Aid for Autistic Children using VR

By

Nashika Yousaf

Safa Fatima

Hira Afzal

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

ABSTRACT

Aid for Autistic Children using VR

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 Autistic children and their caretakers.

Autism Spectrum disorder is a mental condition, present from early childhood, characterized by great difficulty in communicating and forming relationships with other people and in using language and abstract concepts. As the word "spectrum" suggests people with autism spectrum disorder (ASD) may have challenges that run the gamut from mild to severe, with different levels of ability and disability. Someone may have no functional speech, or may have a rich vocabulary. He may be intellectually disabled or have an average or above average IQ. He may be socially withdrawn or may be socially active, although in an oblivious, eccentric way. Standard therapy methods include taking them into the real life situations or creating it one physically at the resource centers. This can be overwhelming process with little to no outcome. Digitizing the methods will help the children and caretakers to complete the therapies in an engaging way.

An android VR application has been developed for children and their caretakers targeting mild to medium level cases focusing on natural environment and social skill therapies been developed in a virtual environment. Subject will have to wear a headset which will make them interact with the application virtual environment for different levels of the therapies. The results of the evaluation revealed that application has potential benefits to foster the learning process and help autistic children by improving their social skills and reduce their anxiety.

CERTIFICATE FOR CORRECTNESS AND APPROVAL

It is certified that work contained in the thesis –Aid for Autistic children using VR carried out by Nashika Yousaf, Safa Fatima, and Hira Afzal under supervision of Dr. Naima Iltaf for partial fulfillment of Degree of Bachelor of Software Engineering is correct and approved.

Approved By

Dr. Naima Iltaf

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, Dr. Naima Iltaf, who has given us great support and valuable suggestions throughout the implementation process.

ACKNOWLEDGEMENTS

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Chapter 1. Introduction

1.1. Overview

Autism Spectrum disorder is a psychological state that is present in a person from childhood, exemplified by problem in conversing and forming bond with others and in using language and abstract concepts. As "spectrum" tells children and grown-ups with ASD may have difficulties that shift from gentle to serious, with various dimensions of ability and disability. Somebody may have no useful discourse, or may have a great vocabulary. He might be mentally debilitated or have a normal IQ. He might be socially saved or might be socially dynamic, in spite of the fact that in an unaware, eccentric way. The purpose of this project is to help autistic kids in overcoming their anxieties, manage behavioral symptoms and improving their social skills using different levels of therapies. Virtual Reality will increase their interest and focus.

1.2. Problem Statement

Children suffering from Autism Spectrum Disorder get anxious and are overwhelmed by being a part of the real life scenarios. To deal with that, they at times react in a really aggressive manner which can be harmful for them or the others. Conducting the therapies in the real life scenarios can be challenging for the children and the caretaker, both. No digital methods are available to aid them or make the process any better.

1.3. Approach

An android VR application will be implemented for autistic children and their caretakers on Unity engine for social skill and natural environment therapies. 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 levels of the above mentioned therapies.

1.4. Scope

Aid for autistic children using VR is intended to help Autistic children in their daily routine, so that they, with the help of simple therapy techniques, can interact and engage in the real life situations without being anxious by using a mobile phone and a virtual reality headset. Through this application they shall constantly receive first hand training by using the two therapies available in the application.

1.5. Objectives

The main objective of this system is efficient therapies process for improving behavioral issues and social skills of autistic children, by using certain therapies in VR.

During the project, from requirement gathering to testing phase, all 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 'Aid for Autistic children using VR'. 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's 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)

   To check and evaluate that they are developing the project that fulfills the requirements mentioned in this document.

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

   In order to have a list of the features and functions that must respond according to the 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:** (Dr. Naima Iltaf)

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)

To know the scope of 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.

 Moreover, undergraduate students of MCS, NUST of batch 2018 developed a virtual reality application for the rehabilitation purpose of dyslexic patients which had the exercises to improve the reading and writing skills of the patients and help them do their tasks independently. While many projects have been developed in VR in Pakistan, very few have been done for medical purpose.

Since Virtual Reality (VR) innovations previously ended up prevalent during the 1960s, their one of a kind qualities set them apart from other data advances, making them incredible asset for treatments and a couple of other medicinal reasons. Mixing a technological and conceptual methodology, Mikropoulos and Strouboulis recommended the accompanying 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"

Autism spectrum disorders (ASDs) are known by impaired social interactions and repetitive behaviors, often accompanied by atypical reactions to sensory stimuli.
In USA, 1 out of 59 children have autism. In Pakistan, there is no autism prevalence data available.

