which aim on temporal lobe of human brain, to gain or protect human's memory and specially which is focused on senior citizens' culture in Sri Lankan as most of the adult people in Sri Lanka is not familiar with English Language. Reinforcement learning is used as research component, level of game is predicted by using Deep Q Learning algorithm which helps to make personalized game to Dementia patient.

Until this time period there were many mind or brain game applications introduced, this research field is focused into ways of applying above mentioned procedures to give the best solution for Sri Lankan Dementia patients.

Keywords—Dementia, Dementia patient, Reinforcement Learning, Cognitive, MMSE, Q-Learning, Rehabilitation

ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS

Abbreviation   Description

RL   Reinforcement Learning
UI   User Interface
MMSE   Mini- Mental State Examination
AD   Alzheimer Dementia
AI   Artificial Intelligent
SDLC   Software Development Life Cycle

1.INTRODUCTION

1.1 Background

Dementia is collective term for assemblage of diseases which mainly focuses on frontal lobe and temporal lobe from the cerebral cortex of the human brain and which can be affected to on human's memory, cognitive abilities and personal behaviors which help to maintain their diurnal activities in lifetime. People with Dementia is impaired or harmed their brain cells and nerve cell due to degeneration in the cerebral cortex. Further, mutilation which is affected on human's frontal and temporal lobes due to that Dementia grounds to person's communication, decision making, language skills and loss of memory overtime which will impact destructively of peoples' living style.

Since until now there is no way to no cure or stop dementia, doctors are gone through some of non-drug therapies and drug treatment which can help alleviate indications of Dementia. Additionally, to that Dementia patients are advised by doctors to take themselves through software application such as memory games which known as mind or brain games where they can prevent or recover their disorders by keep practice on those games.

When it is come to Dementia Patients in Sri Lanka, though there are lots of memory gaming applications in the worldwide none of them are hundred percent suite for Sri Lankan culture. Reason for that is most of Dementia patients in Sri Lanka is fallen to elderly generation and those patients are not proficiency with English language and there is another problem cause due to characteristics of Dementia, patient to patient characteristics of Dementia disease can be varied due to that, gaming applications were introduced to the world can be not actually support for Dementia Patients.

To overcome above mentioned problems, develop a system which is mainly focus in Sri Lankan Dementia patients and which is personalized game for each and every patients using Reinforcement Learning (RL) and support on both Sinhala and English Languages and to make good interaction with game and patient get the usage of voice to text

communication. Ensuing sectors are discussed on with literature survey, objectives and methodology etc.

1.2 Background Literature

1.2.1 Dementia

In year **2005, C. Berr , J. Wancata and K. Ritchie** have established that Dementia is one of the most well-known sicknesses in the old, with unrefined commonness rates between 5.9%–9.4% for subjects matured more than 65 in the European Union [3].

Moving further, in year of **2010, Polidori, Maria Cristina, Nelles, Gereon and Pientka, Ludger** authors have exemplified that the least and sexual orientation explicit administration of all-causes dementia detailed in the writing is 61.1% among ladies aged100 or more prominent so the inquiry "on the off chance that we live long enough, will we as a whole be unbalanced?" is turning into a gravely intermittent one. Dementia influences day by day life and regular individual exercises are frequently connected with social side effects, character change, and various clinical confusions, it builds the risk for urinary incontinence, hip crack, and most uniquely reliance on nursing care. Therefore, it is not amazing that the expenses of care for patients with dementia are huge [4].

However, **Clive Baldwin and Bradford Dementia Group (2008)** have argued that the historical model for identifying dementia has been the medical model of cognitive deficit. And also, that model describes dementia uniquely as a neurological illness and concentrates on deficit and loss. Further, that model individuals with dementia are first and leading ill, the prognosis destitute and controlling consists of the reflection of decline and that interpretation has been worsened by the lack, up until comparatively freshly, of somewhat effective treatment and even nowadays the likelihood of treatment is indeterminate [5].

Step further than, in year of **2017, Gill Livingston et al.** have demonstrated that Dementia is the greatest global challenge for health and social care in 21st century and also they

have argued that occurred people who are older than 65 years. Therefore, this problem rises in quantities and expenditure are pushed worldwide by heightened endurance resulting from the welcome drop in people go dead ahead of time. March more, above authors have stated that internationally, roughly 47 million individuals were staying with dementia in 2015, and this amount is expected to boost by 2050. Dementia touches the folks with the condition, who progressively misplace their capabilities, as well as their relations and supplementary supporters, who partake to handle with seeing a family participant or colleague convert ill and decline, while answering to their wishes, such as cumulative dependency and variations in comportment [6].

1.2.2 Reinforcement learning

Szepesvári, C has stated that Reinforcement learning is a learning paradigm concerned with learning to control a system so as to maximize a numerical performance measure that expresses a long-term objective [7], further **Ahmad Hammoudeh** has discussed that reinforcement learning is different from other branches of machine learning both supervised and unsupervised learning and consider it as third model of machine learning, at the edge of unsupervised learning and supervised learning [8]. Further open-handed to consideration to explanation of RL, will be learning through the communication with a situation by taking various activities and encountering numerous disappointments and victories while attempting to augment the gotten rewards.

Furthermore, in year **2019 Matthew Botvinick et al.** have stated that RL methods have led remarkable improvements in artificial intelligence (AI) in recent years, outstripping human being routine in territories varying from Atari to Go to no-limit poker and they have argued that this growth has haggard the consideration of cognitive scientists involved in understanding human learning. However, authors have illustrated that there is a concern which has been raised up that deep RL may be too sample-inefficient – that is, it might merely be too slow down – to offer a credible version of in what way people learn. In the present review, illuminated counter this critique by way of explaining not long-ago established methods that make available deep RL to conduct further lightly, deciphering

difficulties far beyond rapidly than aforementioned techniques. Nevertheless, authors have confirmed that these procedures were formed in an AI context, and recommend that they may well come up with powerful consequences for psychology and neuroscience. A vital insight, occurring from these AI approaches, affects the underlying relationship between rapid RL and slower, more incremental types of learning [9].
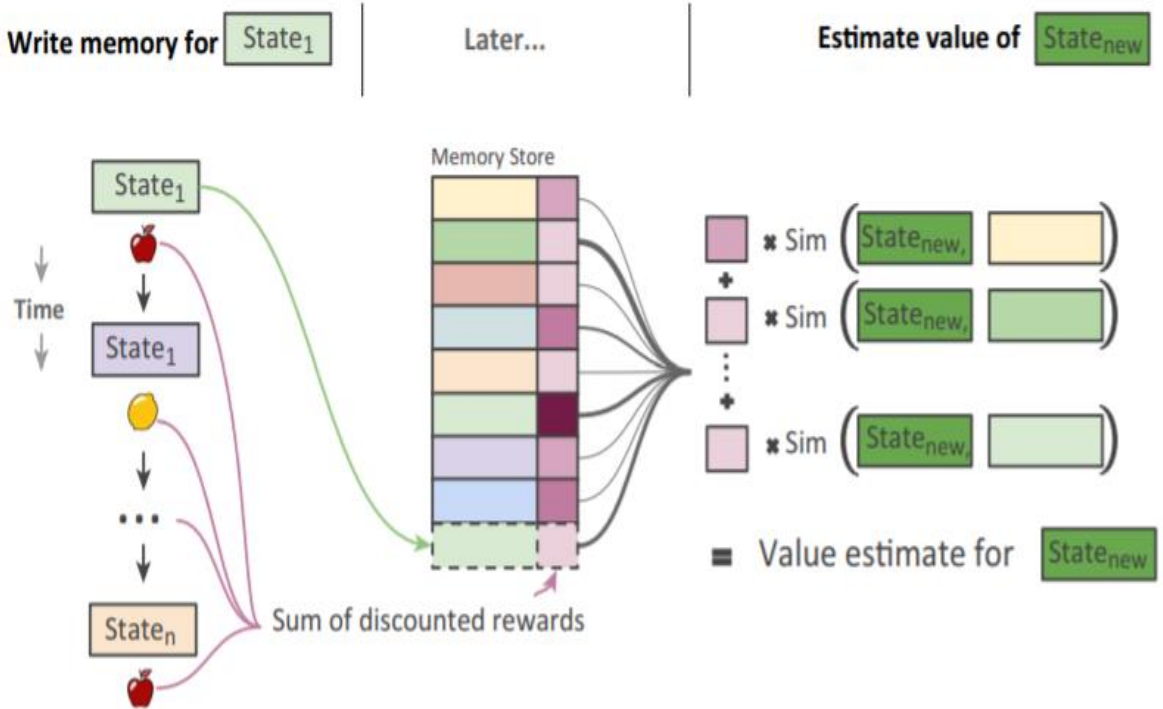
Figure 1: Illustration of an example of RL [9]

Expand further, **Mikula´s Zelinka (2018)** has stated that Reinforcement Learning is a field of machine learning approaches and concerns dependent relative on the concept of discovering from numerical rewards obtained by an agent all the way through communicating with a domain and in some random development, the agent guards a condition of the earth and gets a prize sign. Because of the present state and the agent's perform work — the approach — the agent pick and choose a shift to make. The activity is then sent to the environment which is refreshed and the loop repeats. Figure 2 is exhibited the interaction in the middle of an agent and the environment [10].

