# PERSONALIED APPLICATION FOR DEMENTIA PATIENTS IN CONGNITIVE REHABILITATION WITH CONTINUOUS MONITORING

Project Id: 2020-017

Project Proposal Report

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## DECLARATION

We declare that this is my own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

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## ABSTRACT

Sri Lanka has one of the world's quickest maturing populations [1]. As indicated by the ongoing forecasts, 20% of Sri Lankans will become more than 60 years in 2020 [1]. In this way, diseases like Dementia will turn out to be increasingly prevalent in the network. The current medication can't fix this Disease [2]. Be that as it may, during the beginning times like mild or moderate in Dementia, there are a few different ways to help those patients to keep their mind dynamic by easing back the indications of one phase to the following stage for somewhat more. Dementia is a general term for illnesses and conditions described by a decrease in memory, language, critical thinking and other reasoning aptitudes that influence an individual's capacity to perform regular activities. Because of the successful utilization of brilliant devices at present, the usage of new application including games and exercises for expanding the memory intensity of Dementia patients will be useful. Among the core mental functions of dementia, this research component study and focus on executive functions. There are number of mind preparing versatile applications on the planet that could be valuable to develop executive functions skills however there isn't appropriate portable application for Sri Lankan culture in light of the fact that the greater part of the dementia patients in Sri Lanka are senior residents and they are not capability with the English language and the accessible current applications are not free and the clients must pay an expense for utilizing those applications. The execution of the research part will incorporate a brain game dependent on reinforcement learning and algorithms along with the supervision and suggestion from a Consultant Psychiatrist in Sri Lanka.

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# 1. INTRODUCTION

Sri Lanka has one of the world's quickest maturing populations. As indicated by the ongoing forecasts, 20% of Sri Lankans will become more than 60 years in 2020 [1]. Accordingly, sicknesses like Dementia will turn out to be progressively common in the network. Be that as it may, during the stages like mild or moderate in Dementia, there are a few different ways to help those patients.

Because of the regular use of smart devices at present, the execution of new application including games and exercises for expanding the memory intensity of Dementia patients will be advantageous. The individuals who are encountering early indications of dementia or the patients in mild or moderate stages in dementia can utilize this application bit by bit and lift their condition with the continual checking. Among the core mental functions of dementia, Executive functioning involves the ability to organize, plan and carry out a set of tasks in an efficient manner. Development of this domain will be helped to improve the effectiveness and speed process of executive functions.

With the development of machine learning techniques, different applications are created to tackle genuine issues. Reinforcement learning (RL) is one of the algorithms that is used for game development. Right now, would be a decent chance to examine whether the above advances can be used in the wellbeing business to give an exact and dependable application to give some assistance to dementia patients.

# 2. BACKGROUND AND LITERATURE SURVEY

## 2.1.Background

Dementia is a disorder wherein there is rot in memory, thinking, direct and the ability to perform customary activities. Even though dementia, generally, impacts progressively prepared people, it's not a normal bit of developing. Around the globe, around 50 million people have dementia, and there are around 10 million new cases every year. Dementia is one of the huge explanations behind insufficiency and dependence among progressively settled people far and wide. Dementia has a physical, mental, social, and money related impact, on people with dementia, yet also on their considerations, families, and society free to move around at will. Dementia impacts each person in another way, dependent upon the impact of the sickness and the person's character before becoming ill. The signs and reactions associated with dementia can be interpreted in three stages.

1. Early stage
2. Middle stage
3. Late stage

There is no treatment starting at now open to fix dementia or to alter its dynamic course. Different new prescriptions are being examined in various periods of clinical primers. Regardless, much can be offered to help and improve the lives of people with dementia and their considerations and families.

