Rehabilitation Approach for Dyslexia

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In the name of Allah, the Most Beneficent, the Most Merciful

ABSTRACT

Rehabilitation Approach for Dyslexia

Technology has a very deep social impact on our lives in today's world, with the increase in technology humans are more prone to comfort compared to what they were some years ago. Virtual Reality being one of the emerging technologies of present era is proving to be a lot useful in number of fields. Idea proposed is of a Virtual Reality application for Dyslexic patients and trainers.

Dyslexia is a chronic disorder that affects the life of subjects and often influences their life choices, patients have difficulty in reading, writing and in comprehending simple things accurately. Standard rehabilitation and diagnosis methods all use a classic paper and pencil training format but these exercises are boring and demanding for children who may have difficulty in completing the treatments. Digitizing these methods would help patients and trainers in a funny and engaging way. Research has proven that when patients use multiple senses their percentage of improvement increases quite remarkably.

An android VR application has been developed for patients and trainers targeting developmental and directional dyslexia for remedial therapies, 3 standard procedures being followed normally have been developed in a virtual environment, subject will have to wear a headset which will enhance focusing ability and will enable patients to interact with the application virtually for different reading and sight exercises. Results will be displayed at the end to analyze subject's performance. The results of the evaluation revealed that application has potential benefits to foster the learning process and help children with dyslexia by improving their foundational reading and judgment skills.

CERTIFICATE FOR CORRECTNESS AND APPROVAL

It is certified that work contained in the thesis –Rehabilitation Approach for Dyslexia carried out by Aiman Almas, Muhammad Wajahat Iqbal, and Sehrish Sajid under supervision of Lec. Ayesha Naseer for partial fulfilment of Degree of Bachelor of Software Engineering is correct and approved.

Approved By

Lec. Ayesha Naseer

Department of CSE, MCS

Dated:

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DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

To our parents, without whose support and cooperation, a work of this magnitude would not have been possible. To our supervisor, Lec. Ayesha Naseer who has given us great support and valuable suggestions throughout the implementation process.

ACKNOWLEDGEMENTS

There is no success without the will of ALLAH Almighty. We are grateful to ALLAH, who has given us guidance, strength and enabled us to accomplish this task. Whatever we have achieved, we owe it to Him, in totality. We are also grateful to our parents and family and well-wishers for their admirable support and their critical reviews. We would like to thank our supervisor. Lec. Ayesha Naseer, for her continuous guidance and motivation throughout the course of our project. Without their help, we would have not been able to accomplish anything.

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Chapter 1. Introduction

1.1. Overview

Dyslexia disorder is an irreversible, progressive brain disease that hinders the ability of a person to read efficiently who appear to be intelligent otherwise. Ultimately, the person with dyslexia suffers lack of self-confidence and years of depression by blaming himself for a disease which has neurobiological basis and he has no control over it. The purpose of this project is helping kids maintain mental function using various training exercises, manage behavioral symptoms, and assist them in living an independent life like normal people with the addition of virtual reality playing important role of increasing the interest and focus of patients.

1.2. Problem Statement

Patients suffering from dyslexia get bored from basic pencil and paper rehabilitation exercises. It's difficult for them to focus on one thing for more than few minutes. Lack of interest results in a very bad overall impact on their rehab process .Digital methods available are also not proving to be that successful for them.

1.3. Approach

An android VR application will be implemented for dyslexic patients and trainers on Unity engine for remedial therapies, 2 or 3 standard procedures being followed worldwide will be developed in VR, subject will have to wear a headset which will enhance focusing ability and will interact with the application virtually for different reading and sight exercises.

1.4. Scope

RAD is intended to help Dyslexic kids in their daily routine, so that they can with the help of simple training techniques read a bit efficiently and live more independent life just by using a cellphone and a virtual reality headset. Through this application they shall constantly receive first hand training by using the three exercises available in the application and reviewing their results at the spot.

1.5. Objectives

The main objective of this system is efficient rehabilitation of reading disabilities in dyslexic patients, by using certain therapy exercises in VR.

During the course of this project, all the aspects of software engineering are covered i.e. survey and feasibility analysis, requirement gathering, architectural and detailed design, implementation and testing along with documentation (SRS, SDS, Test Document, Final Report and User manual). Students are also expected to develop extensive knowledge and technical skills in the following fields:

1. Interacting with 3D objects.
2. Programming in a 3D environment.
3. Social behavior analysis.
4. SDK and other open source software understanding.

1.6. Deliverables

Sr.	Tasks	Deliverables
1	Literature Review	Literature Survey
2	Requirements Specification	Software Requirements Specification document (SRS)
3	Detailed Design	Software Design Specification document (SDS)
4	Implementation	Project demonstration
5	Testing	Evaluation plan and test document
6	Training	Deployment plan

7	Deployment	Complete application with necessary documentation

Table 1-1 Deliverables

1.7. Overview of the Document

This document shows the complete working process of our application RAD. It starts off with the literature review which shows past work done in similar field, requirement analysis of the system, system architecture which highlights the modules of the software and represents the system in the form of component diagram, Use Case Diagram, Sequence Diagram and general design of the system. Then it will move on to discuss the detailed Description of all the components involved. Further the dependencies of the system and its relationship with other products and the capacity of it to be reused will be discussed. At the end test cases and any future work proposal has been presented.

1.8. Document Conventions

Heading are prioritized in a numbered fashion, the highest priority heading having a single digit and subsequent headings having more numbers, according to their level. Font used is Times New Roman. All the main headings are of size 18 and bold. All the second level sub-headings are of size 16 and bold. All the further sub-headings are of size 14 and bold. All references in this document are provided where necessary, however where not present, the meaning is self-explanatory. All ambiguous terms have been clarified in the glossary at the end of this document.

1.9. Intended Audience

This document is intended for:

1. **Developers:** (Project Group)

   In order to be sure that they are developing the right project that fulfills the requirements provided in this document.

2. **Testers:** (Project Group, Supervisor)

   In order to have an exact list of the features and functions that must respond according to requirements.

3. **Users:**

In order to get familiar with the idea of the project and how to use/respond in failure situations and suggest other features that would make it even more functional.

4. **Documentation writers:** (Project Group)

   To know what features and in what way they have to explain. What technologies are required, how the system will respond in each user's action, what possible system failures may happen and what are the solutions to all those failures etc.

5. **Project Supervisor:** (Lec. Ayesha Naseer)

   This document will be used by the project supervisor to check whether all the requirements have been understood and in the end whether the requirements have been implemented properly and completely.

6. **Project Evaluators:** (CSE Dept. MCS)

   In order to know the scope of the project and evaluate the project throughout the development for grading.

Chapter 2. Literature Review

Detailed description of projects previously carried out in this context will be discussed in this section.

With the advancement in Virtual technology many useful projects have been developed in VR. Undergraduate Students of SEECS, NUST developed a project named SMART SIM, whose purpose was to teach medical students how to do surgery virtually without the need for an instructor to be present physically.

MCS, NUST students of batch 2017 developed a table tennis game in virtual reality with the sole purpose of developing a game without the need for playing it using primitive Nintendo controllers. While many projects have been developed in VR in Pakistan, very few have been done for medical purpose.

Since Virtual Reality (VR) technologies first surfaced in the 1960s, their unique characteristics differentiated them from other information technologies, making them powerful educational tools. Blending a technological and conceptual approach, Mikropoulos and Strouboulis propose the following definition: “Virtual Reality is a combination of high-end computing, human computer interfaces, graphics, sensor technology and networking which allows the user to become immersed in, interact and experience in real time a three-dimensional (3D) artificial environment representing realistic or other situations”

Dyslexia affects the ability to obtain accurate and fluent reading skills in children without neurological impairment who have a normal IQ score. Among Italian young people, the reported prevalence of dyslexia is between 2.5% and 3.5% .

Subjects with dyslexia may show specific patterns of atypical brain activation during reading or phonological tasks. For example, one patient presents hypo activation of the left temporoparietal cortex, the left prefrontal cortex, and the left fusiform gyrus. Structural MRI studies show several abnormalities such as a decrease in grey matter volume, reduced cerebral white matter gyrification, or a bigger corpus callosum.

In the last fifteen years there have been some remarkable technological and scientific advances in this area, making VR from a sophisticated toy and powerful educational mean, to a valuable assessment and intervention tool. Features such as 3D dynamic yet controllable environments, stimuli control, and behavioral documentation and quantification are important assets of VR technology and its clinical applications (assessment, intervention, and training) . There are now numerous studies that support the

use of VR applications in cognitive, psychological, and physical (motor and functional) disorders. The wide repertoire of such clinical applications ranges from specialized simulations for pain management to virtual environments for populations with cognitive impairments , special needs (e.g. autism) as well as learning difficulties . In the case of dyslexia, there are only a handful of studies that present virtual reality applications for the child and adult dyslexic population.

Many dyslexic adults may have difficulty in finding an adequate job. As de Beer et al. showed in their review, the structured corporate environment is stressful and not supportive of dyslexic employees. In this kind of work environment, the positive characteristics of dyslexic people (creativity, solving problems, and persistence) may be overshadowed by the negative ones (problems in reading or writing, slowness, and negative feelings about dyslexia). It often happens that dyslexic people become entrepreneurs in order to open a new business and work for themselves.

According to Torgesen , rehabilitation training must focus on phonological awareness and decoding tasks; the program has to be intensive (almost an hour per day for 2 months) and must involve few students. Dyslexic and poor reader children may show phonological difficulties as early as kindergarten. Through an individual screening, based on the knowledge of letter names and sounds, phonological awareness, and speed of naming, it is possible to predict the future reading ability. Thus, it is important that an intensive phonological rehabilitation program be proposed for the high-risk students. This kind of exercise is challenging and could be helpful for many children but not for all.

Adams and colleagues proposed a Virtual Classroom as a tool to increase motivation in children with attentional deficit , while some authors proposed VR as a test to identify the visuospatial strengths in dyslexia . In the present study, we propose a Virtual Reality training for attention in order to improve the reading skills in a sample of dyslexic children.

Chapter 3. Software Req. Specification (SRS)

3.1. Introduction

The introduction of the Software Requirements Specification (SRS) provides an overview of the entire SRS with purpose, scope, definitions, acronyms, abbreviations and references. The aim of this document is to present detailed description of the RAD (Rehab application for dyslexia) by defining the problem statement in detail. The detailed requirements of the RAD are provided in this document.

3.1.1. Purpose

This document includes software requirements for RAD. This project is basically for Dyslexic patients and their caregivers. Dyslexia disorder like ADHD is an irreversible, progressive brain disease that hinders the ability of a person to read efficiently who appear to be intelligent otherwise. Ultimately, the person with dyslexia suffers lack of self-confidence and years of depression by blaming himself for a disease which has neurobiological basis and he has no control over it. The purpose of this project is helping people maintain mental function using various training exercises, manage behavioral symptoms, and assist them in living an independent life like normal people with the addition of virtual reality playing important role of increasing the interest and focus of patients.

3.1.2. Project Vision

RAD is an application designed to help Dyslexia patients in their daily routines, so that they can with the help of simple training techniques read a bit efficiently and live more independent life. Through this application they shall constantly receive first hand training while being at home.