- Action (A): moves that the agent can possibly take
- State (S): current situation that is returned by the environment
- Reward (R): immediate feedback returned by the environment in order to evaluate the last state
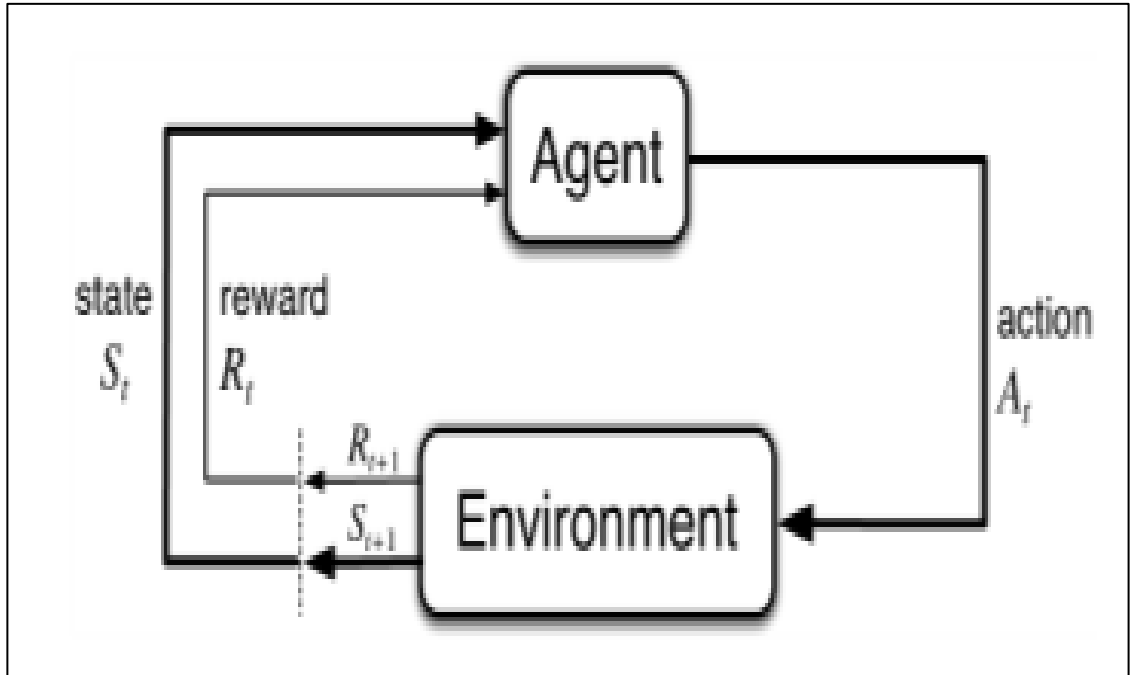
Figure 2: Interaction between agent and environment in RL [10]

1.2.3 Q- learning

Q-learning is a type of model-free algorithm which can be fallen to reinforcement learning. In year of **2010 D. Pandey and P. Pandey** have revealed Q – Learning operates by steadily uplifting the typical approximations of activities in states and for each conceivable state, every conceivable activity is allocated out a cost which is a component of both the immediate reward for assembly that change and the usual award later dependent on the new-fangled express that is the significance of construction that interchange or move. This is conveyed by the one-advance Q-update condition [11].

$$Q(s, a) = Q(s, a) + \alpha \; [r + \gamma \; maxa' \; Q(s', a') - Q(s, a)] \qquad (1)$$

Q – expected value of performing action

s – state vector

a – action vector

r – reward

α – learning rating which controls convergence

γ – discount factor

Algorithm:

> Initialize Q(s, a) arbitrarily
> Repeat (for each episode)
> Initialize s
> Repeat (for each step of episode):
> Choose a from s using policy derived from Q
> Take action a, observe r, s'
> $Q(s, a) = Q(s, a) + \alpha [r + \gamma \max_{a'} Q(s', a') - Q(s, a)]$
> $s \leftarrow s'$;
>
> Until s is terminal

The discount factor creates rewards gained before more vital than those learned later. This procedure discovers the estimations of the whole factors deemed, as revealed to simply finding the ideal procedure. This evidence is expensive in terms of the measure of data that must be placed away, however it generates advantages. Q-learning is probe thoughtless, whichever activity can be accomplished whenever the time and data is gathered ahead from this experience [11].

Additionally, in year **2019 Valmik Tilwari et al.** have emphasized that Q- learning is common paradigm of RL and some of attributes of Q-learning that produces it most extensively implemented algorithms are its effortlessness and model free spirit. Move

over, Q-learning notes agent performance all the way through trial-and-error interactions with a dynamic environment across a tuple (S, A, R) such as states, actions, and rewards as shown below figure [12].
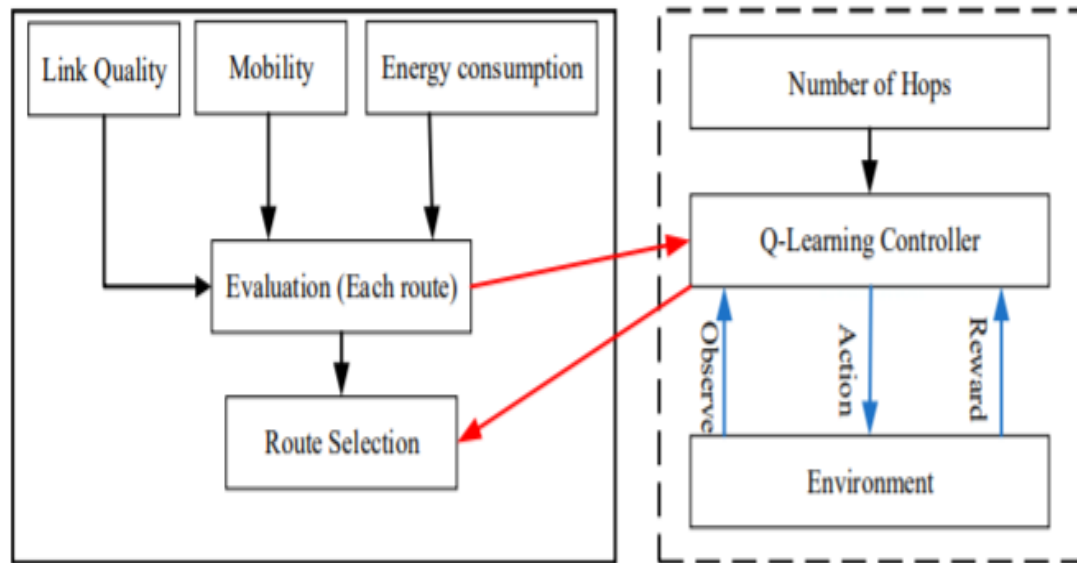
Figure 3: Q- Learning Approach for route selection [12]

1.2.4 Existing products and researches

Innovation can help cross over any barrier among patients and staff to improve the personal satisfaction for the subjectively impeded. Innovation instruments, for example, iPods, help invigorate those with dementia. This examination centers around inventive gadgets, for example, iPads and tablets, which are standard and simple to utilize, can't just assistance decide phase of dementia, yet additionally give incitement to improve subjective working. In a time where Alzheimer's and dementia in more seasoned grown-ups are expanding, parental figures are looking into new answers for interceding the emergency. One of these new arrangements is the utilization of cell phones to animate the perception of more established grown-ups and patients experiencing AD.

New research has demonstrated that the utilization of cerebrum, memory, and taking care of issue games help invigorate the mind and diminish the side effects of AD. The utilization of the cerebrum games and other PC based incitement treatment has given new light to medicinal services experts, guardians, and the patients themselves [1].

1.2.5 Compare existing systems and related work

Features	Lumosity	Brain Games	Elevate	Eidetic	Proposed System
Personalized for user or patient	No	No	No	No	Yes
Support with Sinhala Language	No	No	No	No	Yes
Suitable for elderly people	Yes	No	Yes	No	Yes
Separate game for human's memory function	Yes	No	Yes	Yes	No

Table 1: Comparison of Existing Systems

1.3 Research Gap

In fact, moving on with mobile application which helps Dementia patients, take through about research gap is most vital for forthcoming researches. While in a conversation about mobile applications that were introduced for Dementia patients mainly supported for English Language, as per **Christina Yamagata et al**. have discussed that further efforts will focus on developing apps to help caregivers and individuals reveal early warning signs of dementia and future work will include cross-campus teams and more focus on creating apps to detect early symptoms of dementia and over the summer, students collaborated with a community partner to develop an app that helped clinicians quickly determine level of dementia[1].

However, none of these researchers are mentioned developing apps for Dementia patients which is supported for multi languages, rather developing apps which are supported for only English Languages. In that case novelty of this proposed research component is focused on developing a mobile gaming application to improve or recover memory of Sri Lankan Dementia patient which is supported both Sinhala and English languages.

Moving on furthermore, **Kiho kang** et al. have stated that "Serious Game to Help Prevent Dementia" is mainly played through finger tapping and touch [2]. Nevertheless, proposed research component is used speech/ voice to text communication component to make memory related gaming application more interactive with Dementia patients.

1.4 Research Problem

Now a days, worldwide ageing population is faced with most noteworthy health complications. Crack attention moving frontward to term called Dementia, can be named as one of most significant problematic area in medical science. Human can be affected with memory loss, corrosion in thinking capacity, humans' behavior and general daily actives. Even though Dementia is principally affected on older people, that is not evidenced on the statement "Dementia is a normal part of ageing". According to the statement which is demonstrated by **Christina Yamagata et al**. is illustrated that the

estimated current prevalence of Dementia is 47.5 million worldwide and that given numeral value will nearly double in every 20 years globally[1]. Though, preliminary discussion is turned around into worldwide, this research study is mainly enquired on Dementia patients in Sri Lanka. Dementia is a condition which is not cured by medicines. However, there are medications such as mental and behavioral treatments that help to slowdown the increment of the sickness where Dementia patient could have to completed treatments during the treatment time of the period.