Considered by numerous applications, Lumosity is utilized by more than 85 million individuals over the globe. The application comprises of over 50 glowing and fun minigames intended to prepare five intellectual capacities: speed, memory, consideration, adaptability, and critical thinking. Luminosity is an application that could without much of a stretch design to the two youngsters and grown-ups. Lumosity is allowed to download on Android and iOS yet can't gain access to full form in any case the client needs to pay a cost. Fit Brains is a formation of Rosetta Stone, and it has been made to assist practice with keying psychological capacities, including focus, memory, speed of reasoning, and critical thinking. In view of the consequences of each game played, the client is furnished with a score out of 200 for each psychological zone. The application likewise contrasts singular outcomes and those of

different clients [3]. Decoder is another game created by Cambridge University for fixation and consideration preparing. Decoder is story based and simple to play. Iridis is somewhat not the same as the previously mentioned versatile applications. It is a portable application planned by The University of Stirling for dementia guardians. It gives a great deal of realistic guidance for dementia patients' families and guardians, encouraging them approaches to manage patients' eating regimens and everyday schedules [4].

The wide collection of accessible applications for a general crowd joined with the restricted accessibility of applications explicitly produced for individuals with dementia indicates that careful thought is required to choose usable applications for individuals with dementia. The usage of the application will incorporate brain game for executive functions dependent on reinforcement learning.

## 2.2. Literature Survey

### 2.2.1. Dementia

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 [5]. 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 isn't amazing that the expenses of care for patients with dementia are huge [6].

In Sri Lanka, the normal future from birth has expanded for men from 62 years in 1963 to 70 years in 1991, and females from 61 years to 74 years (Annual Health Bulletin, 2000). Along these lines, the level of the populace matured more than 60 years right now expected to increment quickly from 8% as of now, to arrive at 13% in 2010, and 21% in 2025.

Fundamentally considering lesser accentuation on the wellbeing of more seasoned grown-ups and lesser assets for wellbeing research contrasted and the industrialized nations, Sri Lanka has not had the option to report solid epidemiological information on maturing related scatters, for example, dementia. Along these lines, the degree of the general wellbeing trouble right now presented by Alzheimer's Disease (AD) and different dementias in Sri Lanka is obscure [7].

### 2.2.2. Mobile Applications for Dementia patients

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 [8].

### 2.2.3. Reinforcement Learning

Reinforcement learning will be learning through communication with a situation by taking various activities and encountering numerous disappointments and victories while attempting to augment the gotten rewards. The agent isn't advised which move to make. Reinforcement learning is like regular learning forms where an instructor or a boss isn't accessible and learning process advances with experimentation, unique concerning administered learning, in which an agent should be determined what the right activity is for each position it experiences.

Reinforcement learning is not the same as different parts of machine learning both supervised learning and unsupervised learning. And it is considered as a third model of machine learning, at the edge of unsupervised learning and supervised learning [9].

Reinforcement learning is a field of machine learning strategies and issues dependent on the idea of learning from numerical rewards received by an agent through communicating with a domain. In some random advance, the agent watches a condition of the earth and gets a prize sign. Because of the present state and the agent's conduct work — the approach — the agent picks a move to make. The activity is then sent to the environment which is refreshed and the circle repeats. See Figure 2.1 for an outline of the agent-condition interface [10].

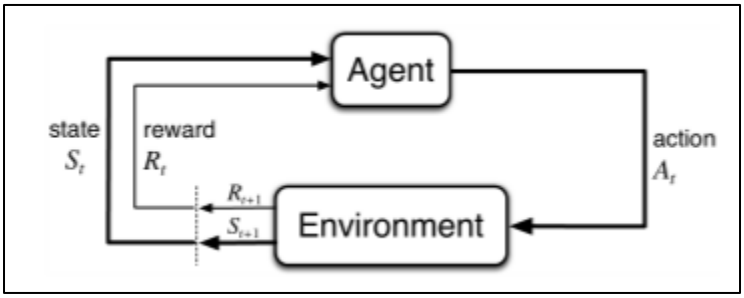


***Figure 2.1: Reinforcement Learning Illustration [10]***

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

In RL issues, a specialist picks an activity at each time step dependent on its present state and gets an evaluative criticism and the new state from the earth. The objective of the specialist is to get familiar with an ideal approach that boosts the collected prize it gets after some time. In this manner, operators in RL don't get immediate directions in regard to which move they should make, rather they should realize which activities are the best through experimentation cooperations with the earth. This versatile shut circle highlight renders RL unmistakable from customary administered learning strategies for relapse or arrangement, in which a rundown of right marks must be given, or from solo learning ways to deal with dimensionality decrease or thickness estimation, which target finding concealed structures in an assortment of model information. Besides, in correlation with other conventional control-based techniques, RL doesn't require an all-around spoke to a numerical model of the earth yet builds up a control

strategy legitimately for a fact to foresee states and prizes during a learning system. Since the plan of RL is letting a specialist controller collaborate with the framework, obscure and time-shifting elements just as changing execution necessities can be normally represented by the controller. Ultimately, RL is particularly fit to frameworks with natural time delays, in which choices are performed without prompt information on adequacy however assessed by a long-haul potential compensation [11].