Subjects with Autism may hint at early stages, for example, diminished eye to eye connection, absence of reaction to their names or detachment to overseers. Other kids may grow regularly for the initial couple of months or long stretches of life, yet then all of a sudden become pulled back or forceful or lose language aptitudes they have officially gained. It is a complex formative condition that includes steady difficulties in social association, discourse and nonverbal correspondence, and dull conduct. The impacts and seriousness of ASD is varied in each individual.

Over the last fifteen years there have been some outstanding technological and scientific advances around there, making VR from a modern toy and ground-breaking instructive mean, to an important appraisal and mediation apparatus. Highlights, for example, 3D dynamic yet controllable conditions, upgrades control, and conduct documentation and measurement are significant resources of VR innovation and its clinical applications. There are presently different examinations that help the utilization of VR applications in intellectual, mental, and physical (motor and practical) issue. The wide gamut of such clinical applications differ from specific recreations for torment the executives to virtual situations for populaces with psychological weaknesses , special requirements (for example autism) just as learning troubles . In case of autism, there are just a couple of concentrates that present computer generated experience applications for the youngsters
.

Burgess and Gutstein [2007] were the first to survey on QoL(Quality of Life) in autistic people. Contrasted with standardizing tests, autistic grown-ups by and large report altogether lower abstract QoL. Gender impacts have additionally been found; Kamio and associates found that autistic males revealed altogether higher mental and social QoL contrasted with the females This gender impact has not been researched in different investigations utilizing the WHOQoL   -BREF thus th
to the comprehension of gender and age contrasts in QoL in a huge changed example of autistic people.

As the research propose, the capability of adjusting the environment as a methodology in working with youngsters with ASD. Such environmental adaptations could increase different intercessions for youngsters with ASD and at last serve to help their investment in significant life areas. Progress to adulthood represents a critical period for youngsters with ASD and their families, when underpins are expected to expand the open doors for youngsters with ASD to accomplish their desire and take an interest completely in the society.

For the studies analyzed, there is moderate evidence that VR-based treatments can help children with ASD. Nevertheless, the promising results and the advantages of VR (especially considering ASD symptomatology) encourage the scientific community to develop new VR-based treatments that will prove to be positive for the autistic children and adults.

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 'Aid for autistic children using VR' by stating the problem in detail. The detailed requirements of the project are given in the document.

3.1.1. Purpose

The document includes software requirements for the project 'Aid for autistic children using VR'. The project is basically for Autistic children and their caretakers. Autism is a complex neurobehavioral condition that includes impairments in social communication and developmental language and communication skills combined with firm, repetitive behaviors. There's no cure for this disorder but several approaches can help in improving social functioning, learning and quality of life for autistic children. Purpose of this project is to help the kids and make the day to day learning easy and comfortable with the help of different therapies. These therapies implemented in VR will help them with social skills training and will manage behavioral symptoms in natural environments. Virtual Reality plays a vital role in increasing the interest, urge to learn and focus of kids.

3.1.2. Project Vision

'Aid for Autistic children using VR' is an application designed to help Autistic kids in their daily activities, so that they can, with the help of simple training techniques, interact with people and get used to environment in a more comfortable way. This application will help them get used to the environment which otherwise they get anxious being a part of. Repetitively, using the same therapies as it cannot be expected of them to learn things in a single session. This application targets two therapies namely SST and NET.Through this application they shall constantly receive first hand training while being at home.

For	People suffering from autism and their caretakers. It is also beneficial for their kin.
What	A mobile application to help patient(s) train using different therapies and for The children and their caretakers to help train them virtually.

The	Aid for Autistic children using VR
Is	An android VR application
That	Provides therapies for autistic children to overcome their anxieties and behavioral issues in different environments.

Table 3-1 Project Vision

3.2. Overall Description

3.2.1. Product Perspective

This application will basically help people suffering from Autism to get used to the daily activities which otherwise can be tough and embarrassing for them. They get irritated if they fail to do those tasks. The application will help them get used to things on their own pace without being guilty or embarrassed for anything. Right now therapies are being implemented in the real environment. Shifting them to Virtual Reality will help the children learn about the environment in a better way by rewinding and replaying the same scenario again and again.