Some of Dementia patients are recommended to use brain training games which are affected in to improve or recover their memory loss therefore there are many numbers of brain games were introduced. But problem is occurred when it is come to Sri Lank, many of Dementia patients are fallen under ageing population is not really conscious of English language, therefore introduced memory/ brain training gaming applications are not suited for Sri Lanka and also already existing memory related applications are not personalized for patient to patient. As in a summary of this research study following can be addressed as main research problem.

• How to introduce a personalized gaming application for Sri Lankan Dementia patients which will be mainly based on human memory ?

1.5 Research Objectives

1.5.1 Main objectives

The main objective of the proposed research component is to develop a personalized mobile interactive gaming application for Dementia patients to improve or recover all aspects of their memory, and this application is implemented mainly converging on elderly Dementia patients in Sri Lanka.

1.5.2 Specific objectives

The main objective is covered with the aid of the resulting specific sub-objectives which will be used with the succor .

• Specific -Objective 1: Design a memory related personalized game each Dementia patient using RL

• Specific -Objective 2: Measure memory weakness and strengths of the Dementia patients

• Specific -Objective 3: Identify the progress of Dementia patient memory continuous monitoring.

• Specific -Objective 4: Motivate Dementia patients to keep tracking on their daily progress of memory skill.

3. METHODOLOGY

This segment helps to illustrate the paths how this research project carry to succeed each task which are processed in successful manner.

3.1 Methodology

3.1.1 Feasibility study for proposed solution

As starting juncture of the project, project initiation was performed. Under project initiation phase several type of feasibility studies was overseen to discover any worthy of the project.

A. Economic Feasibility Study.

Prior to apportion our finacial resources, we did follow this economic feasibility study to ascertain cost and benefits which are correlated with our project. Our proposed soultion is benitifical to people who are undergoing from mild or moderate Dementia to recover through practice which is result in to descrease Dementia from the society. Further more, Dementia has economically impact to country/ world. Since our solution is capable to recover Dementia so that economy situation of the country will be increased.

B. Operational Feasibility Study

Undertake an operational feasibility, we were focused on whether our final product would be easily operated at side of end users. Since our proposed solution interacts with patient's care giver and doctor but not only the patient. Due to that point it will help patient to easily operate with the application and as well our application is proficient with understanding both English and Sinhala languages. Therefore, when we consider about Sri Lankan Dementia patient, this solution is more flexible to them.

C. Technical Feasibility Study

Covered technical feasibility study to focus on technical resources accessible for proposed solution and turned attention on assets that are obliged to activate, install, or obtain the system to develop the ultimate product. As a result

D. Scheduling Feasibility Study

This can be deemed as most important feasibility study area which can be conducted for project success. Under this assessment wrapped up and sketched out the project deadline is suitable for the project and this feasibility study estimated how much of time amount will take up to attain the definitive product containing testing stage.

3.1.2 Requirements gathering, data collection and analysis

For this research project mainly vise most of the important requirements gathered supervision under the Psychiatrist Dr. Chathurie Suraweera Senior Consultant at National Hospital, also conducted quantitative methods for requirements gathering and for the data collection. Therefore, we created a survey consisted of 4 multiple choice answers and 15 questions where responders had to answer with 5-point scale. There was no time limitation given to participant and it could fill anonymously. The aim was to carry out the survey is to get considerable responses with that X number of people will agree with our proposed solution for Dementia. In this case there were not all the surveys fully completed hence, considerable amount of fully completed results included in the analysis.

  Based on the analysis and the requirement which came from the Psychiatrist doctor, research team decided to develop a one single personalize gaming application for both Sinhala and English languages which contain 4 different game components in it which are mainly focus on different skills on Dementia patients.

3.1.3 System overview

Immediately after developing our proposed system, doctor can recommend this application to Dementia patients and based on Mini Mental State Exam (MMSE)test report doctor can recommend the category of the game that patient should carry on. Referring to the Figure 4, caregiver must set the application for patient and should provide all correct personal data into system. Reason for that is report of patient's progress and all depend on these personal data.

After the basic preparation of the application including login, patient can choose the game component which recommended by doctor. Furthermore, patient only allow to start with simple level which is an initial level and with the progress patient can be move further. Progress of the patient including game scoring can be sent as a report via an email. Hence, doctor can continuously do a monitoring on patients when the time needed. Also considering our proposed system level except the initial level, other levels behavior has been changing patient to patient. Nevertheless, this feature can be called as unique characteristic of our solution compared to other existing solution for Dementia patients.
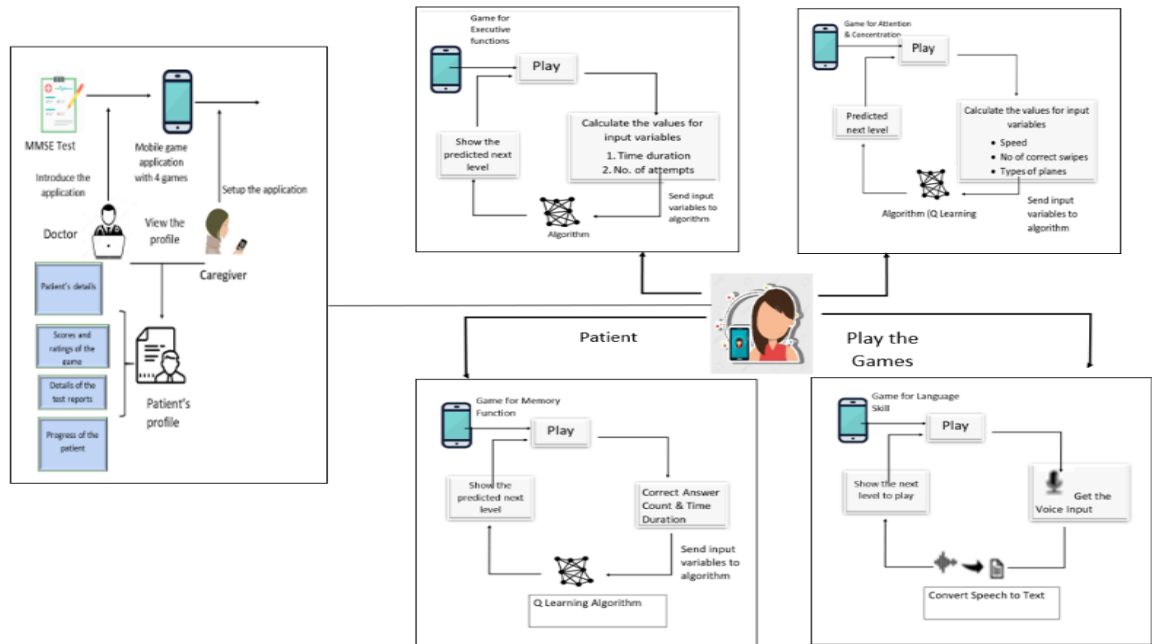
Figure 4: System Overview

3.1.4 System architecture
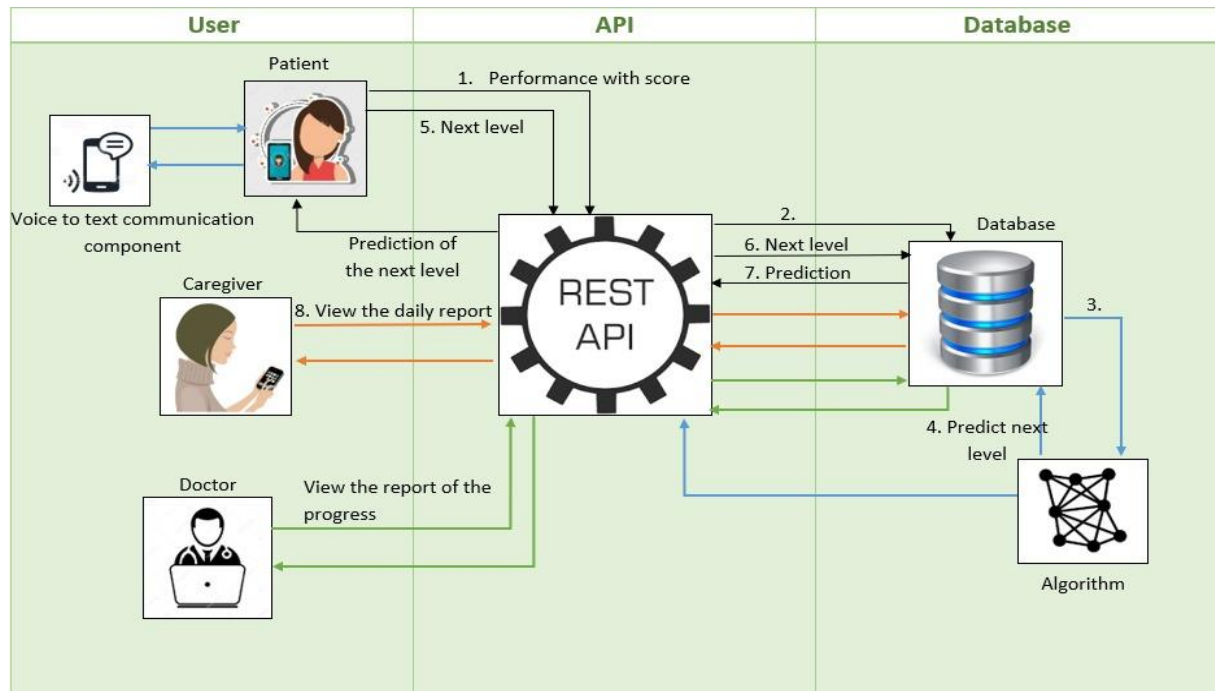
Figure 5: System Architecture

3.1.5 Technological approach

The technologies exploited throughout the implementation of this research component are listed below.