### 2.2.3.1. Different techniques of Reinforcement Learning

In games, machine learning can be utilized for different purposes. It very well may be utilized to acquire the greatest scores, win the game at the base time conceivable, get most collectibles, or improve survivability. As we don't think a lot about the games, it is ideal to actualize the reinforcement learning technique as it can take in without anyone else from its surroundings. Reinforcement learning has its choice of systems, for example, Q learning, SARSA, DQN, and DDPG [12].

There are two kinds of algorithm model which are model-based and model-free. In the model-based algorithm, the model will learn the transition probability T. The agent will realize how to enter a particular and activity space develops; the model-based algorithm will turn out to be more impractical. The model-free algorithm refreshes its information by depending on the experimentation technique. In this way, the blend of states and actions shouldn't be put away in another space. Instances of the model-free algorithm are Q-learning and SARSA.

### 2.3.1.2. Q-learning

Q-learning is a type of model-free reinforcement learning. It works by steadily refreshing the normal estimations of activities in states. For each conceivable state, every conceivable activity is assigned out a worth which is a component of both the immediate reward for making that move and the normal award later dependent on the new express that is the consequence of making that move. This is communicated by the one-advance Q-update condition [13].

$Q(s, a) = Q(s, a) + \alpha [r + \gamma \max_{a'} Q(s', a') - Q(s, a)]$ (1)

Q – expected value of performing action

s – state vector

a – action vector

r – reward

α – learning rating which controls convergence

γ – discount factor

The discount factor makes rewards earned before more important than those got later. This technique learns the estimations of all things considered, as exposed to simply finding the ideal procedure. This information is costly in terms of the measure of data that must be put away, yet it brings benefits. Q-learning is investigation insensitive; any activity can be completed whenever, and data is picked up from this experience [13].

**Q-learning algorithm**

Q-learning is a reinforcement learning technique where the learner assembles steadily a Q-function which attempts to measure the limited potential rewards for taking activity from given states. The output yield of Q-function for the state s furthermore, activity is appeared in equation (1). Q-values are as a rule hidden away investigate the table. Officially a Q-learning can be described as follows:

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

## 3. RESEARCH GAP

After analyzing some existing mobile game applications related to dementia syndrome, there were some drawbacks and there was not any suitable application for Sri Lankan culture because all the mobile game applications, which are currently available in the play store and app store in English language. Most of the patients in Sri Lanka, as well as worldwide, belong to the old generation because they are not proficient with the English language. In this research, the proposed system will be implemented in Sinhala language.

Lumosity is one of those applications which includes several games for control and slow down the impairments of cognitive functions in dementia. But it is not suitable for Sri Lankan elderly people because of the language and game environment. And, the user has to pay an expense to gain the full accessed version.

Table 2.1. Comparison between existing applications and proposed application

| **Features** | **Lumosity** | **Brain Games** | **Elevate** | **Proposed System** |
|---|---|---|---|---|
| Based on the performance of user (learning from user) predict the next levels of game | ✗ | ✗ | ✗ | ✓ |
| Games in Sinhala language | ✗ | ✗ | ✗ | ✓ |
| View the daily report | ✓ | ✓ | ✓ | ✓ |
| View the performance of patient as a history | ✓ | ✗ | ✓ | ✓ |
| Patient's doctor also can connect with this system and view the patients progress | ✗ | ✗ | ✗ | ✓ |
| User can use the application without paying a payment | ✗ | ✗ | ✗ | ✓ |