For	People suffering from dyslexia’s disease and their caregivers. It is also beneficial for their kin.
What	A mobile application to help patient(s) train using different rehab techniques and for patients to help them train by themselves virtually.

The	RAD(Rehabilitation Approach for Dyslexia)
Is	An android VR application
That	Provides training to dyslexia patients for their daily reading/problem solving tasks.

Table 3-1 Project Vision

3.2. Overall Description

3.2.1. Product Perspective

RAD (Rehabilitation Approach for Dyslexia) will basically help people suffering from Dyslexia disorder so that they can live more independent lives. It will prove to be a constant companion of the patients and help them overcome the problems while reading, writing and problem solving.

3.2.2. Product Features:

RAD is a virtual reality mobile application for patients with different exercises for their dyslexic disability to increase their attention span and productivity. Main features of the application are listed below.

1. A main menu-for navigation
2. A mathematical exercise with simple arithmetic questions to help patients with right-left direction confusion.
3. Jumbled up letters game to help patients memorize spellings by interacting with them virtually which they find difficult and boring to learn otherwise.
4. A words dictionary kind of game with difficult words that dyslexic patients normally find hard to grasp and their meanings to help them memorize with repetitive exercises.
5. Constant reminders to take tests after a certain period of time.

3.2.3. User Classes and Characteristics

Following are user classes and their brief description.

Dyslexia Patient

The patient will have to download the android VR application on the phone and use it by wearing a virtual reality headset.

Tester (occasional user)

The testers of the system can check user requirements from this SRS and develop test scenarios accordingly.

Developers

The developers will use this at the developing time and at the time of any defect occurred in the product during maintenance.

Documentation Writers

The document can serve as a future reference for other versions of the SRS.

3.2.4. Operating environment

The product shall be operating in an android environment. It shall be compatible with version 4.3 (Jelly Bean) and all the higher versions of android.

Hardware

RAD operates, either directly or indirectly, with the following external hardware:

1. **Headset:** Dyslexia patient will wear a headset with a phone mounted inside it.

2. **Mobile phone:** Patient will have mobile phone and VR application installed on it.

Software

1. Android Studio.
2. Unity 3D
3. Blender

3.2.5. Design and Implementation Constraints

Android application will keep on working on the phone as long as it is installed from the app store and phone has Google SDK available.

1. Limited memory of the cell-phone device

2. Android devices vary in capabilities / technology supported, and thus we cannot guarantee universal access to our application across all Android platforms.

3. It is not able to entertain multiple users at a time.

3.2.6. User Documentation

A user manual will be provided to the users in which separate instructions will be given according to the particular user i.e., patients, guardians, developers and testers. It will include the details of the software working. Help documents will also be a part of the system. The project report will also be available for the users which will highlight the software's features, working and procedures.

3.2.7. Assumptions and Dependencies

1. User owns a compatible virtual reality headset device and compatible android version on phone.
2. User should know how to use android applications and run VR applications on the phone.
3. The customer knows the language (English) used in the user interface to perform actions.

3.3. External Interfaces Requirements

3.3.1. User Interfaces

1. User interface will be displayed on the display phone mounted inside headset.
2. Main menu for navigation will be used.
3. Interface will be user friendly and the standard English-US will be used

3.3.2. Hardware Interfaces

1. Android phone must be compatible with the HMD (Head Mounted Display).

2. Controllers of headset will be used for selection and clicking.

3.3.3. Software Interfaces

1. Mobile application will run on android version 4.3 and above.

2. Android support library will be needed for swiping and tab views.

Data Input

1. Answer selection from the given choices by the user in respective tests.

3.3.4. Communications Interfaces

RAD will not require communication interface as it is a standalone application.

3.4. System Features

This section describes in detail the system features of the RAD.

3.4.1. Accessing the Main Menu

Description and priority

After starting the application the therapy exercises will be displayed as main menu.

Its priority will be high as without this feature the application will not be navigable and the user will not be able to perform any action.

Stimulus/Response Sequence

1. Open the application.

2. Access the main menu.

Functional requirements

REQ-1: Application shall be properly installed on the mobile phone.

REQ-2: The different options available shall be

1. Therapy sessions
2. Help menu
3. Exit

REQ-3: At any time user shall be able to exit the application when required.

3.4.2 Therapy sessions

Description and priority

This holds a very high priority since it is a core feature of this product.

Stimulus/Response Sequence

1. The user selects Therapy Sessions option from main menu.
2. User selects one of the tests available from the list, virtually, using controllers.
3. User performs the therapy tests by proceeding next.
4. System then takes user to view result screen after the completion of session.

Functional requirements

REQ-4: List of the therapy tests shall be displayed for user to select.

REQ-5: User shall select the category by using HMD controller mechanism.

REQ-6: Set of instructions shall be provided on how to perform the test after selecting a particular test.

REQ-7: User shall be able to replay a particular test or therapy game.

REQ-8: Result of the test shall be displayed after the end of each session.

REQ-9: User shall be able to exit the session and move to main menu when required.

3.4.3 Help Menu

Description and Priority

Help menu holds a medium priority. It will contain all the instructions needed to use the application.

Stimulus/Response Sequences

1. The user selects Help Menu from Main Menu
2. An instruction manual is displayed to guide the user.

Functional Requirements

REQ-11: Choosing Help Menu option shall show Instruction Manual.

3.5. Other Nonfunctional Requirements

3.5.1. Safety Requirements

The use of the software product has no harms whatsoever; nor does it have any possibility of loss or damage that might be inflicted however during the use of the application, users experiencing eye strain should take a break from using the device to avoid further strain and/or possible damage.

3.5.2. Security Requirements

Application running on the mobile shall not need any additional or personal information. There are no connections to other devices or severs so no data will be sent or received or used in any way.

3.5.3. Performance Requirement

The RAD's response should be fast and rapid, so that customer shall not wait for a long time before proceeding to next step or test. Incase application crashes it shall recover in no time after restarting the application.

3.5.4. Software Quality Attributes

Usability

The graphical user interface of app is to be designed with usability as the first priority. The app will be presented and organized in a manner that is both visually appealing and easy for the user to navigate keeping in view the condition of Dyslexic patient as well.

Reliability

Application shall provide reliability to the user. The product will run stably with all the features mentioned above available and executing perfectly. It shall be tested and debugged completely. All exceptions shall be well handled.

Portability

In API, portability can be defined as "compatibility of application with platform (Android's version) upgraded or downgraded versions. In Android platform when an up gradation is done the application will require some changes for compatibility with the new version. As android's OS is backward compatible so no changes will be required in down gradation. The minimum requirement of operating system is Android 4.3.

Flexibility

The design and architecture of the application will be flexible enough for catering any new requirements, if any at some later stage or for the application enhancement.

Scalability

The application is expected to handle one user at a time. One instance of the application could be opened on a phone at a time.

Availability

The application will be available 24/7, provided mobile is in working state and the application is installed and configured properly.

Chapter 4. Design and Development

4.1. Introduction

Dyslexia disorder like ADHD is an irreversible, progressive brain disease that hinders the ability of a person to read efficiently who appear to be intelligent otherwise. Ultimately, the person with dyslexia suffers lack of self-confidence and years of depression by blaming himself for a disease which has neurobiological basis and he has no control over it. The purpose of this project is helping kids maintain mental function using various training exercises, manage behavioral symptoms, and assist them in living an independent life like normal people with the addition of virtual reality playing important role of increasing the interest and focus of patients.

4.2. Purpose

This software design specification (SDS) section describes the architecture and system design of RAD. It mostly contains different design diagrams and their explanation. This is intended to inform stakeholders of the details of the design and the design process. This section will help the developer(s) in implementation and maintenance of the Application (app).

4.3. Project Scope

RAD will help Dyslexic kids in their daily routines, so that they can with the help of simple training techniques read a bit efficiently and live more independent life just by using a cellphone and a virtual reality headset. Through this application they shall constantly receive first hand training by using the three exercises available in the application and reviewing their results at the spot

4.4. System Architecture Description

This section provides detailed system architecture of RAD, overview of system modules, their structure and relationships are described in this section. User interfaces and related issues are also discussed.

4.4.1. Structure and Relationships

This section covers the overall technical description of RAD. It shows the working of application in perspective of different point-of-views and also shows relationship between different components.

System Block Diagram

The diagram(s) show the higher level description of the application(s), generic working of the application(s) and interaction with the user.

User interacts with the virtual environment using I/O devices. VR engine reads user input and recalculates state of VR world before displaying it to user.

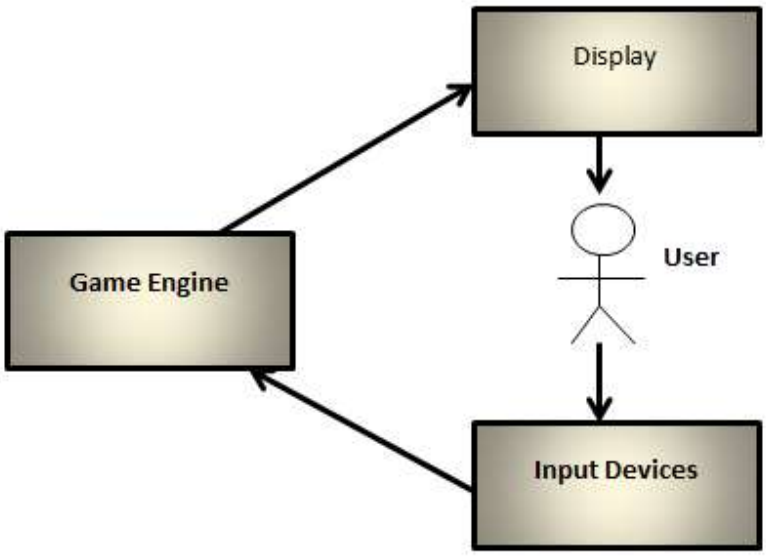

Figure 4-1 System Block Diagram

Component Diagram

The main components are

1. User Input
2. GUI
3. Unity Engine

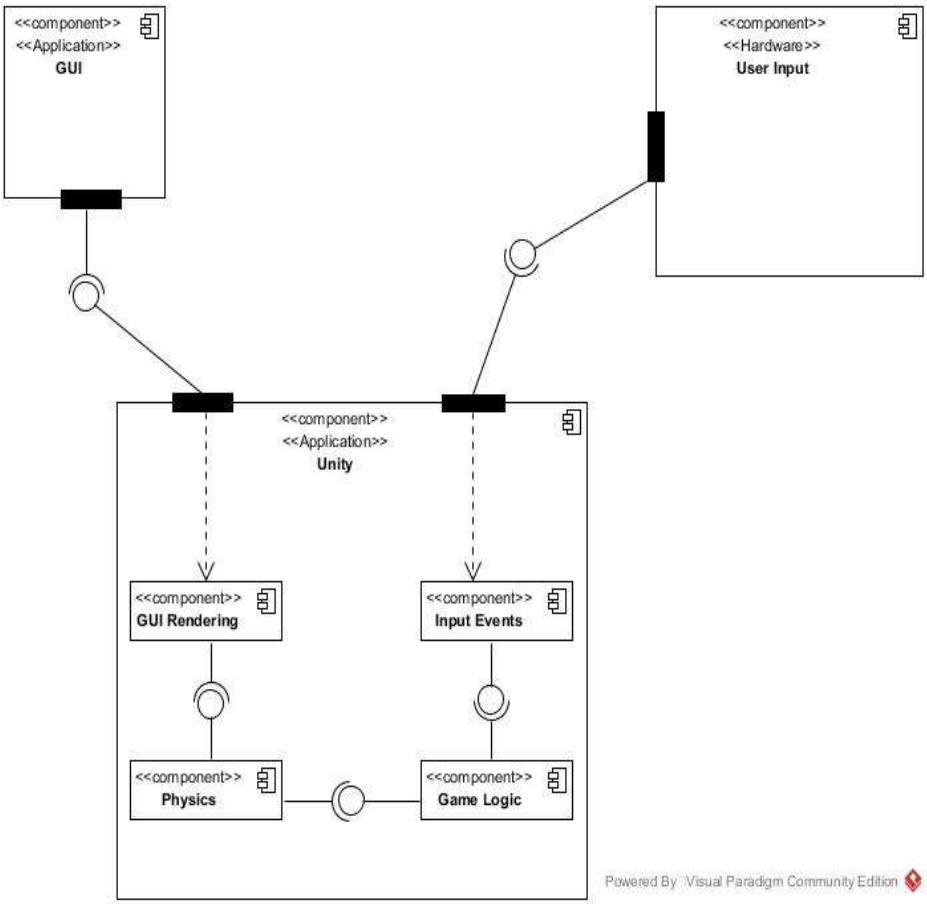

Figure 4-2 Component Diagram

User View (Use case diagram)