This research component mainly used technologies such as C# for games development, Python for machine learning algorithms implementation and SQL for designing, programing, and managing data into relational database management system. Q Learning algorithm also used for this component.

Below table 2 is illustrated the result summary of technical feasibility study

Algorithm	Q- Learning
Programming Languages	C#, Python
Backend Service	PlayFab

Version Controlling	GitLab
Game Development Engine	Unity
Project Management Tool	Trello
Libraries	TensorFlow

Table 2: Results in Technical Feasibility Study

Amalgamation of entirely technologies overhead formed the entire research component.

3.1.6 Memory component

Memory Component is a game which is related to human's memory . The main emphasis of executing this component was, develop a memory game for Dementia patients to principally enhance their memory. If further explain, there are three type of main aspects of memory, Registration, Recall and Recognition which is known as long term memory. Considering about the memory of the Dementia patients, implementation of the activities of this component is chiefly aim at above mention aspects. The game or activity is contained three levels in it and in each level, patient should be covering all the aspects of the memory and these game activities was implemented using the Q – learning algorithm which is fallen under reinforcement learning and also this component implemented for both Sinhala and English languages which is more supportive for Sri Lankan elderly Dementia patients.

• Registration

Ability to memorize set of values in given little time period.

• Recall

Ability to memorize or registered list of value after the given time period.

• Recognition

Ability to identify already registered list of values among of another set of values.

3.1.6.1 Pre- requirements, functional requirements and non- functional requirements of component

a) *Pre-Requirement*

As first step, the relevant consultant Psychiatrist must do the Mini- Mental State Examination (MMSE) test for the patients who meet the doctor. According to the MMSE test result, patients will be categorized into some stages ether tested patient is fallen into which stage of Dementia.

Only the patients under the mild and moderate stages will be recommended to use this gaming application. Through the other diagnose testing of patient for Dementia, from there if doctor is selected patient need to focus on their memory, in that case patient can practice on this memory game.

b) *Functional Requirements*

The proposed research component should be containing memory games which can coverup all aspects of memory such as registration, recall and recognition.

● The proposed research component should contain should be maintain logged history in order track the detail of Dementia patient.

● The proposed research component should be supporting both English and Sinhala languages with the Dementia patient.

● The proposed research component should be contained two or more that levels in it and it should be learning from user via RL algorithm in order to predict the functionality of the next level of the game.

● The proposed research component should be able maintain history related to the level of the game.

● The proposed research component should be allowed doctor to view progress report of the Dementia patient regarding their memory improvement progress.

c) Non – Functional Requirements

● The proposed research component should be able to give the progress report accurately to the doctor.

➢ It should be recognizing the behaviors of the patient and predict the next level of the game very correctly.

● Usability of the proposed research component.

➢ The patient should be fingered the proposed system with effortlessness

● Availability

➢ History of the level of the game such as scores history data should be available to the Dementia patient and for the doctor at any given time to measure their progress level of memory improvement.

3.1.6.2 Component overview

Below diagram in figure: 6 is demonstrated overview of this the memory component. All the interactions done all through doctor, caregiver and patient are shown on component overview.
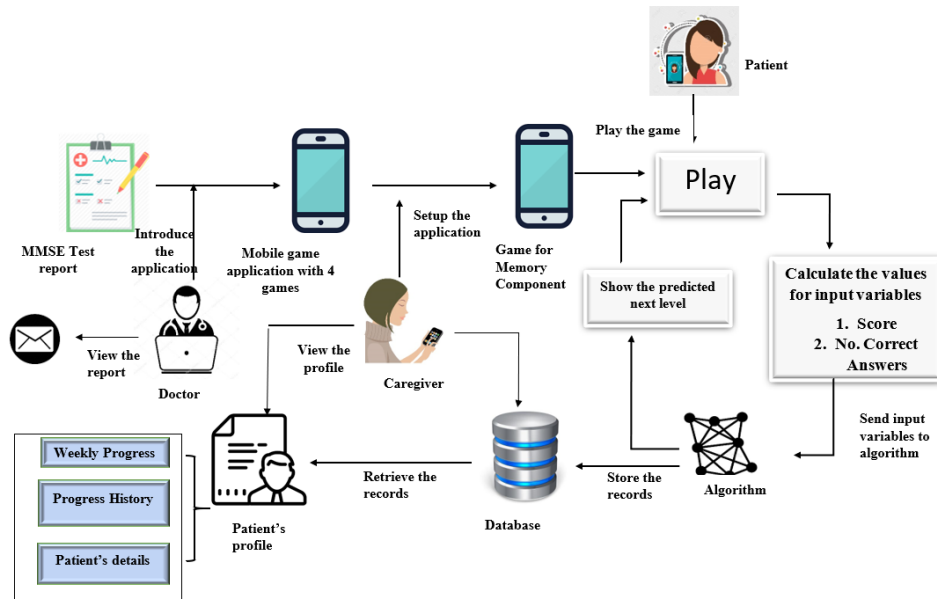

Figure 6: Overview of Memory Component

3.1.6.3 Functional flow of component

Based on MMSE test result and recommendation of doctor for this memory component Dementia patient can involve to this memory game.

In order to involve patient into the game caregiver must be able register patient's self into entire system by providing all personal data. When the stage of proving data caregiver must provide correct data upon that all the preparation and progress reports are generated. After the patient's registration, patient should be able to view on home of the application which will contain 4 different gaming categories. In this overall application, it is provided all the instructions in both Sinhala and English languages. Once all the basic preparations is done, patient by their own or with help of caregiver should select memory game and then patient can step further with basic level of the memory game. End user can use either English or Sinhala language based on their preferences when doing game. With the progress of the Dementia patient's performance, they can step further with other levels of the memory game. This component is kept track of all score earned by patient. And also, doctor can keep continuous monitoring on Dementia patient's progress on memory and progress related report which is combined with this component is sent to doctor's via email automatically.

3.1.6.4 Component designing

➢ System designing

In the phase of system designing predominantly concentrated in the direction of the various type of diagrams that facilitates to get hold of a clear-cut notion concerning what are the use cases, in what manner the classes will be put into effect, exactly how the structure will ensure the positioning etc. In such case quite a few UML diagrams were designed and hardly any of them are as per the way below. Below named illustrations were encompassed in a document called 'software requirement specification' (SRS) document which our team was referred to at the same time as implementing the genuine system. The coverage accomplished from these designs aided to execute the system smoothly ever since

we had a strong idea of by what means each and every smidgen of the system will go to work.

- Class diagram
- Activity diagrams
- Sequence diagrams
- Use case diagram

➢ User Interface Designing

User interfaces designing consist of a lot of reflections on the subject of user experience. Prototype designed using MockFlow tool. It gave us an idea how our mobile application will seem to be once it is implemented. Every factor instigated attractive appearance of UI such as colors, fonts and layout designing was carefully chosen considering the user experience.
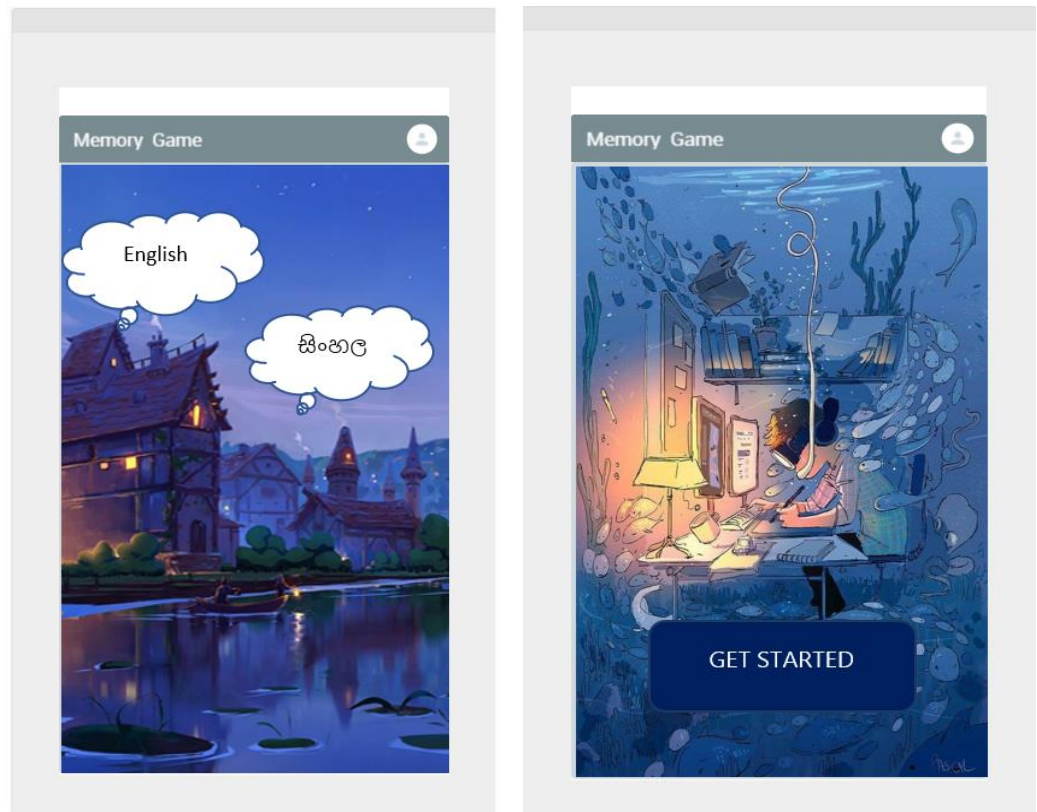
Figure 7: Designed Prototype UIs for Memory Component
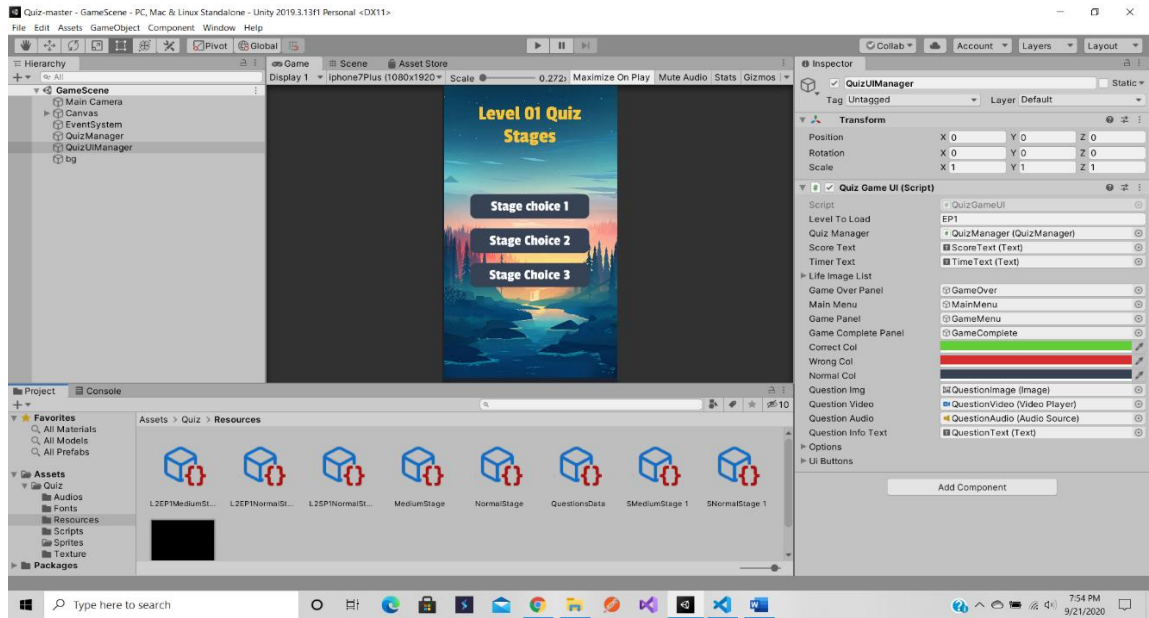
Figure 8: Quiz Panel Designing with Unity Engine