3.2.2. Product Features:

'Aid for Autistic children using VR' is a virtual reality mobile application for patients with different therapies for autistic children. Main features of the application are listed below.
1. A main menu-for navigation
2. A natural environment therapy to help them learn how to be a part of a certain environment
3. A social skills therapy to make the interaction and communication easy.

3.2.3. User Classes and Characteristics

Following are user classes and their brief description.

Autistic children

The caretakers will have to download the android VR application for the autistic children 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 will operate in an android environment. It shall be compatible with version 4.3 (Jelly Bean) and all the higher versions of android.

Hardware

'Aid for autistic children using VR' operates, either directly or indirectly, with the following external hardware:

1.   **Headset:** Autistic children will wear a headset with a phone mounted inside it.

2.   **Mobile phone:** Children 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.

3.3.4. Communications Interfaces

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

3.4. System Features

This section explains in detail the features of the system of our VR application.

3.4.1. Accessing the Main Menu

Description and priority

After starting the application the therapy sessions 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 instance 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 therapy game.

REQ-8: 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-9: 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 application'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 Autistic children as well.

Reliability

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

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 system design and architecture of the application will be flexible enough to accommodate any new requirements, if required at any 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

Autism Spectrum disorder is a psychological condition, present from early age, characterized by great trouble in communicating and forming relationships with people and in using language and abstract concepts. As the word "spectrum" suggests, people with autism spectrum disorder (ASD) may have challenges that run the gamut from mild to severe, with different levels of ability and disability. Someone may have no functional speech, or may have a rich vocabulary. He or she may be intellectually disabled or have an average or above average IQ. He may be socially withdrawn or may be socially active, although in an oblivious, eccentric way.

4.2. Purpose

This software design specification (SDS) document describes the architecture and system design of 'Aid for Autistic children using VR'. It mostly contains different design diagrams and their explanation. The document is intended to inform stakeholders about the details of the design and the design process. This document will help the developer(s) to implement and maintain the Application (app).

4.3. Project Scope

'Aid for Autistic children using VR' is an application designed to help Autistic kids in their daily activities, so that they can, with the help of simple training techniques, interact with people and get used to environment in a more comfortable way. This application will help them get used to the environment which otherwise they get anxious being a part of. Repetitively, using the same therapies as it cannot be expected of them to learn things in a single session. This application targets two therapies namely SST and NET.

4.4. System Architecture Description

This section provides detailed system architecture of our application, 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 'Aid for Autistic children using VR'.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.
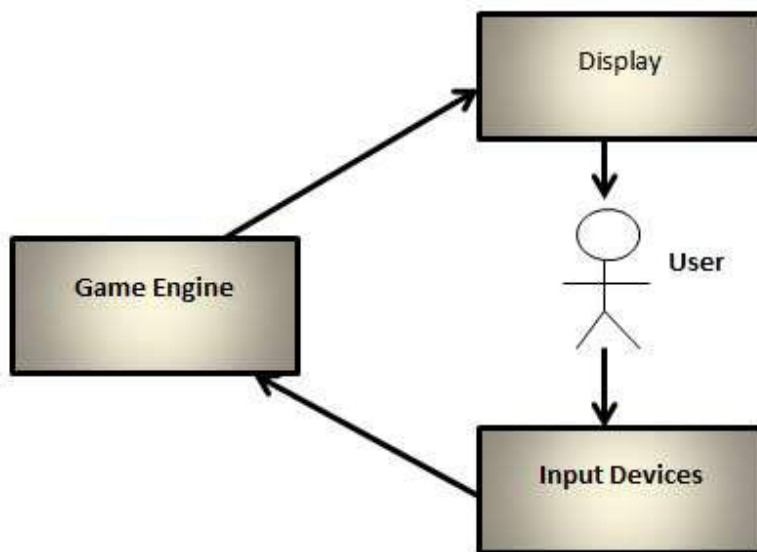
Figure 4-1 System Block Diagram