Figure 4-3 shows course of events that take place when an actor (user and other allowed interactions) interact with the system.It shows the main functionaltiy of the application availaible for a normal user and how it interacts with those.

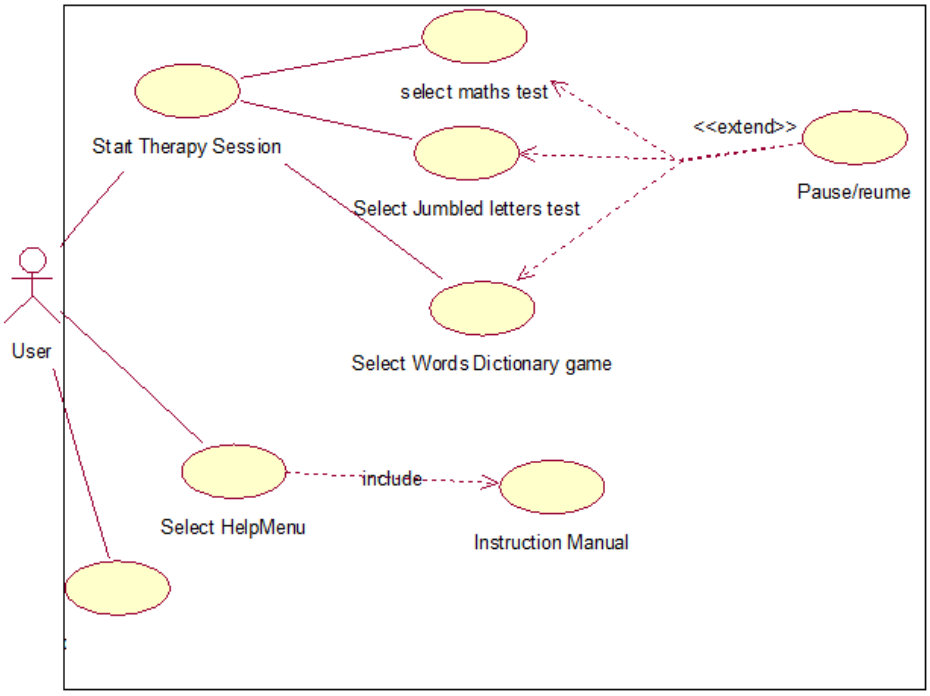

Figure 4-3 System Use Case Diagram

Actors:

Primary Actors:

1. User(Patient)

Secondary Actors:

None

Use Cases:

1. Start therapy session
2. Select help menu
3. Close application
4. Select math test
5. Select jumbled letter test
6. Select words dictionary game

Use Case Description:

Use cases shown in the figure above are described below.

Use Case 1

Use Case	Start therapy session
Actors	User
Use Case Description	This use case will help the user to take different tests according to their own choice.
Normal Flow	Therapy sessions will contain 3 different therapies, which user can choose according to their own choice: (i) Simple arithmetic (ii) Jumbled letters (iii) Word dictionary
Alternative Flow	Application may not be working properly. User has to reinstall the application or check the other requirements necessary to take the therapy session.
Pre-condition	The VR app is installed and working properly on the phone mounted inside the headset
Post Condition	The three different therapy sessions should be displayed from which user is able to choose one to continue the session
Includes	3 therapy sessions (i) Simple Arithmetic (ii) Jumbled letters (iii) Words dictionary

Extends	N/A
Assumptions	Phone is properly mounted inside the headset

Table 4-1 UseCase1

Use Case 2

Use Case	Select Help menu
Actors	User
UseCase Description	This use case will help the user to learn about the therapies by reading the given instructions accordingly
Normal Flow	Select the instruction manual after selecting the help menu to read out all the instructions
Alternative Flow	N/A
Pre-condition	The VR app is installed and working properly on the phone mounted inside the headset.
Post Condition	Instruction Manual is displayed
Includes	Instruction Manual
Extends	N/A
Assumptions	Phone is properly mounted inside the headset

Table 4-2 UseCase2

Use Case 3

Use Case	Close application
Actors	User
UseCase Description	The use case will close the application.
Normal Flow	After opening the application, user decides to close it and use the app later
Alternative Flow	While doing therapy session or reading the instruction manual user decides to close the application. (i) First user has to select "exit" option from pause menu which will directly close the application (ii) User can return back to main menu and then close the application.
Pre-condition	The VR app is installed and working properly on the phone mounted inside the headset.
Post Condition	Application ends properly without any error or corrupting the application
Includes	N/A
Extends	N/A
Assumptions	Phone is properly mounted inside the headset

Table 4-3 UseCase3

Use Case 4

Use Case	Select math test
Actors	User
UseCase Description	A mathematical exercise with simple arithmetic questions will help user to learn right-left directions.
Normal Flow	After selecting therapy session user will select one of the 3 therapies given i.e. "Simple arithmetic". After completing the whole session, result will be generated accordingly
Alternative Flow	User many want to pause the game and resume it later or exit the game.
Pre-condition	Application is working properly and all 3 types of therapies are displayed
Post Condition	After session the system will show the end results.
Includes	N/A
Extends	Pause
Assumptions	Phone is properly mounted inside the headset

Table 4-4 UseCase4

Use Case 5

Use Case	Select jumble letter text

Actors	User
UseCase Description	User will interact with jumbled up letters game to help memorizing spellings virtually which they find difficult and boring to learn otherwise.
Normal Flow	After selecting therapy session user will select one of the 3 therapies given i.e. "Jumbled Up letters". After completing the whole session, result will be generated accordingly
Alternative Flow	User many want to pause the game and resume it later or exit the game.
Pre-condition	Application is working properly and all 3 types of therapies are displayed
Post Condition	After session the system will show the end results.
Includes	N/A
Extends	Pause
Assumptions	Phone is properly mounted inside the headset

Table 4-5 UseCase5

Use Case 6

Use Case	Select words dictionary game
Actors	User
UseCase	A words dictionary kind of game with difficult words which user normally find hard to grasp and their meanings to help them

Description	memorize with repetitive exercises.
Normal Flow	After selecting therapy session user will select one of the 3 therapies given i.e. "Words dictionary". After completing the whole session, result will be generated accordingly
Alternative Flow	User many want to pause the game and resume it later or exit the game.
Pre-condition	Application is working properly and all 3 types of therapies are displayed
Post Condition	After the session system will show the end results.
Includes	N/A
Extends	Pause
Assumptions	Phone is properly mounted inside the headset.

Table 4-6 UseCase6

Sequence Diagrams

Following sequence diagrams show the sequence of activities performed in application.

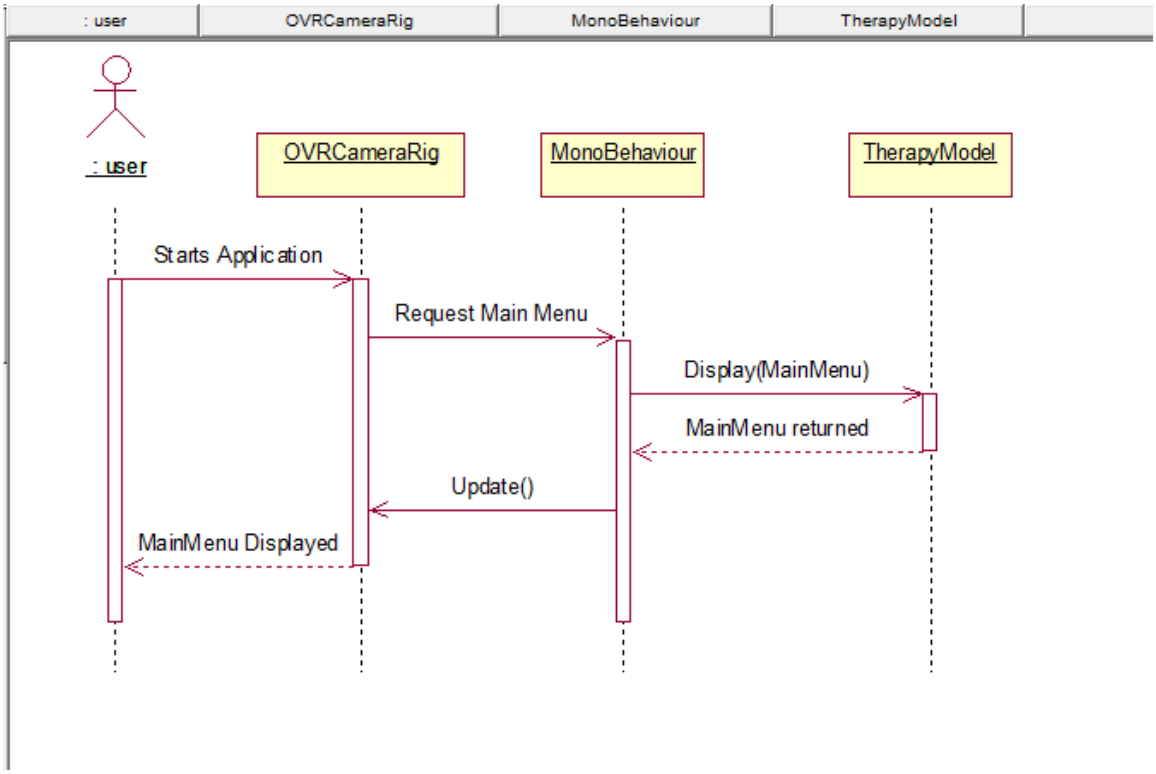

Figure 4-4 Sequence Diagram (Main Menu)

Figure 4-4 shows the sequence of steps that follows when a user interacts starts the application and how main menu is displayed after following a sequence of controls shifting from view to mode and then controller and the back to view.