## 4. RESEARCH PROBLEM

Dementia is one of the most significant problems facing with the increase in the ageing population. The estimated current prevalence of dementia is 47.5 million worldwide [1]. This number will nearly double in every 20 years globally [1]. Just as a similar issue has happened in Sri Lanka. Dementia is a disorder which can't be restored by drugs. That is the primary and significant issue accessible over the world. In any case there are medications that help to slowdown the development of the disorder. But a patient could be performed that medications during their treatment sessions only. Dementia has diverse cognitive functions, for example, attention, concentration, executive functions, language and memory. Among these cognitive functions executive functions incorporates problem solving, decision making, proper judgement, time management. As indicated by the requirements of the specialists, the use of brain training application could be superior to medication. There are some mobile game applications to control the dementia disorder of executive functions however they not reasonable for Sri Lankan old age and culture. And another main problem is all the applications have implemented in English language. Most dementia patients belong to the old generation and they are not proficient with the English language. As per the assets, building up this application is a genuine worldwide requirement for dementia patients.

# 5. OBJECTIVES

## 5.1.Main Objective

The principle and the most significant result of making Personalized Application for Dementia patients to help those patients by giving recovery in an intelligent manner utilizing various types of games or exercises that will be completed right now continual checking. Our proposed application has the capacity to overcome those issues. It has games and exercises to improve the mental functionalities for the Temporal lobe and Frontal projection from the Cerebral cortex. This exploration study is balanced in with achieving a versatile game to improve the executive functioning capacity abilities of dementia patients. A special feature of this game is predicting the next level of the game according to the performance of previous game which is played by the user. Because of that feature this application is called as personalized application.

## 5.2.Specific Objectives

- Implement a game to develop executive functionalities.
- Slow down the moving from one stage to another stage of Dementia.
- Giving rehabilitation with continuous monitoring.

# 6. METHODOLOGY

## 6.1.System Overview

The overall outcome of this research is to implement a versatile application for Dementia patients which incorporates various sorts of mobile games or exercises utilizing Reinforcement Learning and Speech to text components to rehabilitate those patients in a psychological manner. The main outcome of this research component is implementing a mobile game to help dementia patients to improve the effectiveness and speed process of executive functions.

The doctor will do the MMSE testing for the patients who meet the doctor (relevant Psychiatrist). As per the MMSE test result, patients will be ordered into certain stages. Just the patients under the mild and moderate stages will be chosen to utilize this application. Through the other analysis trial of the patient for Dementia, the specialist will be chosen the game for the patient and prescribed to rehearse the game.

- Register the patient to the system and create a profile for the patient. And this task done by a caregiver and he can enter the details of test reports to the patient's profile. It will be helped to the doctor because the doctor can gain a better understanding of the patient at any time.
- Implement a game to develop executive functionalities of the dementia patient. The game is defined as a pattern recognition game because the patient has to identify a pattern of characters. That pattern may include letters or numbers. While the patient plays the game, the system identifies the behaviour of the player (patient).
- Calculate and generate the scores and ratings for the level of the game and display it to the patient. That would be a very strong motivation for the patient for stepping into the next level of the game.
- To predict the next level, we need to give the input values to the reinforcement learning algorithm. The conditioning facts of this game will be shown below.
    1. Time duration (to finish the game level)
    2. Number of attempts

Before sending input variables into the reinforcement learning algorithm, we need to calculate and get the values for the input variables.

- Apply the algorithm and predict the next level.
- Store all the records of each game level in the database. The records are scores and ratings of each level, time duration to finish the level and number of attempts. That records can be viewed in the patient's profile and the doctor and caregiver have the authority to view the patient's records.