Component Diagram

The main components are

1. User Input
2. GUI
3. Unity Engine
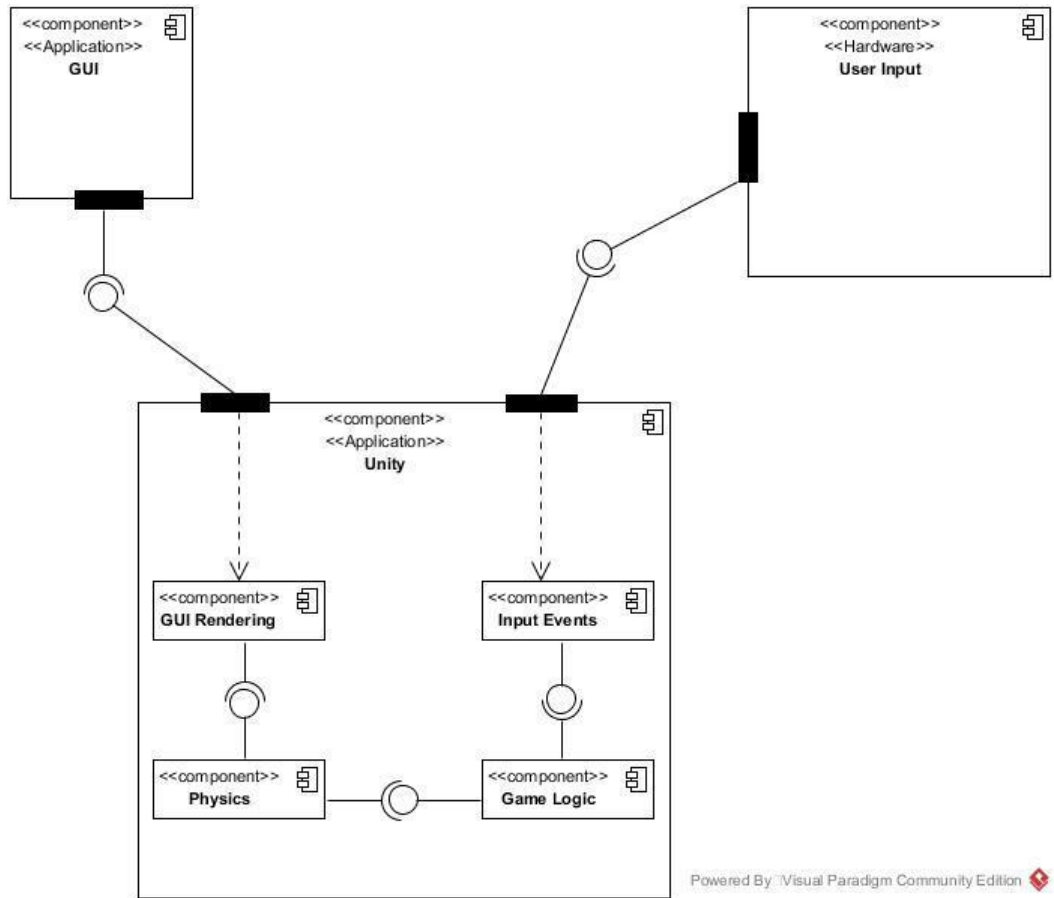
Figure 4-2 Component Diagram

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.
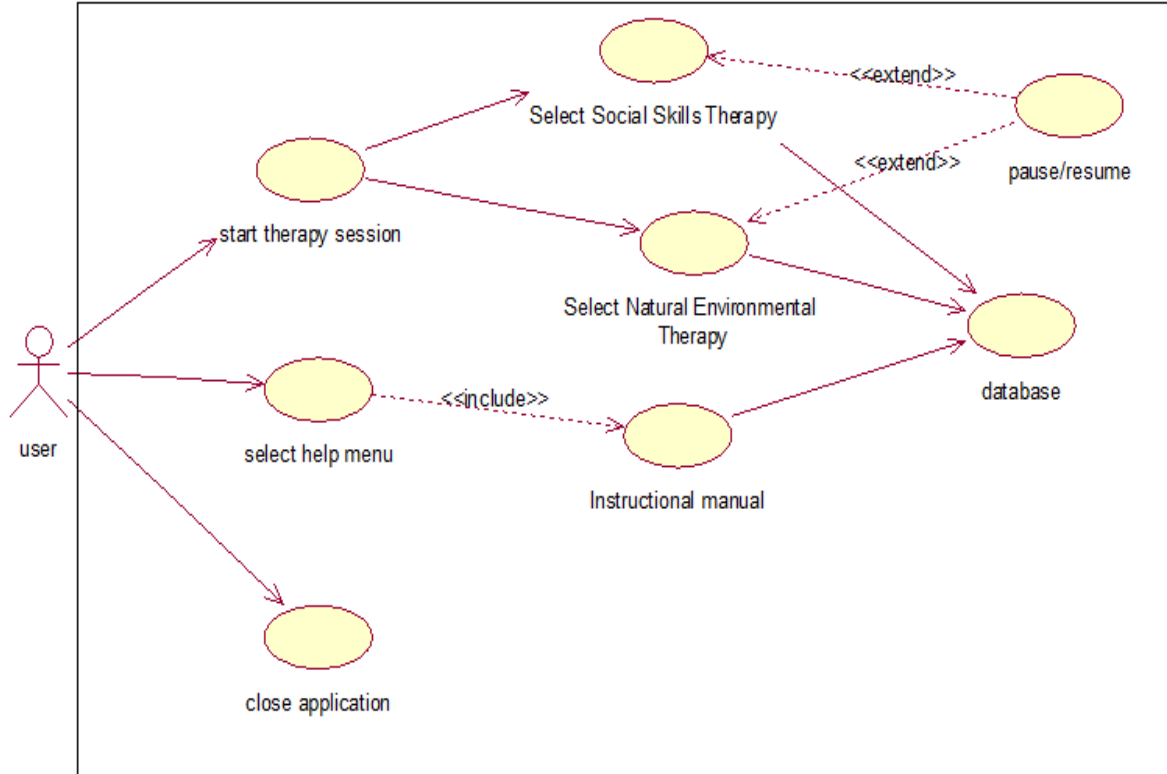
Figure 4-3 System Use Case Diagram