Above figure 8 is illustrated design of main quiz panel. Inside this single scene, it can change their UI with time when playing the game. Once user chose one of choice within the same scene it is loaded into another UI where questions are displayed. Based on the performance during the quiz, this quiz panel change their UI into game over panel or game completed panel but within same scene as shown below figures.

Figure 9: UI changes in Single Game Scene with Unity

3.2 Commercialization Aspect of the Product

Nowadays, we all are encircled by a globe of electronic machines and it is a vital role of the day-to-day life expectancy of human being. Move About attentiveness to the necessity of manipulating mobile app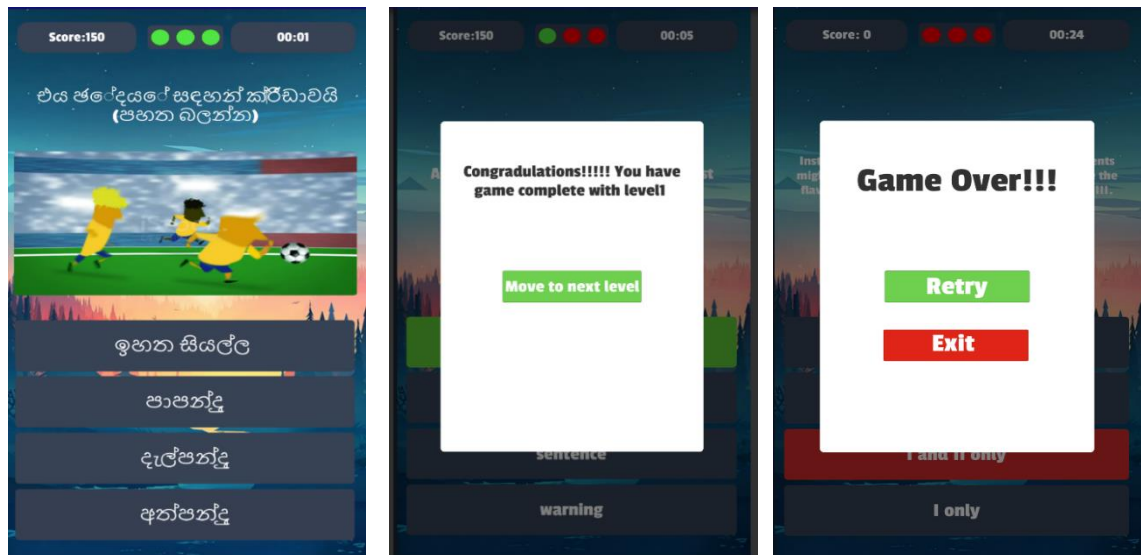lications or products are an observant reality in our time. Agreeing to that statement is resulting to handing up a solution all the way through games on a mobile application for Dementia syndrome will be advantageous for the Dementia patients.
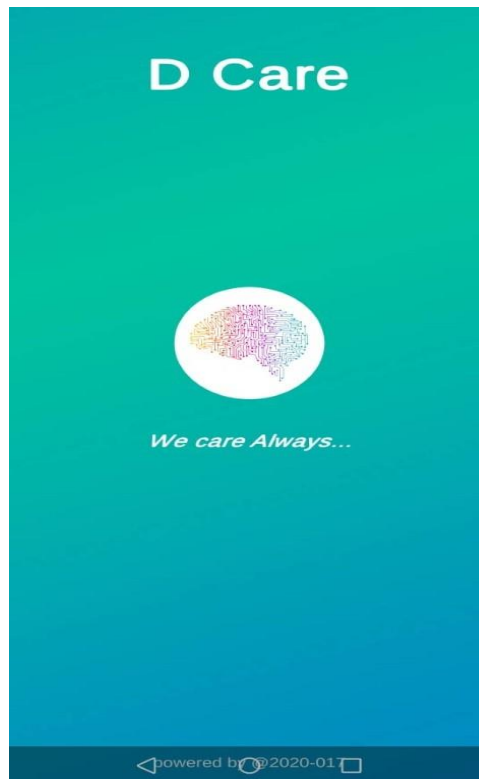
Figure 10: Splash Screen of D-Care

As a commercialization of our implemented application for Dementia patients, be able to announce this application to psychiatrist doctors who are dealing with Dementia patients. Psychiatrists do follow up the relevant testing processes like MMSE testing for Dementia patients. Later all psychiatrist doctor can discover the essential cognitive functionality or spiritual functionalities to be enhanced for the applicable patient. Permitting to the

endorsement of the doctor, patient performs the suggested activities or games to expand the weakening of needed intellectual functionality or functionalities.

Further than, this solution can commercial caregivers be indicating out the advantages of tapping this brain training mobile game application for patients who are dropped to illness called Dementia. We can imply the caregivers to provide this application or solution to play a part for Dementia patients in conjunction with the endorsement of the relevant psychiatrist doctor. Patients who have Dementia, can have one month of trial time period. After one month of trial period patients can install this cognitive rehabilitation based personalized solution which was implemented for Dementia patient using reinforcement learning to their smart phones and continue the with the games when the time of need. Meanwhile, doctors can keep on monitoring the progress of the patient and determine in what way the patients should play-act the games afterwards.

3.3 Testing and Implementation

Moving to step further, this section is illustrated implementation and testing of the component. When consider about implementation and testing phases are coming after the phase of designing of SDLC. As this research has built up by utilizing software development methodology called Agile Scrum Process and due to that for sometimes, had to follow implementation and testing phases together.

Implementation phase is discussed how this research component has been implemented and how the way testing is done, is discusses under section 3.3.2 'Testing'

3.3.1 Implementation of component

This implementation step is also well-known as programming phase. The implementation phase of this software component design commenced in terms of writing program code in the appropriate programming language and developing error-free executable procedures or programs efficiently.

As mentioned in above sections, this component is consisted with a game for human's memory and also 3 main levels were implemented in it. Implementation of this game with

its levels was done for both Sinhala and English languages and user who is interacting with this game can ability to choose their preferred language. The game implemented for memory is quiz-based game where user is given a passage with limited time and ask to memorize much they can. After the given time is up, user is given set of questions based on the passage with time limitation. In order to move to next level, game was implemented to check constrains such as remaining life timer and score. And there were few of functions were implemented for timer, life timer and specially these questions can be display in mode of images, text, audio and also videos, due that there were special scripts were implemented for UI panel of the game. Time to time when playing on this game at any, it was implemented to change the order of the questions.