## 6.2.System Architecture

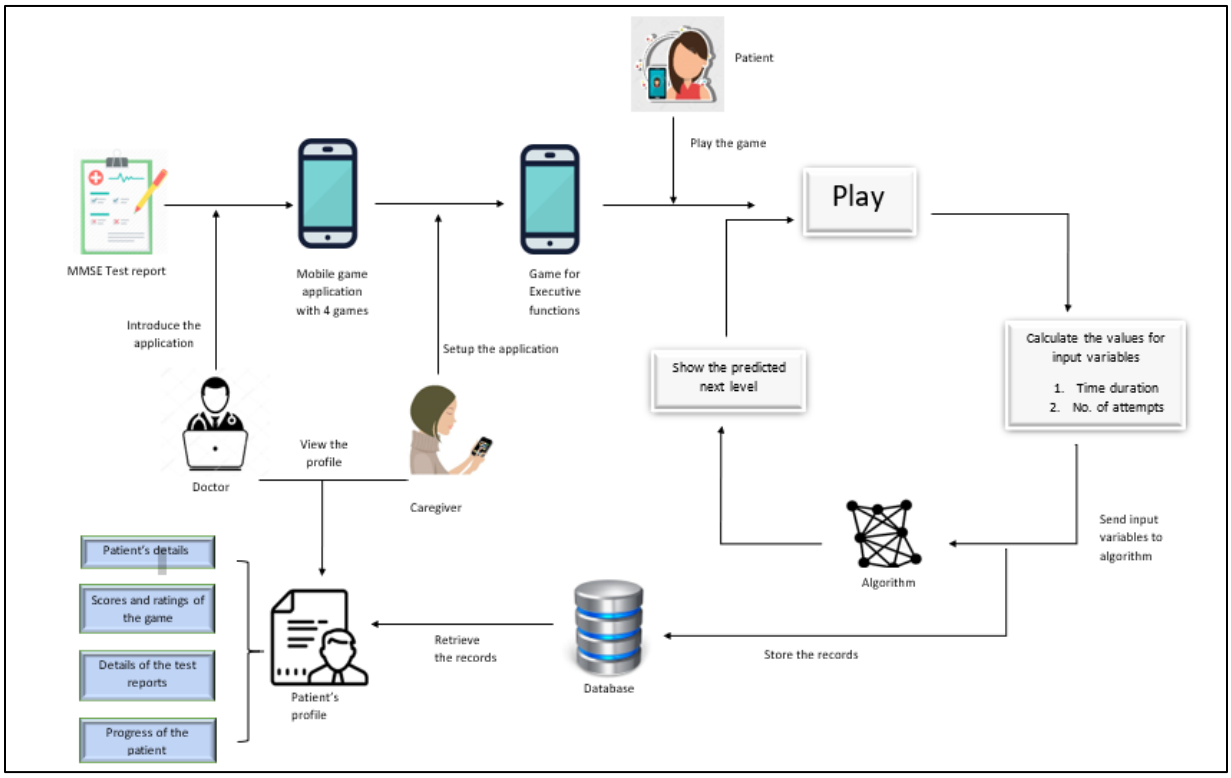


***Figure 5.1: System Architecture***

### 6.3. Software Development Life Cycle

SDLC is a procedure followed for a product venture, inside a product association. It comprises of a point by point plan describing how to create, keep up, remove and change or upgrade explicit programming. The existence cycle characterizes a procedure for improving the nature of programming and the general improvement process.

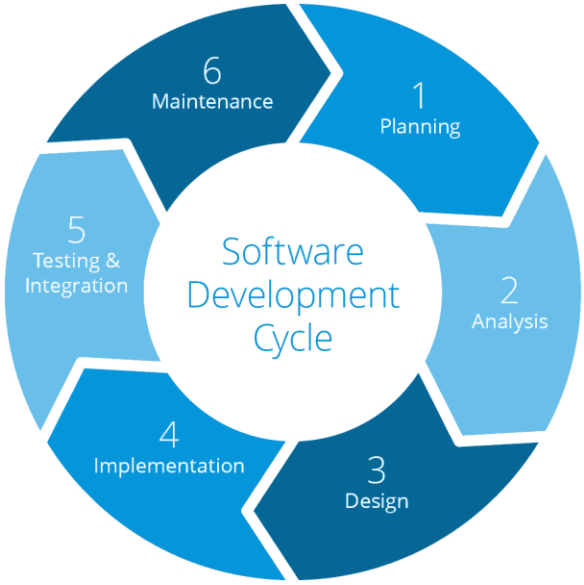


***Figure 5.2: Phases of Software Development Life Cycle***
***Source: (https://www.mendix.com/blog/pursuing-a-full-agile-software-lifecycle/)***

### 6.3.1. Agile Scrum Model

Scrum is a subset of Agile. It is a lightweight procedure structure for agile development and the most broadly utilized one. Scrum is a system that assists groups with cooperating. Scrum encourages groups to learn through encounters, self-sort out while taking a shot at an issue and think about their successes and misfortunes to continuously improve. When considering about this research project, there are lots of changes to be done in the future while implementing the system. It is suitable when comparing to processes like Waterfall model etc. Scrum process is mostly focused on task management within a time-based environment. This process is supported for team performance and solved the problems individually since this project is going to be done among four members. Having daily scrum meetings will help to understand the updates of all members of their research area.