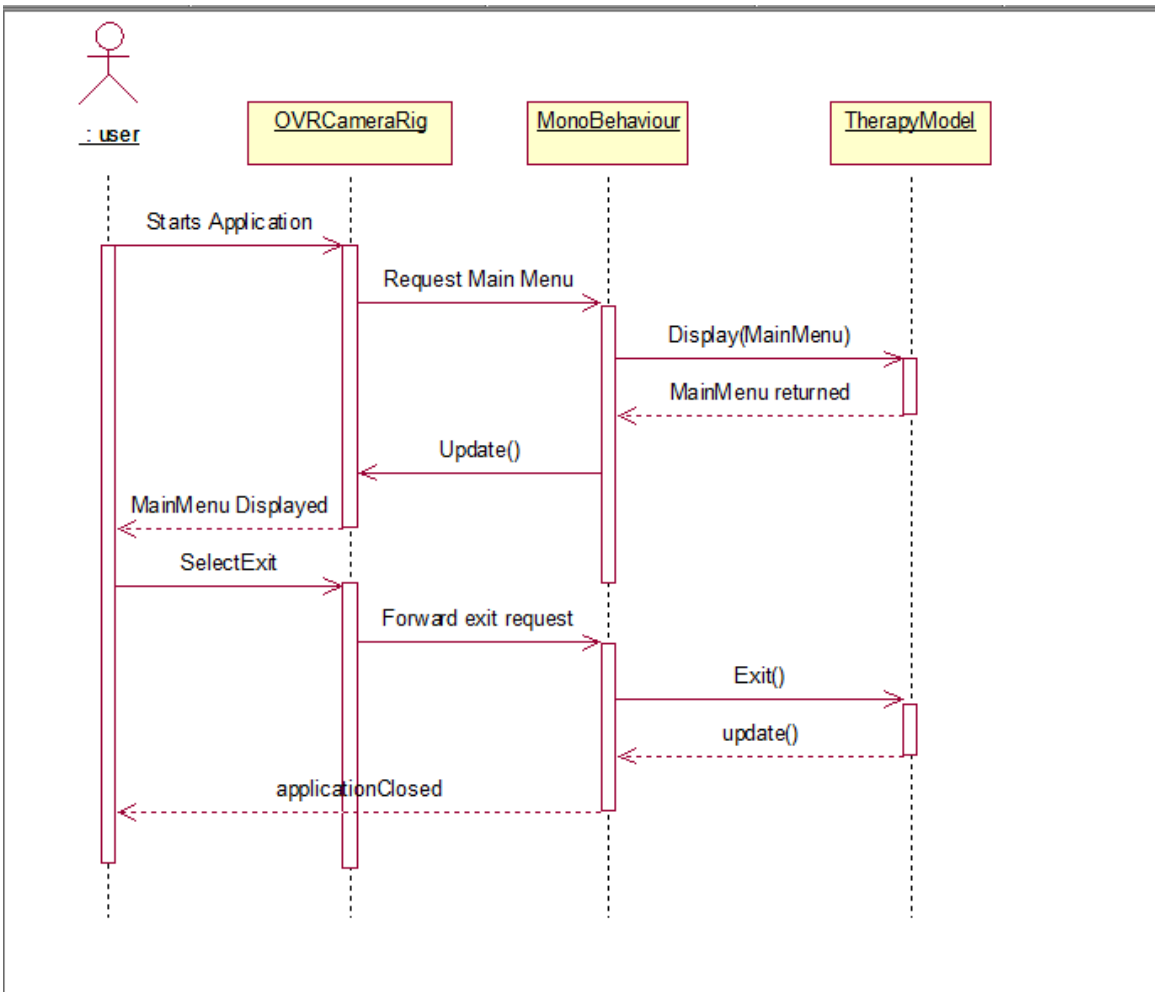

Figure 4-5 Sequence Diagram(Exit)

Figure 4-5 shows the sequence of steps required to exit an application by the user. User shall be in main menu and have to select exit option from there in order to close the application.

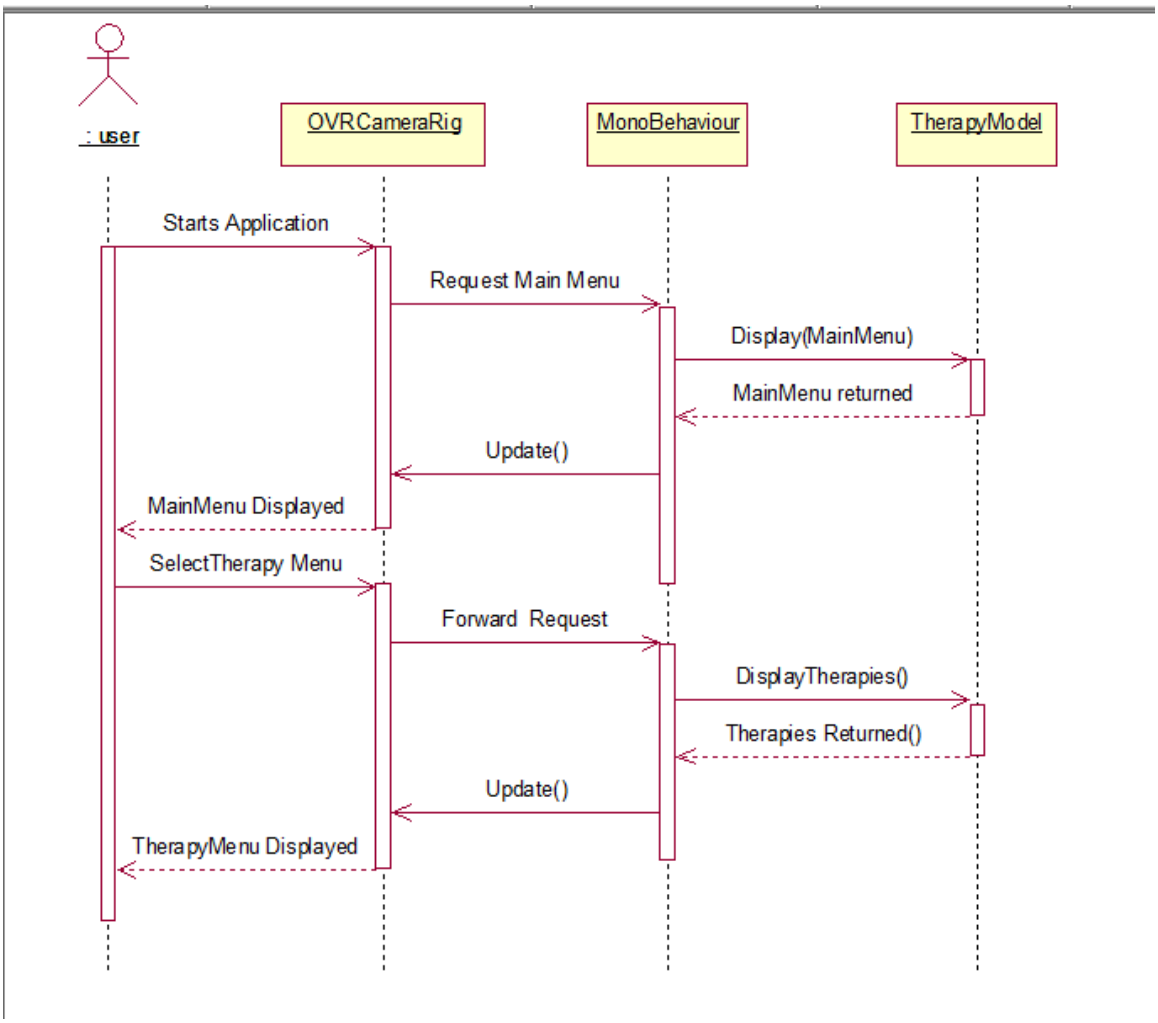

Figure 4-6 Sequence Diagram (TherapyMenu)

Figure 4-6 shows how user can go to list of therapies available in the application from main menu and how view is updated.

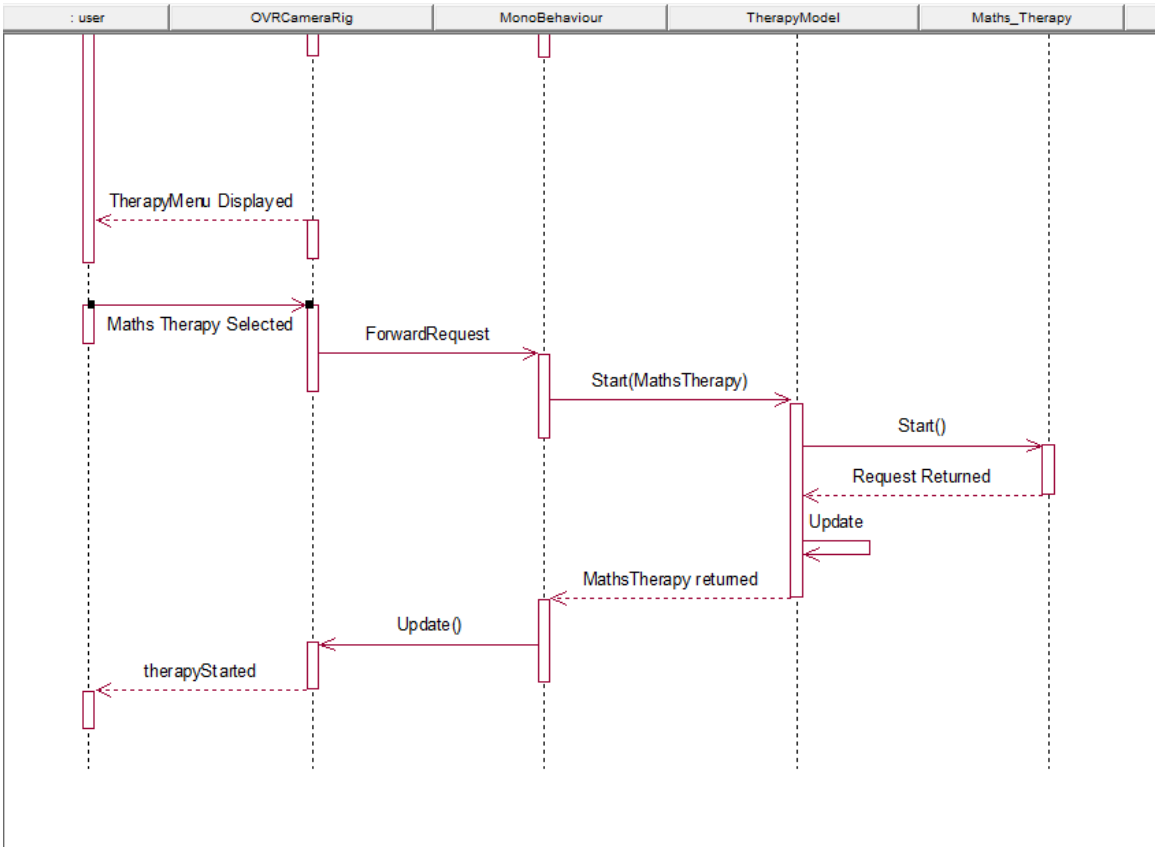

Figure 4-7 Sequence Diagram(Maths_Therapy)

Figure 4-7 shows how user can go to list of therapies available in the application from main menu and how he can select Math's therapy from there and how control is shifted back and forth between view and model by controller.