Basic Game UIs

The development of the user interfaces for memory game were done using the Unity engine based on the C# programming language. Below figures are indicated level and language selection, and passage displaying UIs that were implemented.
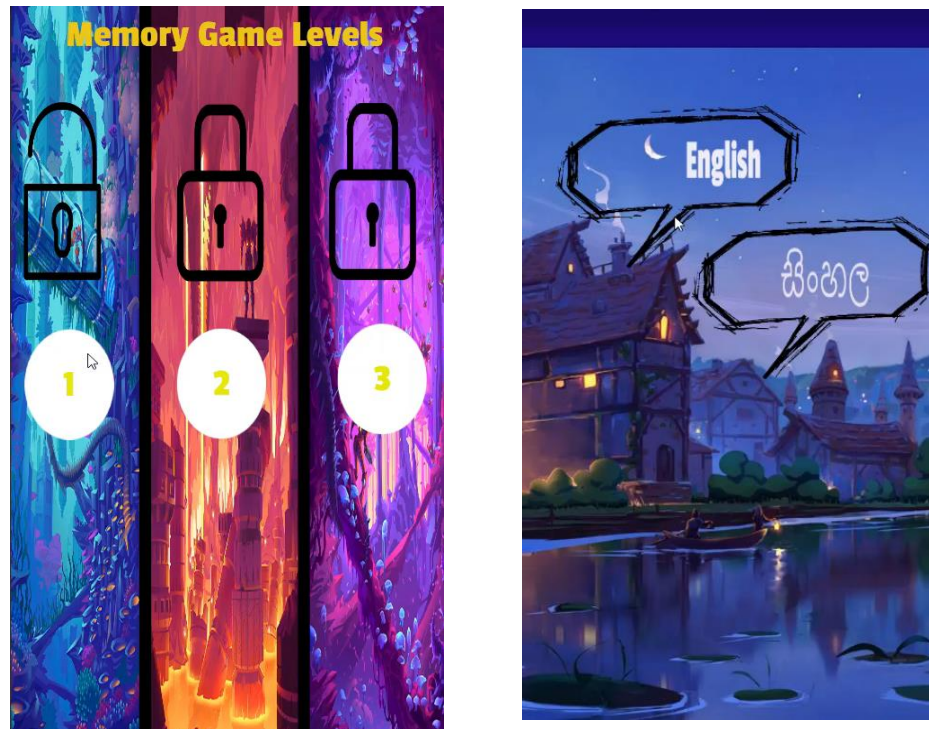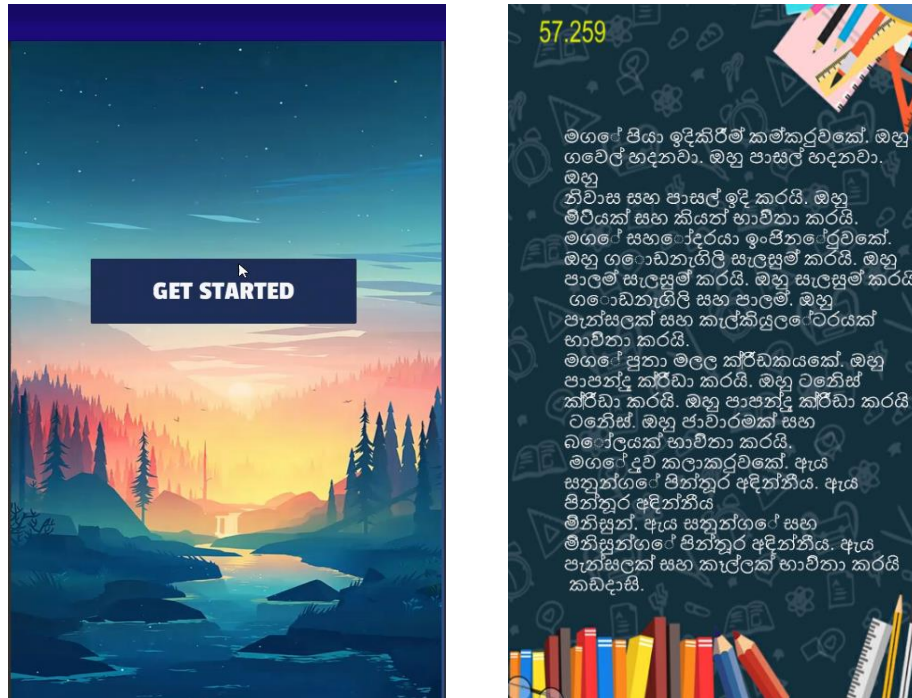

Figure 11: Basic Memory Game UIs

Figure 12: Basic Memory Game UIs

Implementation of UI functionalities

```
public void NavigateToPage()
{
    switch (gameObject.tag)
    {
        case "English":  // If the menu selection is English this will redirect to to Starting page of the game in English
            //SceneManager.LoadScene("Estarted");
            Application.LoadLevel(levelToLoad);
            break;
        case "Sinhala":  // If the menu selection is Sinhala this will redirect to Starting page of the game in Sinhala
            //SceneManager.LoadScene("Sstarted"); // put scene name which should navigate when press this
            Application.LoadLevel(levelToLoad);
            break;
        case "Estarted": // Get Started with English
            //SceneManager.LoadScene("EP1");
            Application.LoadLevel(levelToLoad);
            break;
        case "Sstarted": // Get Started with Sinhala
            //SceneManager.LoadScene("SP1");
            Application.LoadLevel(levelToLoad);
            break;
        case "L2Estarted": // Get Started with English
            //SceneManager.LoadScene("L2EP1");
            Application.LoadLevel(levelToLoad);
            break;
        default: break;
    }
}
```

Figure 13: Implementation of Page Navigation Function

Above code segment in figure 12 was implemented to navigate among few of pages. According to that it used simple switch statement along with public C# function called NavigaeToPage(). As in this image there is a parameter which is called levelToLoad, is declared as in below figure. That parameter should be the name of scene where to navigate.
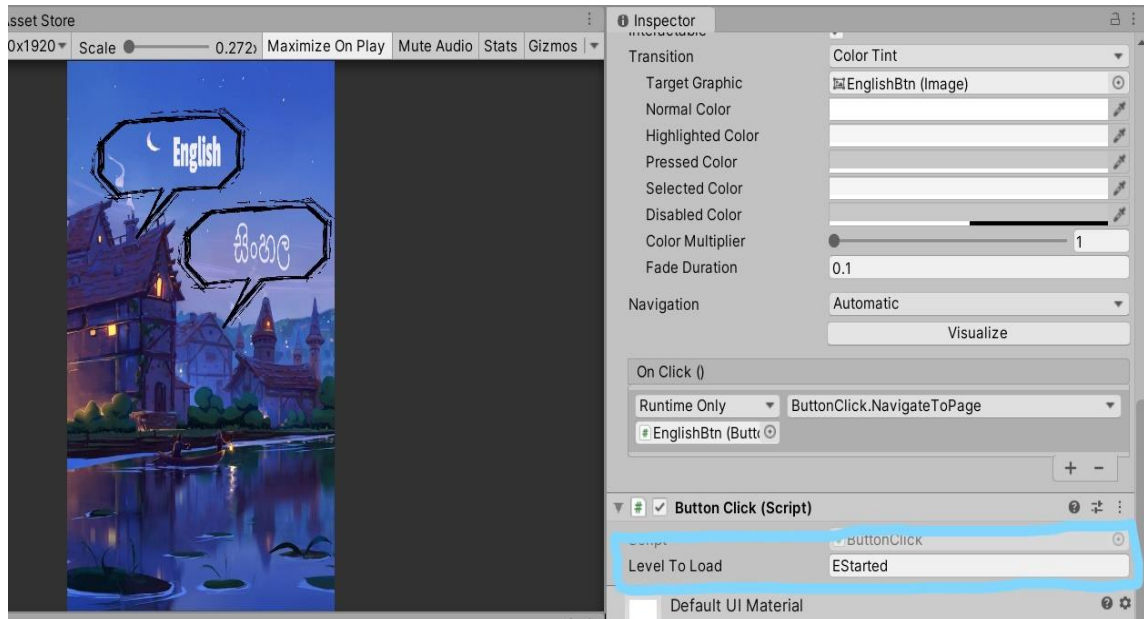
Figure 14: Unity Game Engine Inspector Section for UI

```
public class TimeDuration : MonoBehaviour
{
    public string levelToLoad;
    public float timer = 30f;
    public Text timerSeconds;




    // Start is called before the first frame update
    void Start()
    {
        timerSeconds = GetComponent<Text>();
    }


    // Update is called once per frame
    void Update()
    {
        timer -= Time.deltaTime;
        timerSeconds.text = timer.ToString("f3");
        if (timer <= 0)
        {
            Application.LoadLevel(levelToLoad);
        }
        if (timer <= 5)
        {
            timerSeconds.color = Color.red;
        }
    }

}
```

Figure 15: Code for Timer function

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Furthermore, in this game passage display timer was implemented with color changing. There is a UI where passage is display with 60s of time duration shown in yellow color as shown as figure 11. That timer's color will change in to red when it is less than 5s. Refer to above figure 14 which is tried to demonstrate the function of that behavior. Also, this was implemented their function when the timer become 0s it is moved to next scene to be loaded. This function was implemented by using simple if- else statement within in-built function called update() in unity.

```csharp
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

public abstract class ShuffleList
{
    public static List<E> ShuffleListItems<E>(List<E> inputList)
    {
        List<E> originalList = new List<E>();
        originalList.AddRange(inputList);
        List<E> randomList = new List<E>();

        System.Random r = new System.Random();
        int randomIndex = 0;
        while (originalList.Count > 0)
        {
            randomIndex = r.Next(0, originalList.Count); //Choose a random object in the list
            randomList.Add(originalList[randomIndex]); //add it to the new, random list
            originalList.RemoveAt(randomIndex); //remove to avoid duplicates
        }

        return randomList; //return the new random list
    }
}
```

Figure 16: Code Segment for Change Order of Questions in Quiz

3.3.2 Testing

Testing stage can be consider as incredibly indispensable phase of SDLC. Testing is evaluation of the product prerequisites congregated from clients. Programming testing incorporate of both check and approval or it can call out that testing combine with verification and validation. Furthermore, testing is associated with each phase of programming life cycle, yet the testing done at each degree of programming improvement is diverse in nature and has various targets. When considering about the goal of the software testing, is to support planners, engineers, and administrators develop frameworks with high caliber. Subsequently innovative work on testing focus on productively performing powerful testing – to discover more mistakes in necessity, plan and usage, and to expand certainty that the product has different characteristics.