Actors:
Primary Actors:
1. User (Patient)

Secondary Actors:
 None

Use Cases:
1. Start therapy session
2. Select help menu
3. Close application
4. Select Social Skills Therapy
5. Select Natural Environment Therapy
6. Database

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 2 different therapies, which user can choose according to their own choice: (i) NET (ii) SST
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	Both therapy sessions should be displayed from which user is able to choose one to continue the session
Includes	2 therapy sessions (i) SST (ii) NET

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 SST
Actors	User
UseCase Description	A scenario will be displayed that will help user learn basic manners and develop some social skills
Normal Flow	After selecting therapy session user will select one of the 2 therapies given i.e. "SST". After completing the whole session, 'session end' will be displayed and the screen will return to the Main menu
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 2 types of therapies are displayed
Post Condition	After session the system will display the 'session end' and will return to the main menu.
Includes	N/A
Extends	Pause
Assumptions	Phone is properly mounted inside the headset

Table 4-4 UseCase4

Use Case 5

Use Case	NET

Actors	User
UseCase Description	User will be shown some natural environment scenario and will be told how to deal with that environment
Normal Flow	After selecting therapy session user will select one of the 2 therapies given i.e "NET". After completing the whole session, 'session end' will be displayed and the screen will return to the main menu
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 2 types of therapies are displayed
Post Condition	After session the system will display 'session end' and then will return to the main menu
Includes	N/A
Extends	Pause
Assumptions	Phone is properly mounted inside the headset

Table 4-5 UseCase5

Use Case 6

Use Case	database
Actors	Secondary actor
UseCase	This use case will help the user to connect with the database of system