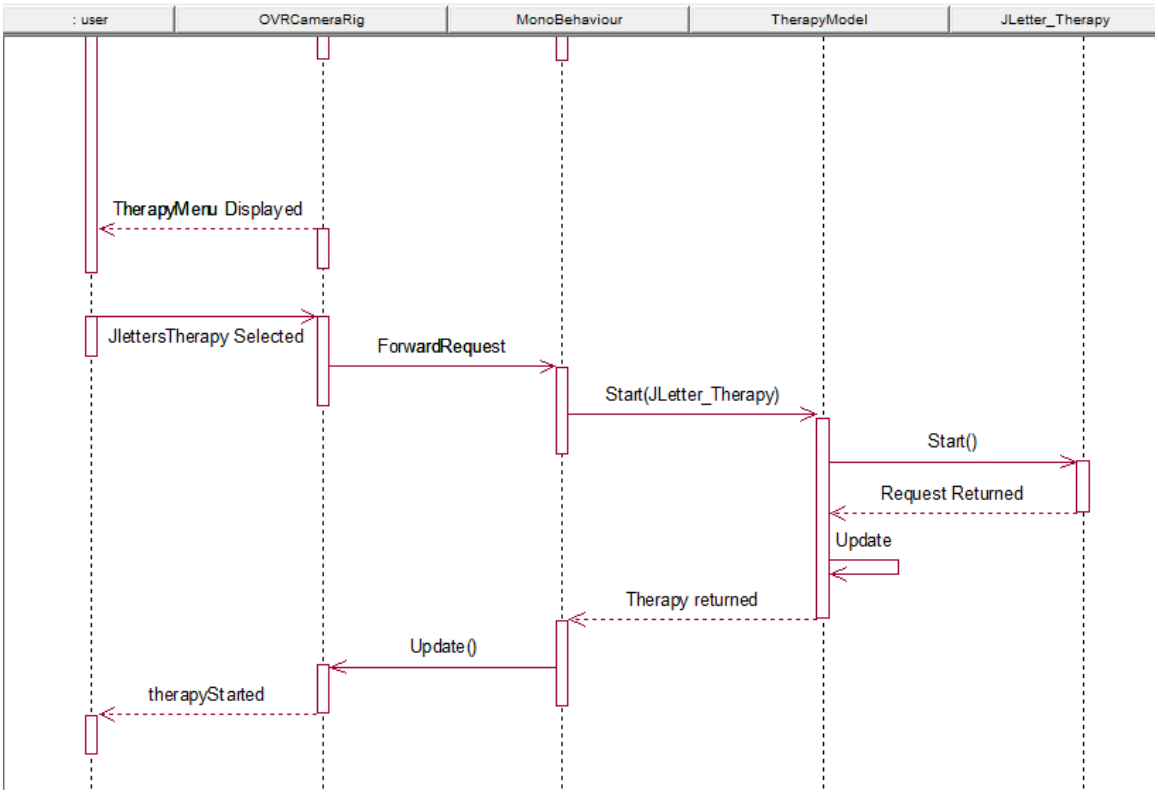

Figure 4-8 Sequence Diagram(JLetters_Therapy)

Figure 4-8 shows how user can go to list of therapies available in the application from main menu and how he can select Jumbled up letters therapy from there and how control is shifted back and forth between view and model by controller.

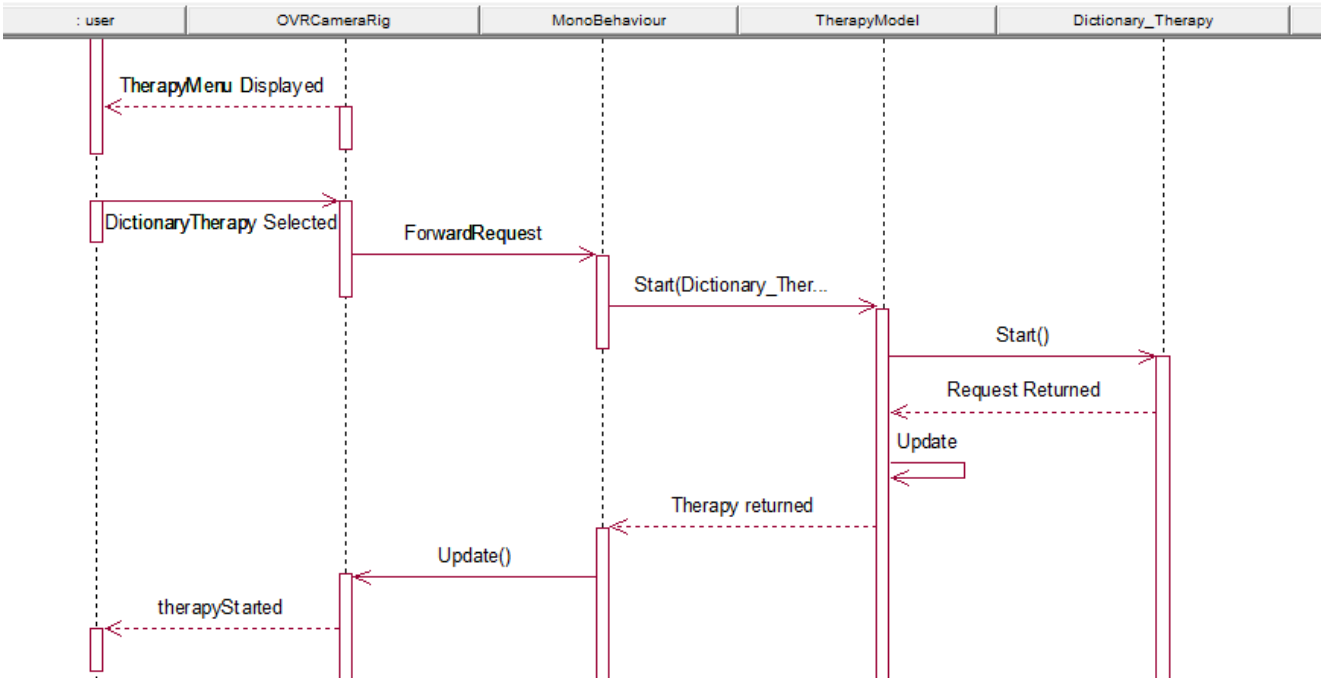

Figure 4-9 Sequence Diagram(Dictionary_Therapy)

Figure 4-9 shows how user can go to list of therapies available in the application from main menu and how he can select Dictionary therapy from there and how control is shifted back and forth between view and model by controller.

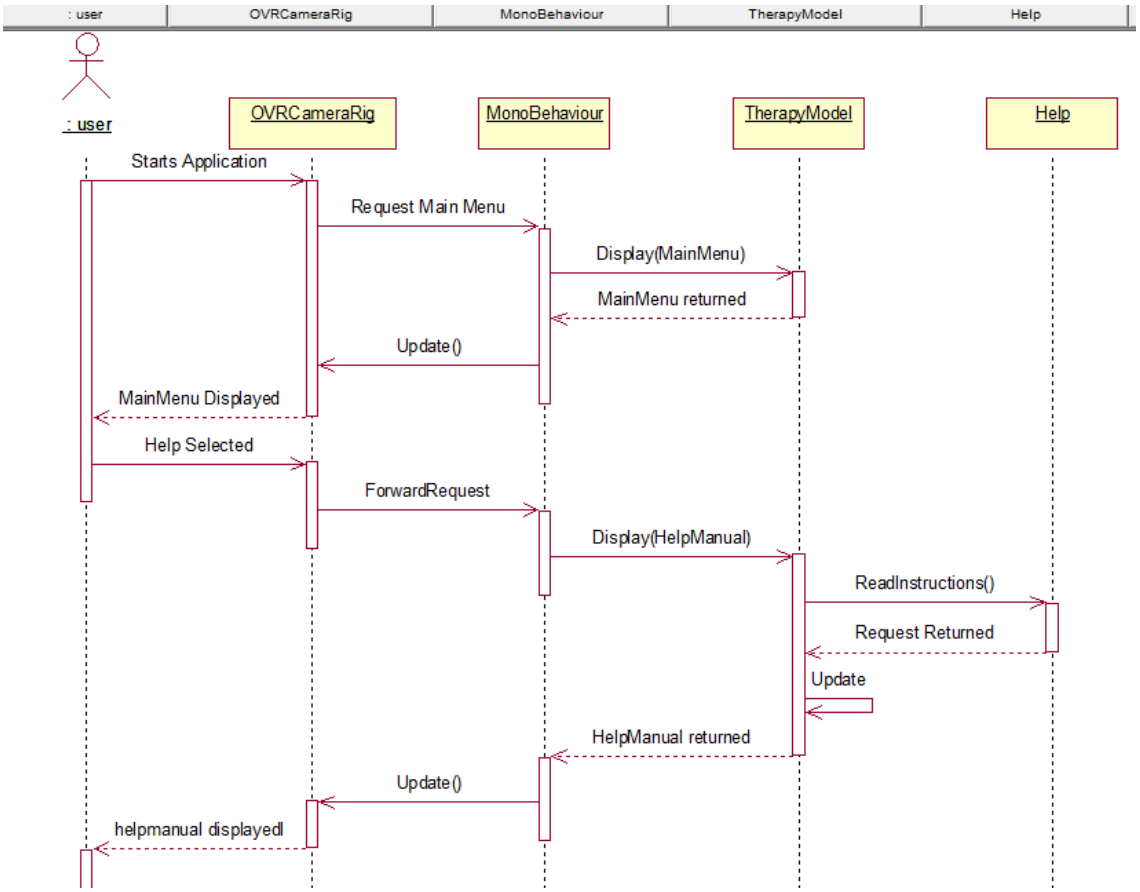

Figure 4-10 Sequence Diagram(HelpMenu)

Figure 4-10 shows how user can go to instruction manual available in the application from main menu and how control is shifted back and forth between view and model by controller.