Unit Testing was done at the most minimal level. It was tested the essential unit of programming for memory component, which was the littlest testable bit of our solution, and is frequently called "unit", "component", or "module" conversely. D-Care, our personalized solution for Dementia Patients with continuous monitoring application's unit test process was done through all the executions , so as to guarantee the individual module worked by the normal yield. When doing unit testing for memory game (component of memory), was utilized Test Runner for unit testing preparing. The unit tests can be run automatically from any content through the Test Runner API. This permits to recover a rundown of tests that will run in Edit Mode, Play Mode or both without running them.

The accompanying tables are a portion of the manual experiments which were utilized to watch that the highlights and functionalities of the application working appropriately true to form.

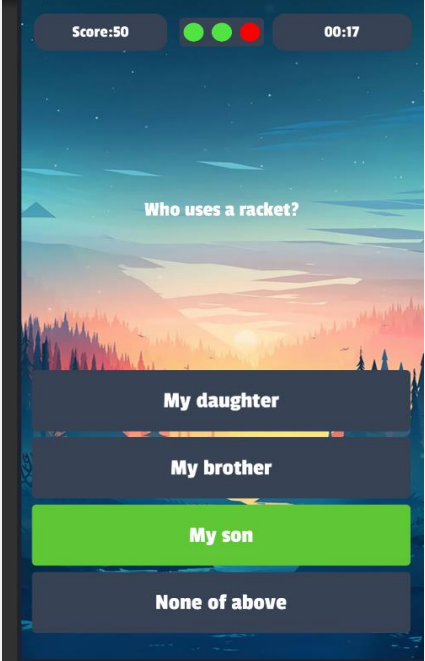| Test ID	001
Test Priority (Low, Medium, High)	Medium
Module Name	Quiz panel in memory game
Test Designed By	Roshni Silva
Test Executed By	Roshni Silva
Test Description	Patient selects a correct answer for given question in the quiz panel based on passage displayed.
Pre- condition	Install D-Care application to patient mobile device and join with memory game component
Test Step/s	1. Open the application 2. Join with memory section 3. Read the instruction given for memory game 4. Select the level "1" or "2"button 5. Select the preferred language 6. Get started with the game 7. Try to memorize the given passage 8. Attend with the quiz 9. Among the answer buttons given for the question, choose the correct answer without exceeding the time limit for entire quiz
Expected output	The correct answer button turn into green color and the score will increased by 50
Actual output	The correct answer button turned into green color and the score increased by 50

Status (Pass/ Fail)	pass
Note	 Figure 17: Result of actual output for selecting correct answer

Table 3: Test case for correct answer button function

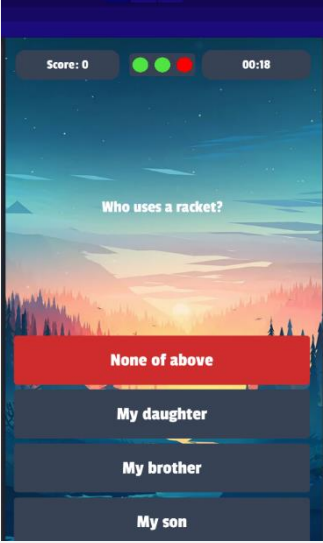| Test ID	002
Test Priority (Low, Medium, High)	Medium
Module Name	Quiz panel in memory game
Test Designed By	Roshni Silva
Test Executed By	Roshni Silva
Test Description	Patient selects a wrong answer for given question in the quiz panel based on passage displayed.
Pre- condition	Install D-Care application to patient mobile device and join with memory game component
Test Step/s	1. Open the application 2. Join with memory section 3. Read the instruction given for memory game 4. Select the level "1" or "2" button 5. Select the preferred language 6. Get started with the game 7. Try to memorize the given passage 8. Attend with the quiz 9. Among the answer buttons given for the question, choose the wrong answer without exceeding the time limit for entire quiz
Expected output	The wrong answer button turn into red color and there will be no affect in score
Actual output	The wrong answer button turned into red color score did not affect

Status (Pass/ Fail)	pass
Note	Figure 18: Result of actual output for selecting wrong answer

Table 4: Test case for wrong answer button function

4. RESULTS AND DISCUSSION

4.1. Results

When discussing aftereffect of the exploration venture, the rule and the hugest outcome of making Customized Application for Dementia patients is to help out those patients by providing recuperation in a wise manner utilizing various types of games and activities.

Memory component resulted in develop a game which can cover up aspects of memory such as registration, recall and recognition. The main feature of this game component is it can support for both English and Sinhala language. Please refer to below figure 19. And furthermore, as another aftereffect of execution of this game can be consider as progress level. This game isn't simply to play however to see and assess improvement of patient by their own. And furthermore, these advancement report can be sent to the specialist and parental figure consequently once per seven day stretch of a period. By those highlights can top off previously existing examination hole with is the best consequence of this individual segment.
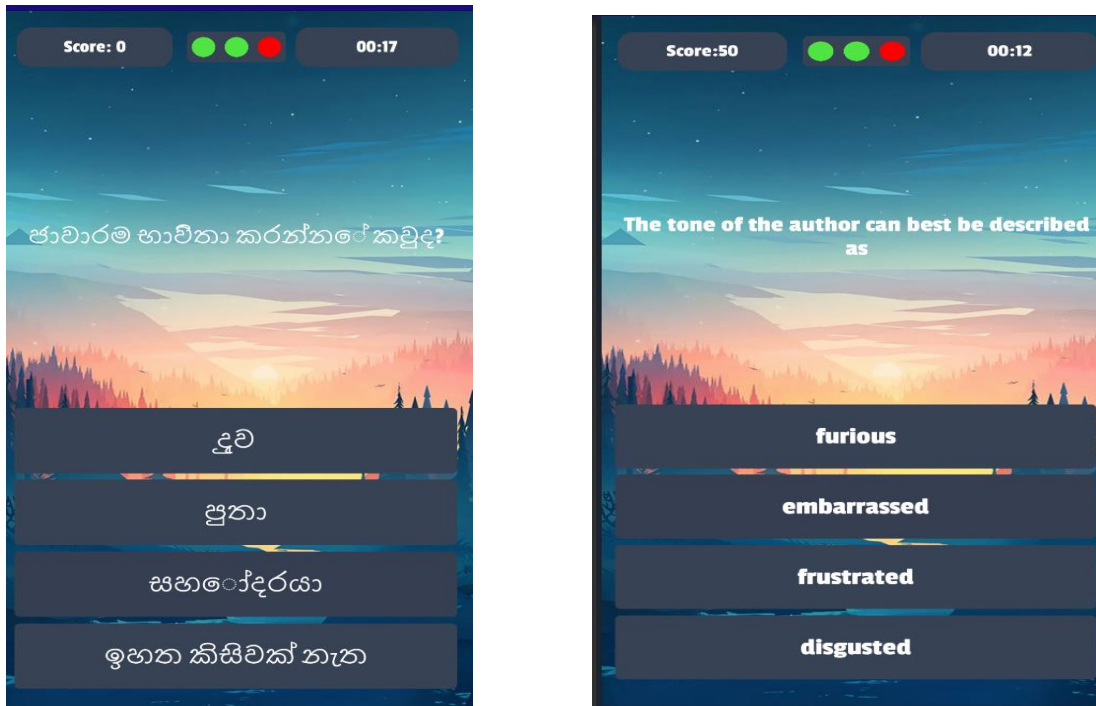
Figure 19: UIs in English and Sinhala

4.2. Research Finding

As a primary examination finding, have recognized that this game is customized game. Further clarify this game levels can be shifting for patient to understanding. In order to customize this game as a research area RL was used.