Description	Database entry of the therapies
Normal Flow	User will be directed to database by selecting any therapy
Alternative Flow	N/A
Pre-condition	Database is correctly fed into the system
Post Condition	It provides the relevant output
Includes	N/A
Extends	N/A
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.
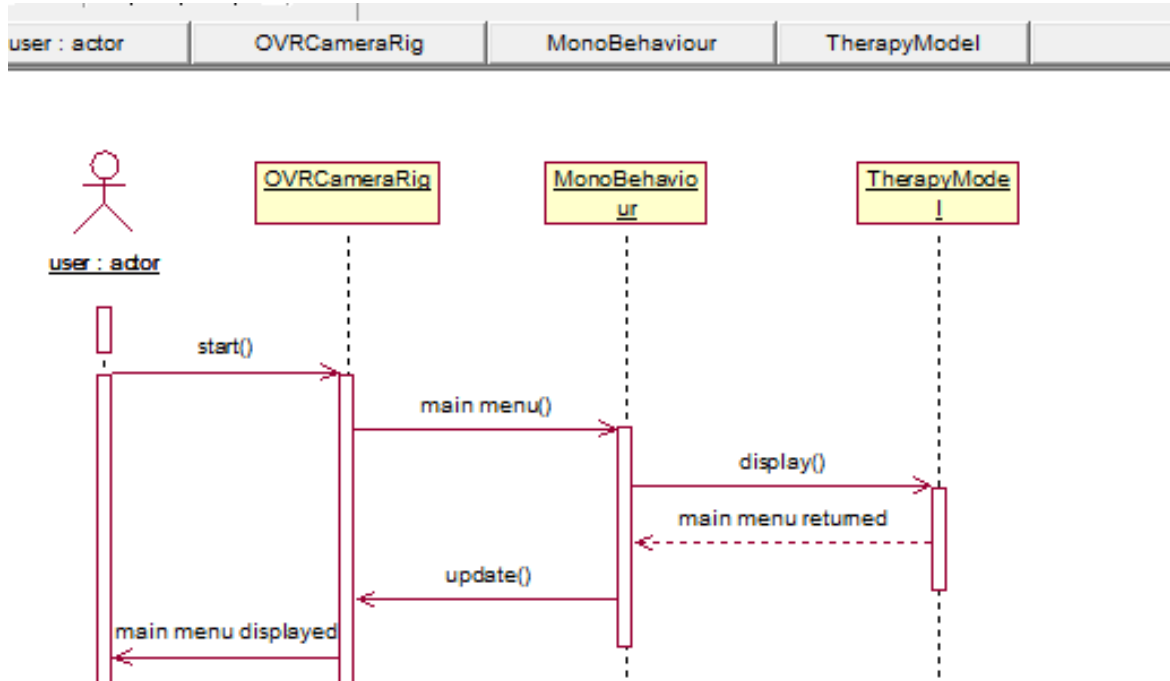
Figure 4-4 Sequence Diagram (Main Menu)

Figure 4-4 shows the sequence of steps that follows when a user 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.
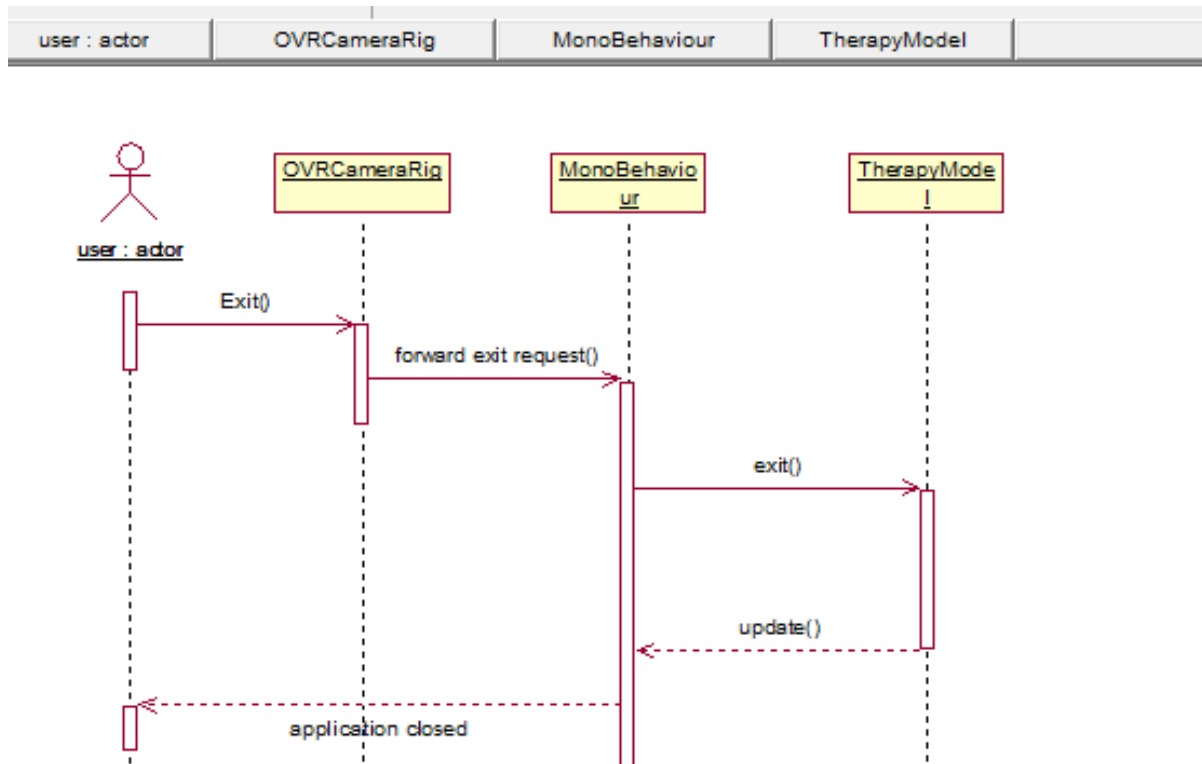
Figure 4-5 Sequence Diagram(Exit)