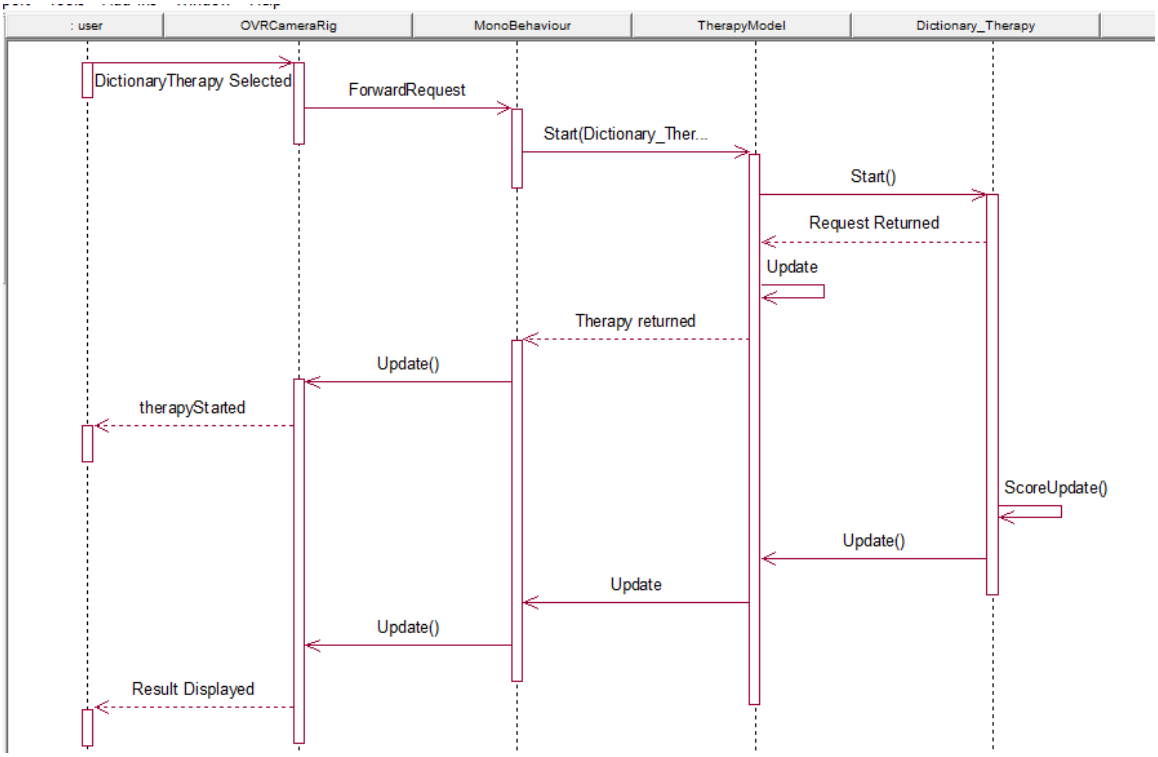

Figure 4-11 Sequence Diagram(Result)

Figure 4-11 shows how a user can view results of the therapy session that he has undergone and how control is shifted back and forth between view and model by controller.

Implementation View (Class Diagram)

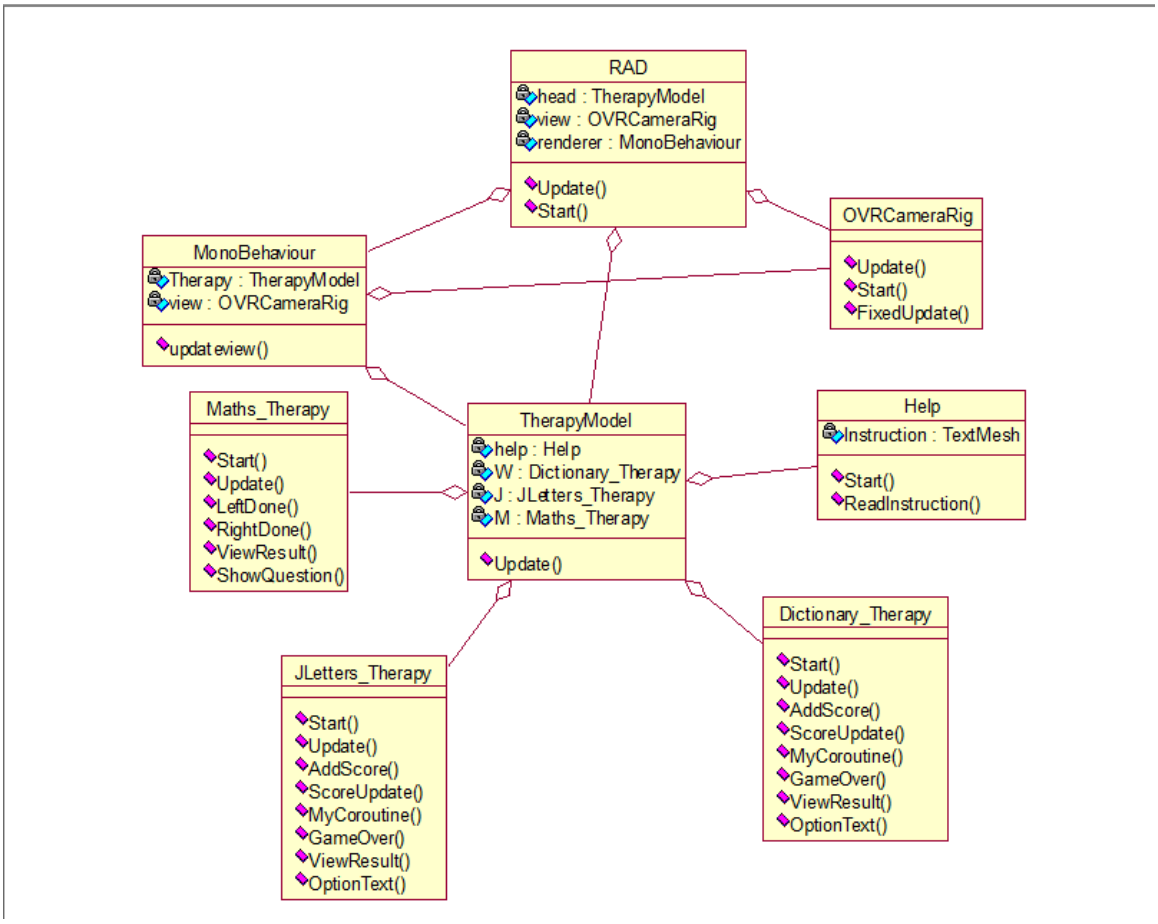

Figure 4-12 Class Diagram

Class's description

Name	Description
Rad	It has the objects of View, Controller and Head classes. It implements the MVC design pattern.
MonoBehaviour	Here this class is performing the MVC's Controller class functionality. It gets actions from view and tell model to act accordingly. It invokes the events by making function calls to different

	methods in model.
OVRCameraRig	This class plays the role of View class of MVC and generates view.
TherapyModel	TherapyModel plays the main role of MVC's Model class. All the events are generated through its functions. It contains all the model classes objects to generate events and all the data that is required to generate results and therapy sessions
Help	Displays the instruction manual to the user.
Maths_Therapy	Maths Test. This class contains all the functions that deal with the animations, GUI and physics components of this particular therapy. A mathematical exercise with simple arithmetic questions to help patients with right-left directional confusion.
JLetters_Therapy	Jumbled Letters Therapy. This class contains all the functions that deal with the animations, GUI and physics components of this particular therapy. It contains jumbled up letters game to help patients memorize spellings by interacting with them virtually which they find difficult and boring to learn otherwise.
Dictionary_Therapy	Words Dictionary. This class contains all the functions that deal with the animation, GUI and physics components of this particular therapy. Words dictionary kind of game with difficult words that dyslexic patients normally find hard to grasp and their meanings to help them memorize with repetitive exercises.

Table 4-7 Class's Description

Dynamic View (Activity Diagram)

In activity diagram, the dynamic view of the system is shown. All the activities are shown.

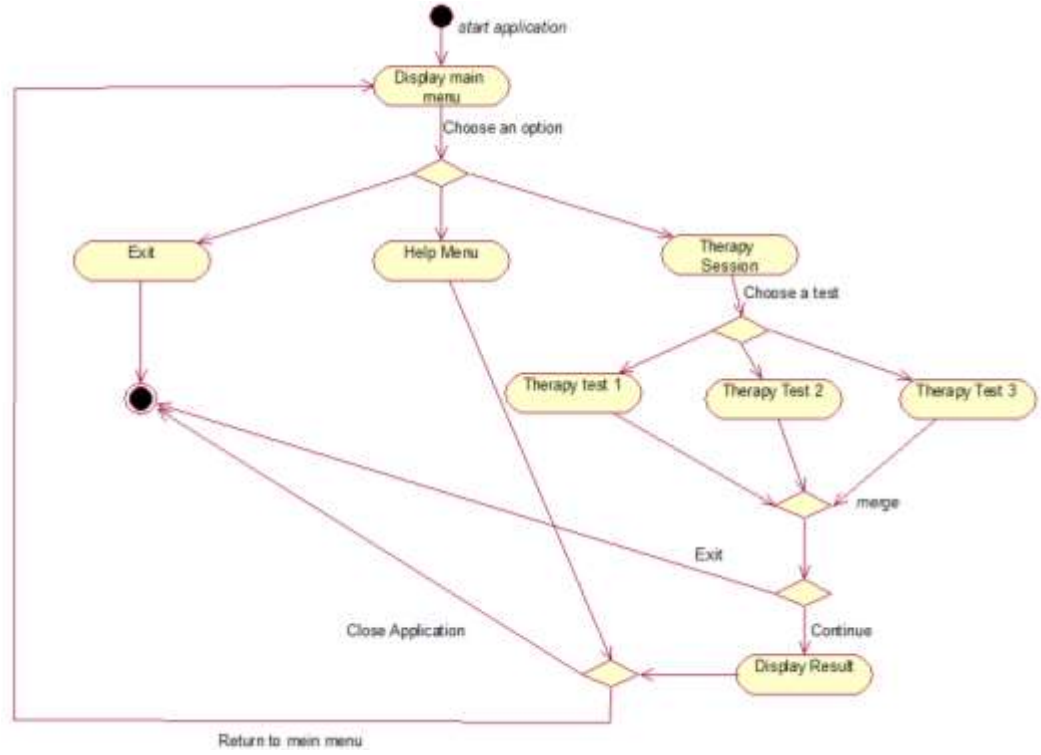

Figure 4-13 Activity Diagram

State Transition Diagrams (Logical view)

In this section, state transition of application is shown and how flow changes to other states.