RL is somewhat of extensive area of machine learning study. Through this examination concentrate under fortification learning discovered to approach to tweak this game part dependent on persistent execution of the past degree of the game. Reinforcement learning algorithms such as Q – learning and deep q learning were used to predict next level of the pervious level for memory game by passing score and correct answers gained during the quiz of pervious levels. Thus, in view of the presentation for the level calculation is chosen for the unpredictability of the entry would be. Underneath figure 20 is shown complexity of fluctuate of a level dependent on execution picked up during the past level.
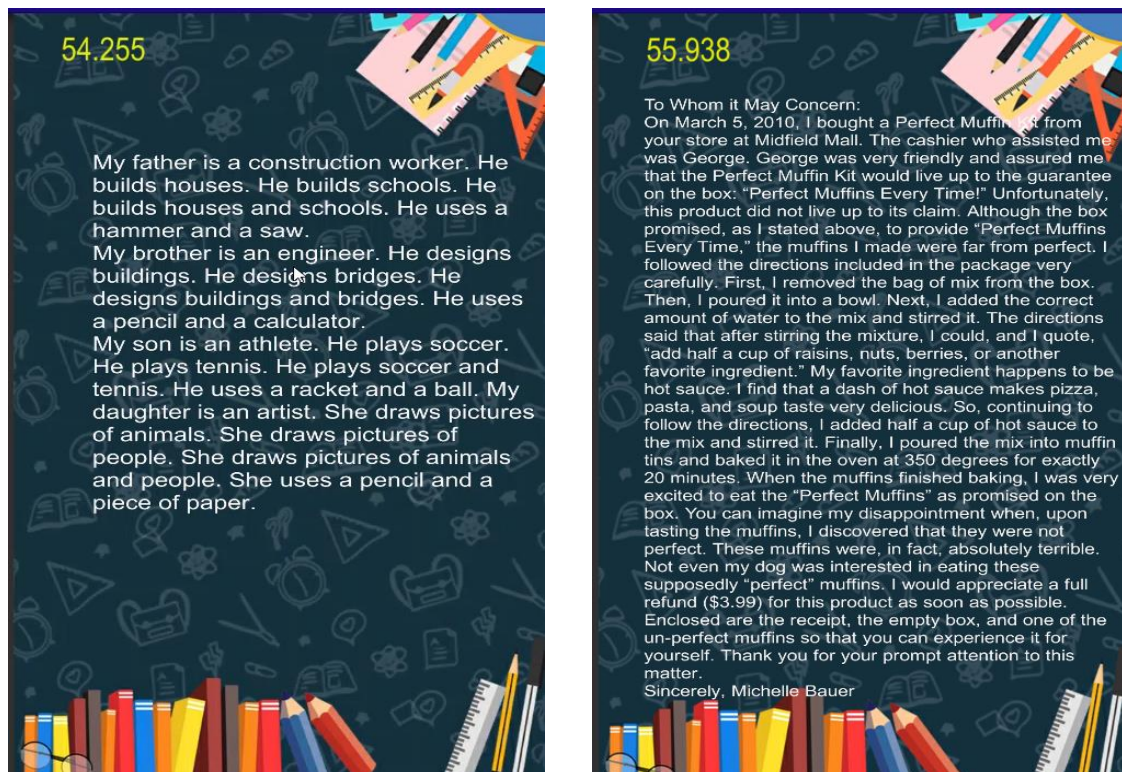

Figure 20: Variation of Complexity due to Performance

We assembled and examined the advancement consequences of the clients utilizing same application with and with utilizing machine leaning advances. With the outcomes we can say the customized application shows great outcomes than the other.

4.3 Discussion

This part essentially centers around talking about the issues that looked during plan and execution and how those issues were settled. What's more, this segment talks about how to enhance the system and prevail with regards to picking up the accomplishments.

Research project named "Cognitive Rehabilitation based Personalized Solution for Dementia Patients utilizing Reinforcement Learning " for Bachelor of Science (Honours) Information technology was started on November 2019 to find a best modified response for recuperation of Dementia open minded through an electronic contraption. The game plan was perceived as a flexible application with games and exercises using present day advances like Reinforcement Learning and Deep Neural Network.

The principal question we face is to which intellectual capacities to decide for this application. At that point we masterminded a few gatherings with the outer chief and discussed it and settled on an ultimate conclusion. Different issues emerged in planning games and exercises to suit chosen psychological capacities. This is on the grounds that every one of the intellectual capacities must be planned similarly as the medicines given by the specialist. While executing the calculations for anticipating following stages of certain games there were a few issues came up in light of the fact that the chose ML zone. As indicated by the Q learning calculation it was difficult to apply without fixed number of activities. Consequently, as an answer for that utilized the Deep Q learning calculation too.

When coordinating four sections which were executed freely, there were various bugs. The best issue was system crushing. In there, in the wake of joining parts, the email structure using SMTP was slammed. Along these lines, we expected to complete it again because of it.

4.4 Summary of Individual Contribution

Actualized memory game for Dementia patients to primarily upgrade their memory and capacity to improve. Considering about the memory of the Dementia patients, execution of the exercises of this part is predominantly focus on above notice viewpoints, for example, registration, recall and recognition. The game will have two or different levels in it and in each level, patient ought to cover all the parts of the memory and this game will be actualized utilizing the fortification learning. Fortification Learning is utilizing to foresee the following degree of the game for memory. In light of the exhibition of the patient that level will be anticipated. Executed reports which showing tolerant advancement. What's more, the email usefulness to send letters to specialist and guardian. Actualized help page and other required pages for the game.

5. CONCLUSION

This cognitive rehabilitation based personalized solution which was implemented for Dementia patient using reinforcement learning is a combination of four-spot complicated individual modules. Therefore, determination of all four representatives of the research project team were required to assemble up a success story of the ultimate product of this system or application. To care for the patients personalized therapies, a user-friendly application was established in a very interactive way containing four different games. These games are under four main functional zones from human's frontal and temporal lobes of cerebral cortex such as attention and concentration, executive functions, language and memory. The games are performed in touch screen and all the required locales mutually Sinhala and English languages are employed eradicating the disparity between the technology disparity for the aging people. In memory related game QL and deep q learning calculations of Reinforcement Learning is utilized to gain from the client and anticipate the client explicit next level for every client. This will assist the patients with getting modified and most fit recovery for the Dementia patients.

Concerning the future work, the application can be improved by expanding the precision of anticipating the following degree of the games. Also, in the Language game and Memory related exercises, improve the discourse to message correspondence by utilizing the voice contributions subsequent to eliminating the foundation commotion. We plan to present more games covering the other useful regions identified with Frontal projection and Temporal flaps of the Cerebral cortex. Furthermore, to incorporate the test to distinguish the Dementia patients utilizing ML.

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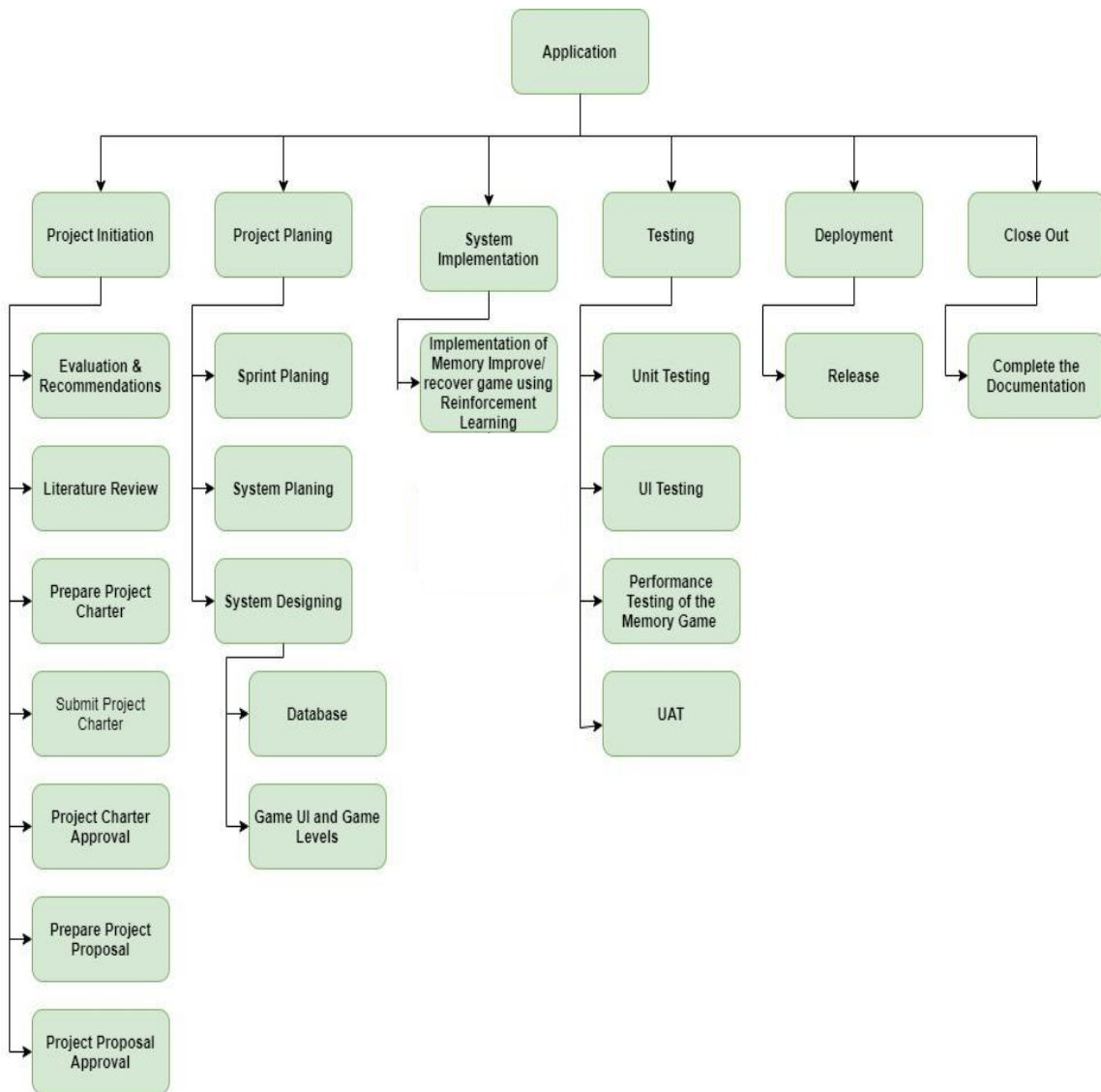
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GLOSSARY

Cognitive rehabilitation	Alludes to a wide scope of proof-based intercessions intended to improve psychological working in cerebrum harmed or in any case intellectually hindered people to reestablish ordinary working, or to make up for intellectual shortages
Reinforcement Learning	A zone of machine worried about how programming specialists should take activities in a situation so as to boost the idea of combined prize.
cerebral cortex	the external layer of neural tissue of the cerebrum of the mind in people and different well evolved creatures

APPENDICES

Appendix A – Work Breakdown Structure

Appendix B – Gantt Chart