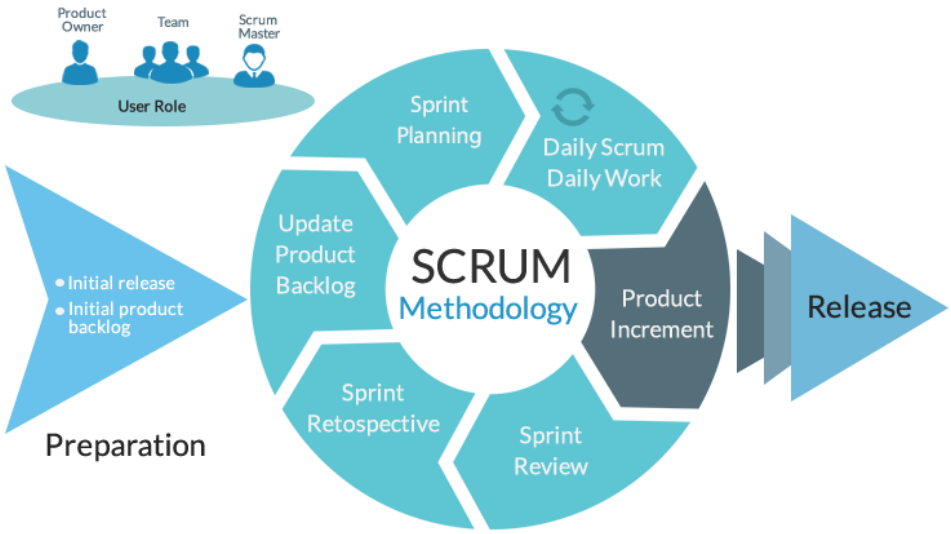


***Figure 5.3: Scrum model***

***Source: (https://theinscribermag.com/tech-difference-between-agile-methodology-and-scrum-methodology/)***

## 6.4.Work Breakdown Structure

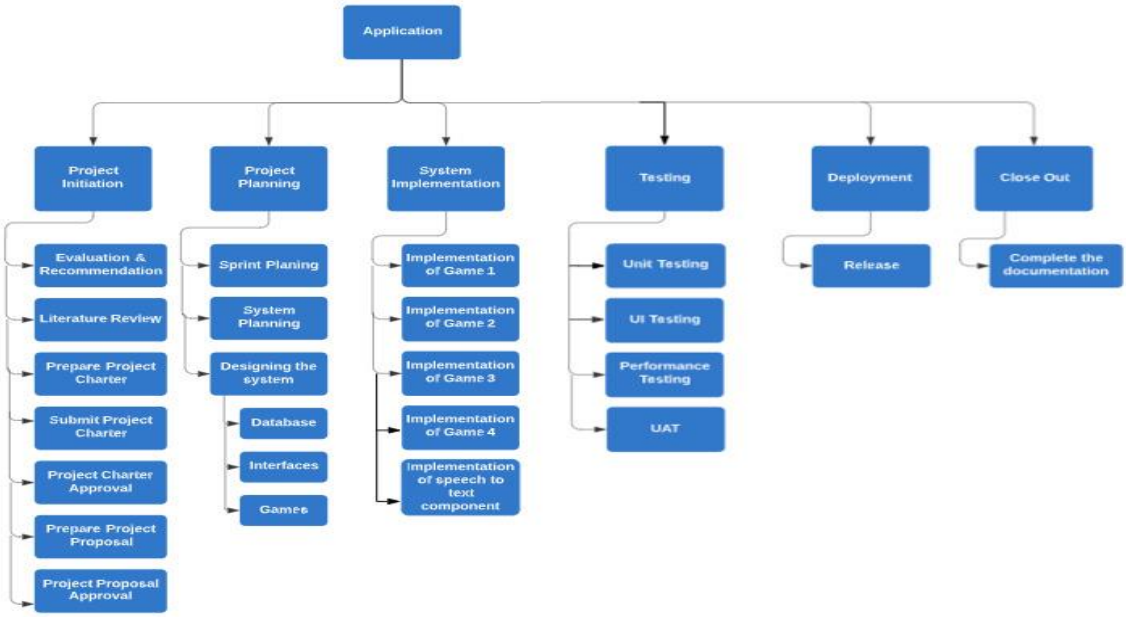


*Figure 5.3: Work Breakdown Structure*

## 6.5.Gantt Chart

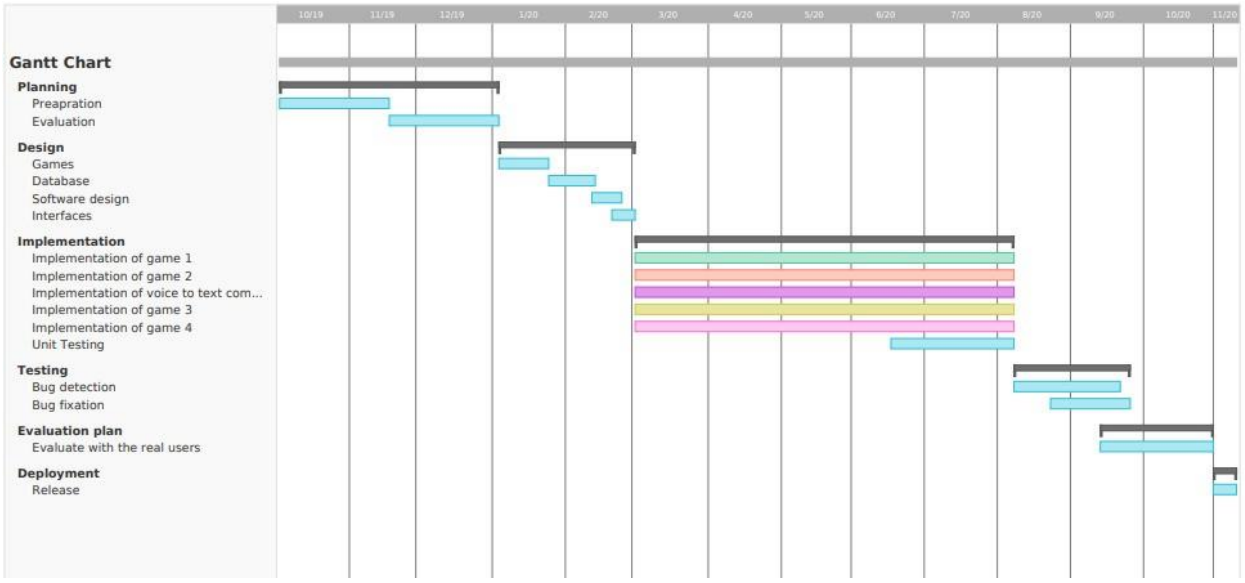


*Figure 5.4: Work Breakdown Structure*

# 7. PROJECT REQUIREMENTS

Real world requirement is given by consultant psychiatrists Dr. Chathurie Suraweera at National Hospital of Colombo.

## 7.1.Functional Requirements

- The proposed system should be supported both English and Sinhala languages with the Dementia patient.
- The proposed system should be able to maintain history of games or activities under Executive functions component.
- The proposed system should be allowed doctor to view progress report of the Dementia patient and the report should be included the progress of Executive functioning skills separately.

## 7.2.Non-Functional Requirements

- Games and activities should be user-friendly.
- Performance of the relevant games and activities should be good.
- History of the level of the game such as scores history data to the relevant Language component should be available to the Dementia patient and for the doctor at any given time.

## 8. BUDGET AND BUDGET JUSTIFICATION

| Item | Cost (Rs) |
|---|---|
| Travelling | 10 000.00 |
| Internet | 7 500.00 |
| Hospital Charges | 15 000.00 |
| Web Hosting | 40 000.00 |
| **Total** | **72 500.00** |

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