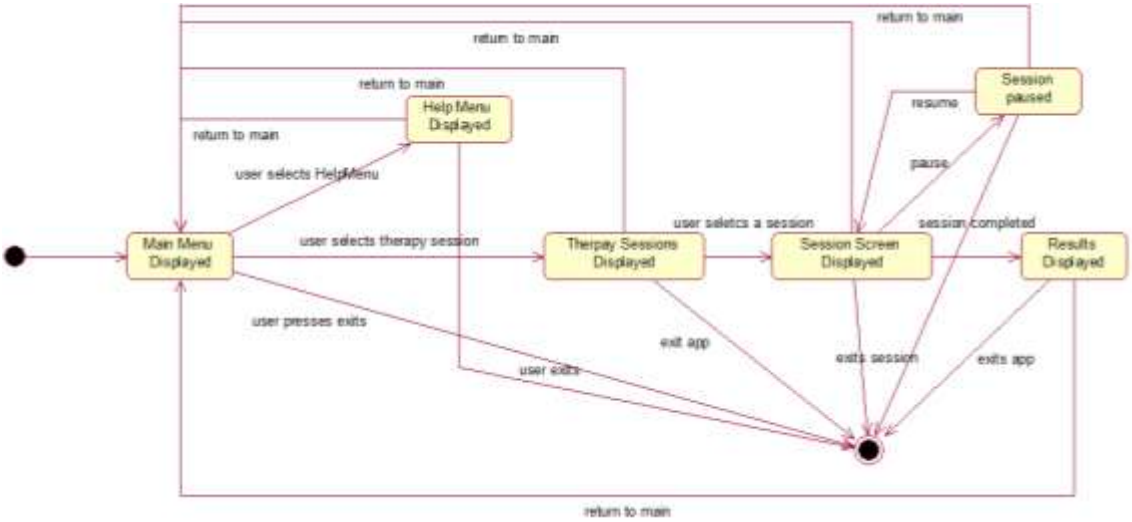

Figure 4-14 State Transition

Work Breakdown Structure

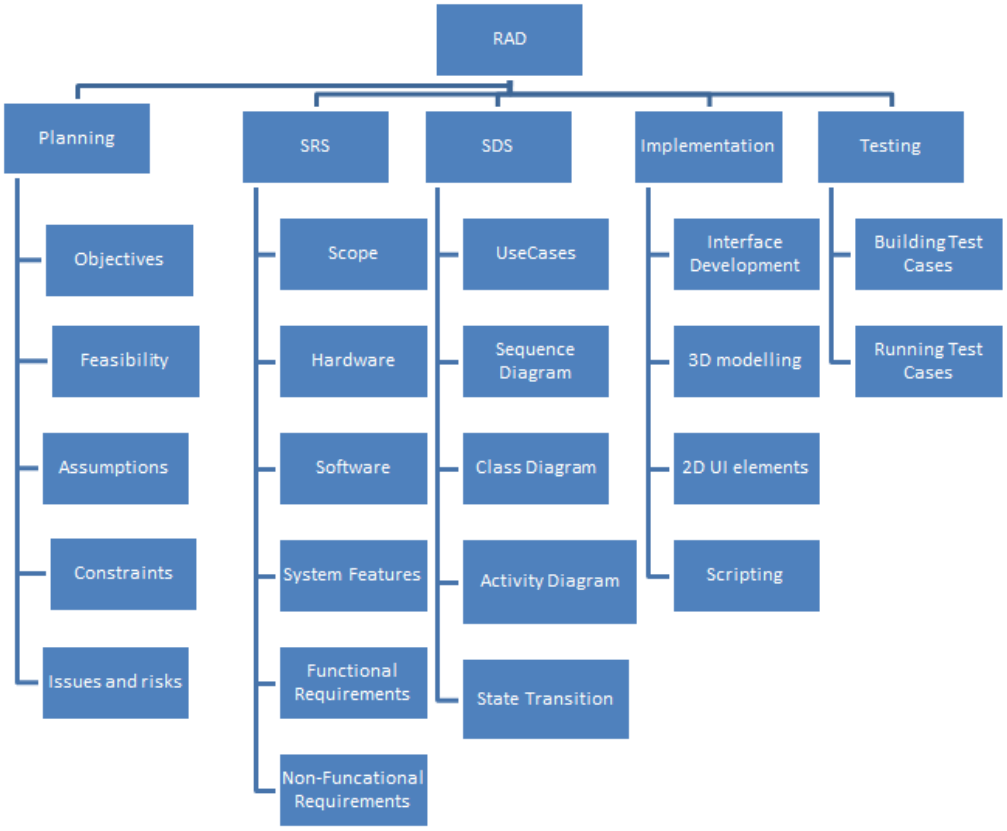

Figure 4-15 Work Breakdown Structure

Work Breakdown structure of RAD application has been shown in Figure 4-15. It shows in what phase's application has been developed and sub phases required for its completeion. Figure 4-16 shows the structure chart of the application that we've developed.

Structure Chart

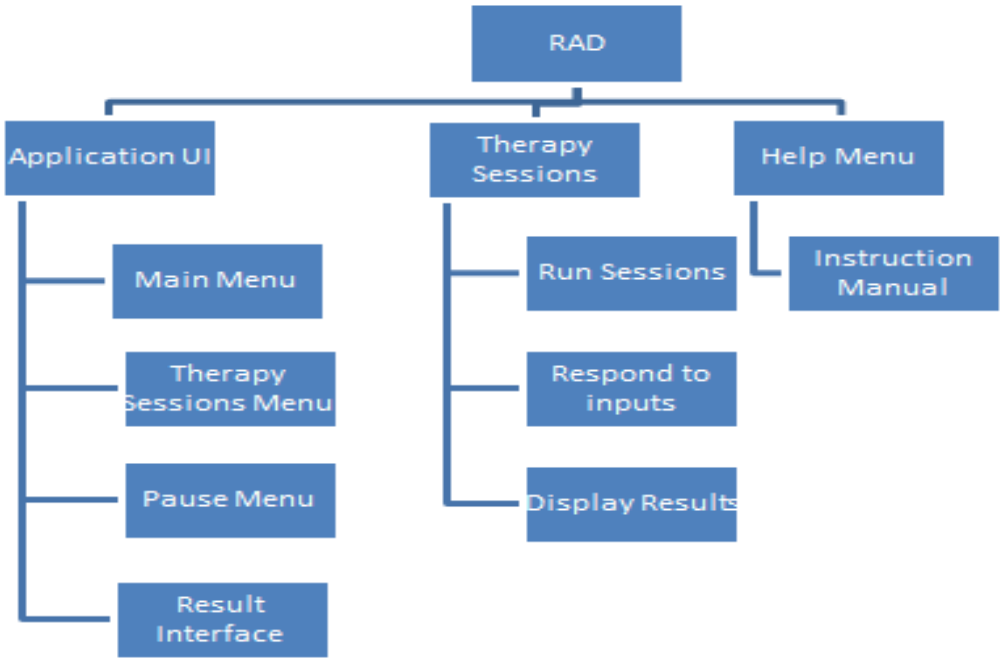

Figure 4-16 Structure Chart

4.4.2 Detailed Description of Components

This section describes in detail all components of Smart Classroom powered by RAD application.

User Input

Identification	**Name**: User input **Location**: View
Type	Component
Purpose	1. The purpose of this component is to receive user input. 2. The input through controller will be processed by this component and will be further sent to unity game engine. 3. The user head gestures and hand gestures will be received by

	this component.
Function	**What the component does:** Detect input in the form of phone orientation, head movement and hand movement.
Subordinates	**Constituents of the component:** The component has no sub-components. **Functional Requirements:** **Requirement 1:** The user will be able to view the play environment in 360 degrees by looking around. **Requirement 2:** The user will be able to simulate the movement as per the movement of the phone.
Dependencies	**Components using this component:** The sub component input events of the unity component will get its input from this module. This input will be further processed by input events component.
Interfaces	The external hardware interfaces interacting with this component will be: 1. HMD Controller/ Default Controller **Error messages:** Controller Not Found.
Resources	The resources used by this component are HMD Controller (for head gestures inputs) and Default Controller (for hand movement).

Processing	The processing required for this component is receiving the user's input and giving this input to the input event module of the unity game engine
Data	Player inputs (head gestures, hand movement).

Table 4-8 User Input

GUI

Identification	**Name:** GUI (Graphical User Interface) **Location:** View
Type	Component
Purpose	To display the application.
Function	**What the component does:** 1. The complete application environment is displayed by this component.
Subordinates	**Constituents of the component:** GUI basically contains all the game objects. **Functional Requirements:** **Requirement 1:** The user will be able to see a play area after selection from the menu.
Dependencies	GUI is dependent on unity engine. The rendering component of the

	unity will be providing input to the GUI.
Interfaces	**External interface requirement for GUI** An output display screen which it will be using to display all the objects created by the unity engine and all the menu and app mode screen.
Resources	1. It will be using graphics engine of the system as per unity requirements. 2. Android smartphone screen
Processing	The processing required of this component is to respond and display results of player input during the game and also during navigation.
Data	User input (hand gestures, head gestures)

Table 4-9 GUI

Unity Engine

Identification	**Name:** Unity engine **Location:** Model
Type	Module
Purpose	Unity is a game development ecosystem. It is a powerful rendering engine fully integrated with complete set of intuitive tools and rapid workflows to create interactive 3D and 2D content. Unity built in physics engine provides component that handles physics simulation with just a few parameters setting. Physics can be controlled from scripts

Function	**What the component does:** The main functions of this module are as follows: 1. Handle game physics 2. Game play rendering 3. Manage game resources on system 4. Manage all other major components of game
Subordinates	**Constituents of the component:** The other components using this component are: 1. GUI 2. Player Input **Functional requirements:** **Requirement 1:** The application shall allow the player to pause game.
Dependencies	**Components using this component:** 1. Player input controls 2. GUI rendering
Interfaces	The external interfaces interacting with unity game engine are 1. Processing Head gestures and Hand movements to get Input 2. Speakers

Resources	The resources used by this module are 1. RAM 2. Graphic memory 3. CPU usage 4. Controller
Processing	The processing done by this module is that it: 1. Initiates game, game objects and all required global variables 2. Allocates required system resources for game 3. Manages memory requirements
Data	Float values, integer values, strings

Table 4-10 Unity Engine

4.5. Reuse and Relationships to other Products

RAD is not based on any previous systems neither it's an extension of any other applications at any level. But it can be evolved into a bigger and more complex system with more features and functionality. Developers can also reuse some of the modules of the system. The application can also be enhanced to further include more activities such as a database can be maintained to help user keep a record of his performance throughout and see if any there is any improvement i.e. were the sessions effective? It can also be further enhanced by developing an augmented reality version of the application to make it more immersive.

4.6. Design Decisions and Tradeoffs

RAD is an interactive application which requires multiple types of user interface. Developing such systems require thorough consideration on the design factors as it might result in complexity problem. A poorly-designed system results in a system consuming

more resources with very little efficiency and a slower response time which directly affects the experience of the target user besides this, poor designs make testing and maintenance activities difficult.

MVC pattern will be used for the implementation of this application. General behavior of MVC is shown below.

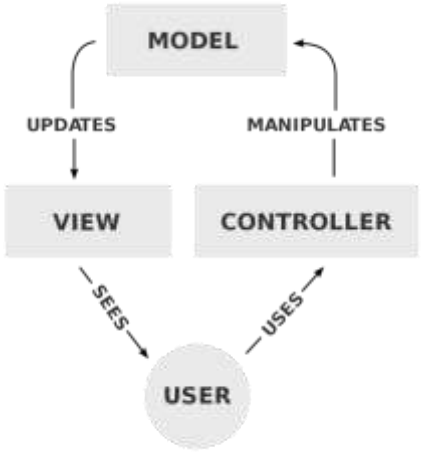

Figure 4.17 Architectural Diagram

Chapter 5. Project Test and Evaluation

5.1. Introduction

This test plan section describes the appropriate strategies, process and methodologies used to plan, execute and manage testing of the "RAD". The test plan will ensure that RAD meets the customer requirements at an accredited level.
Manual Testing will be followed which includes testing a software manually, i.e., without using any automated tool or any script. In this type, the tester takes over the role of an end-user and tests the software to identify any unexpected behavior or bug. Each Unit will be tested separately and then will be integrated with other units; therefore, Unit Testing and Integration testing will be followed. For each unit, Black box Testing is done and for combined units Acceptance Testing is done.
The test scope includes the Testing of all functional, application performance and use cases requirements listed in the *requirement document.*
Software testing, depending on the testing method employed, can be implemented at any time in the development process. However, most of the test effort occurs after the requirements have been defined and the coding process has been completed.
This document includes the plan, scope, approach and procedure of the testing of RAD. The pass/fail criteria of the test items are also defined. The document tracks the necessary information required to effectively define the approach to be used in the testing of the product.

5.2. Test Items

The test items selected for testing include the following

1. Performance
2. Interface
3. User control

5.3. Features to Be Tested

The features of our game include the functionality mentioned in our design document. Following features are to be tested keeping in view the test items and system features aforementioned

1. Application shall be properly installed on the mobile phone.
2. The different options available on main menu shall be

a) Therapy sessions
b) Help menu
c) Exit

3. At any time user shall be able to exit the application when required.
4. User shall be able to pause/resume therapy session when needed.
5. List of the therapy tests shall be displayed for user to select.
6. Result of the test shall be displayed after the end of each session.
7. User shall be able to exit the session and move to main menu when required
8. Choosing Help Menu option shall show Instruction Manual.
9. All therapy sessions shall be working correctly
10. Scope of View of user shall be changed with his head movement.

5.4. Test Approach

Functional Testing will focus on each use case that is included in the version currently being worked on. Testing will mainly consist of execution of test cases written to address the gap identified. It will focus on inputs, outputs and system changes due to the actions.
The testing strategy for RAD will be Alpha testing (Black box and White box techniques). Black Box testing technique will be used for testing functionality of each module.

5.5. Item Pass/Fail Criteria

Details of the test cases are specified in section Test Deliverables. Following the principles outlined below, a test item would be judged as pass or fail.

1. Preconditions are met
2. Inputs are carried out as specified
3. The result works as what specified in output => Pass
4. The system doesn't work or not the same as output specification => Fail.

5.6. Suspension Criteria and Resumption Requirements

Testing procedure will be suspended whenever a defect is found that restricts further testing. A corrective measure will be applied depending upon the criticality of the defect and testing will be resumed.
Efforts have been made to remove all and every chance of failure but there are certain unpredictable factors such as network issues, corrupt input data, or system failure that may lead to some issues. Error handling is applied more deeply to cover all these issues but unforeseen circumstances may happen.

5.7. Test Deliverables

Testing tasks

1. Develop Test Cases.
2. Execute tests based on the test cases developed.
3. Report defects during tests if any.
4. Manage the changes made after testing.

Test cases

Following are the Test Cases:

5.7.1. Displaying the Main Menu

Test Case ID	**TC 1**
TestCase Description	It shall display Main Menu once the application is launched
Testing Technique used	Black Box Testing.
Preconditions	1.The application must be installed properly

	2. Mobile phone is mounted on headset correctly. 3. Mobile phone is compatible with headset.
Steps	1. Launch Application on mobile phone.
Expected output	User shall be able to see a Main Menu in a virtual environment
Actual output	Main Menu is displayed having options 1.Therapy Sessions 2.Help menu 3.Exit
Status	PASS

Table 5-1 TestCase1

5.7.2 Change in Scope of View

Test Case ID	**TC 2**
Test Procedure	The player moves his head while playing the game /application to look around in the playing environment
Testing Technique used	White Box Testing, Black Box testing
Preconditions	1.The application must be installed properly 2. Mobile phone is mounted on headset correctly.

	3. Mobile phone is compatible with headset. 4.User has launched the application
Input values	Gestures due to head movement
Expected output	OVRCAMERARIG class shall be called in every game scene with each head movement and the view shall span left, right, up and down as player looks left, right, up, and down respectively,
Actual output	OVRCAMERARIG class is called and the view spans left, right, up and down as player looks left, right, up, and down respectively
Status	Pass

Table 5-2 TestCase2

5.7.3. Help Menu Feature

Test Case ID	**TC 3**
Description	This test case will check whether application contains all the necessary instructions needed to use the product or not.
Testing Technique used	Black Box testing
Preconditions	Application is launched and a Main menu is displayed.
Steps	1. Launch application. 2.Select Help Manual From Main Menu
Expected output	User shall be able to see a Help manual with all the instructions

	needed to play the therapy sessions.
Actual output	Help manual is displayed with all the instructions.
Status	PASS

Table 5-3 TestCase3

5.7.4. Exit Application Feature

Test Case ID	**TC 4**
Description	This test case tests the functionality of exit button displayed on every screen.
Testing Technique used	Black Box Testing
Preconditions	Application has been launched; user is either on Main menu, Help menu, is taking a therapy session or has paused the game.
Steps	1.Application in in working form 2. User presses exit at any point.
Expected output	Application shall exit.
Actual output	Application Exits
Status	PASS

Table 5-4 TestCase4

5.7.5 View Therapy Session Menu

Test Case ID	**TC 5**
Description	Therapy session menu will contain all the therapy sessions included in the application, user will select the one of its choice.
Testing Technique used	Black Box Testing
Preconditions	Application has been launched and main menu is displayed
Steps	1.Application is launched 2. User has pressed Therapy Session option from Main menu.
Expected output	Application shall display Therapy Session Menu.
Actual output	Application displays Therapy Session Menu with options 1.Directional Therapy 2.Jumbled Words 3. Dictionary 4.Return to Main menu

	5. Exit
Status	PASS

5.7.6 Directional therapy

Test Case ID	**TC 6**
Description	This will test whether Directional therapy works correctly, i.e. there is change in score with every right and wrong answer and user is able to control his gestures with controllers in game or not.
Testing Technique used	Black Box Testing
Preconditions	The user has launched the application.
Steps	1.User launches application 2.User Selects therapy Sessions from Main menu 3. User Selects Directional therapy from Therapy Sessions Menu.
Expected output	Math's sums shall be displayed on screen in a virtual environment with a time limit; user shall be able to answer the question using controllers.

Actual output	Math's sums are displayed and therapy game is working fine.
Status	Pass

Table 5-6 TestCase6

5.7.7. Jumbled Words

Test Case ID	**TC 7**
Description	This will test whether Jumbled words therapy works correctly, i.e. there is change in score with every right and wrong answer and user is able to control his gestures with controllers in game, jumbled letters are displayed correctly.
Testing Technique used	Black Box Testing
Preconditions	The user has launched the application.
Steps	1.User launches application 2.User Selects therapy Sessions from Main menu 3.User selects Jumbled letters from Therapy Sessions Menu
Expected output	Jumbled letters shall be displayed on screen in a virtual environment with a time limit; user shall be able to make words using those jumbled letters.

Actual output	Jumbled up letters are displayed and therapy game is working fine.
Status	Pass

Table 5-7 TestCase7

5.7.8 Dictionary therapy

Test Case ID	**TC 8**
Description	This test case will tell whether dictionary therapy is working correctly therapy works correctly, i.e. there is change in score with every right and wrong answer and user is able to control his gestures with controllers in game.
Testing Technique used	Black Box Testing
Preconditions	The user has launched the application.
Steps	1.User launches application 2.User Selects therapy Sessions from Main menu 3.User Selects Dictionary therapy from Therapy Sessions Menu
Expected output	A word with its meaning in a multiple choice form shall be shall be displayed on screen in a virtual environment with a time limit, user shall be able to answer the question using controllers.

Actual output	Words with meanings are displayed and therapy game is working fine.
Status	Pass

Table 5-8 TestCase8

5.7.9 Return to Main Menu Feature

Test Case ID	**TC 9**
Description	It will test whether user can revert back to main menu when required or not.
Testing Technique used	Black Box Testing
Preconditions	User has launched the application
Steps	1.User launches application 2.User Selects and thing less Exit from Main Menu and proceeds further 3. User presses Return to Main Menu feature at any point.
Expected output	Application shall move to Main menu.
Actual output	Main Menu is displayed.

Status	Pass

Table 5-9 TestCase9

5.7.10. Scorecard

Test Case ID	**TC 10**
Description	There will be a change in points of the player as the therapy game proceeds.
Testing Technique used	Black Box Testing
Preconditions	The player is playing the game
Expected output	The scores will be displayed in the scoreboard and every time a change in the score will be notified to the player
Actual output	Scores are being displayed correctly and are visible to user.
Status	Pass

Table 5-10 TestCase10

5.7.11. Pause/Resume

Test Case ID	**TC 11**

Description	It will test whether user can pause or resume game whenever needed or not.
Testing Technique used	Black Box Testing
Preconditions	The player is playing the game
Steps	1.User launches application 2.User Selects therapy Sessions from Main menu 3.User Selects any therapy from Therapy Sessions 4. User Selects pause/resume in between Therapy Session
Expected output	Therapy Session shall be paused/ resumed when clicked.
Actual output	Therapy Session was paused/ resumed when clicked on respective button.
Status	Pass

Table 5-11 TestCase11

5.8. Responsibilities, Staffing and Training Needs

5.8.1. Responsibilities:

All developers of the project are responsible for the completion of all components testing and integration testing tasks.

5.8.2. Staffing and Training Needs:

Basics knowledge of testing strategies and techniques is needed for the testing of the project. Techniques such as Black Box testing, integration testing should be known to developers.

All the developers will be testing each other's work and will be actively participating in the development and testing of the project simultaneously.

5.9. Risk and Contingencies

Efforts have been made to remove all and every chance of failure but there are certain unpredictable factors such as network issues, corrupt input data, or system failure that may lead to some issues. Error handling will be applied more deeply to cover all these issues but unforeseen circumstances may happen.

5.9.1. Schedule Risk:

The project might get behind schedule so in order to complete the project in time we will be needing to increase the hours/day that the project is being worked on.

5.9.2. Operational Risks:

Operational risks will be eliminated by Scheduling daily meetings and regular deadlines to meet the goals of the project as well as provide proper communication within the group.

5.9.3. Technical risks:

Technical risks will be eliminated by keeping the once defined requirements constant.

5.9.4 Programmatic Risks:

In case of a programmatic risk the scope of the project will be limited in order to stay inside the constraints of the project.

Chapter 6. Future Work

This project can be extended further for future support of dyslexia patients

1. Extension for AR (Augmented Reality) support.
2. Multi-platform build.
3. Real time therapy sessions.
4. Analytics and report generation on gathered data.
5. Machine learning for early detection of symptoms.

Chapter 7. Conclusion

By utilizing the modern technology features, we have developed an application addressing the diverse needs of dyslexic children with learning differences focused on improving their reading and judgmental skills. It was designed and evaluated with the collaboration of dyslexic children, their parents and remedial teachers having hands on experience in field of dyslexia, to ease the learning difficulties of dyslexic children as well as to measure their improvement progress over a brief period of application usage. The preliminary results of application evaluation showed the promising effectiveness of developed application in advancing in the overall learning performance of dyslexic children which otherwise was hard to observe.

The initial evaluation yielded that both the user interface design and learning content structure of application fulfills the elicited requirements of dyslexic children .Since the application implements a great deal of learning material design based on educational aspects of special education sector, therefore it is expected to prove as an efficient and cost-effective technology-based educational resource solving the issues of educational technology awareness, affordability and accessibility.

Appendices

Appendix A: Glossary

1. **ADHD**: Attention deficit hyperactivity disorder
2. **APP:** Application
3. **GUI:** Graphical User Interface
4. **RAD:** Rehabilitation Approach for Dyslexia
5. **SDS**: Software Design Specification
6. **UML**: The Unified Modeling Language (UML) is a general-purpose modeling language in the field of software engineering, which is designed to provide a standard way to visualize the design of a system
7. **VR:** Virtual Reality
8. **WBS:** The project management Work Breakdown Structure

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