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.
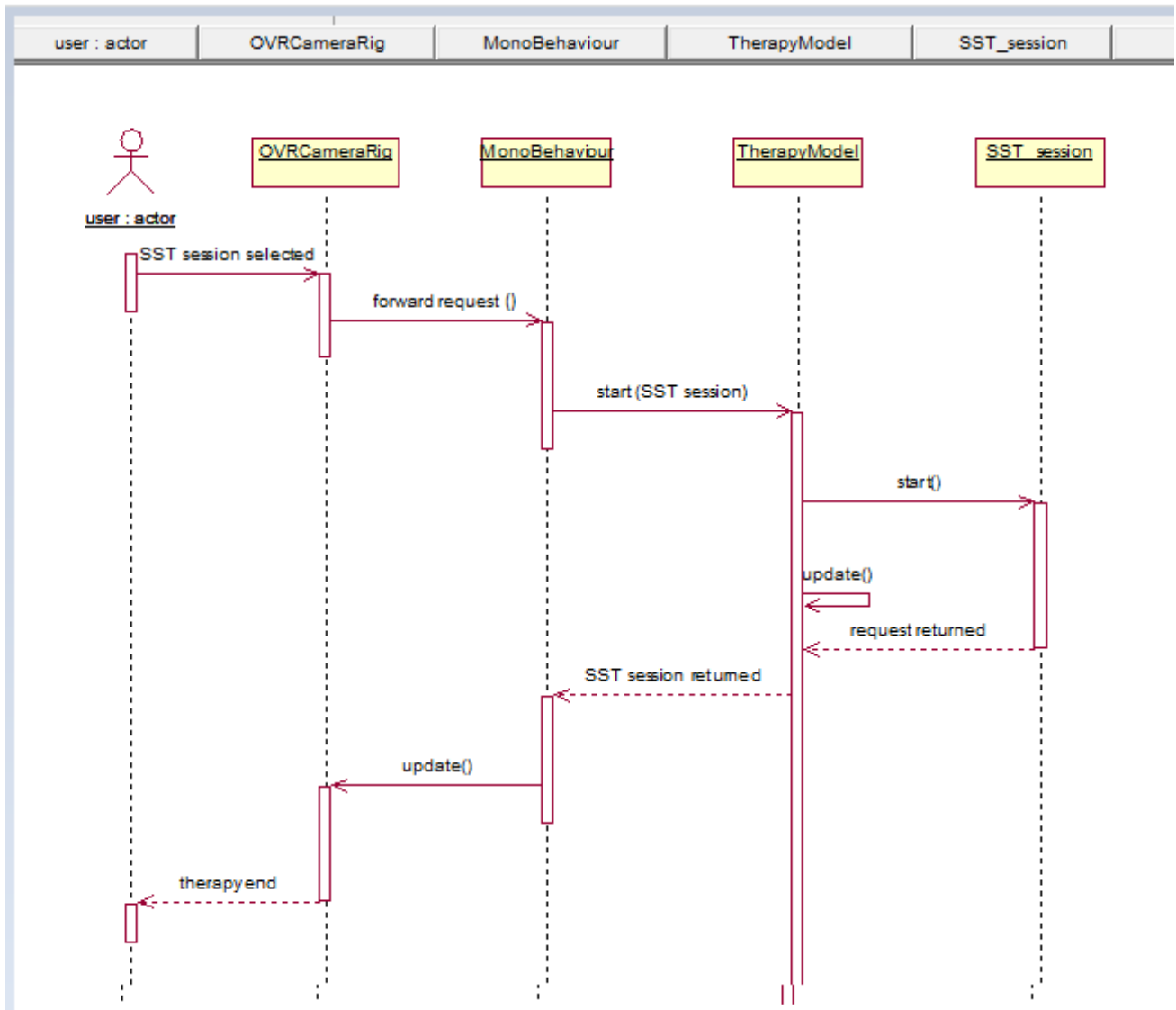
Figure 4-7 Sequence Diagram(Therapy 1)

Figure 4-7 shows how user can go to list of therapies available in the application from main menu and how he can select SST therapy from there and how control is shifted back and forth between view and model by controller.
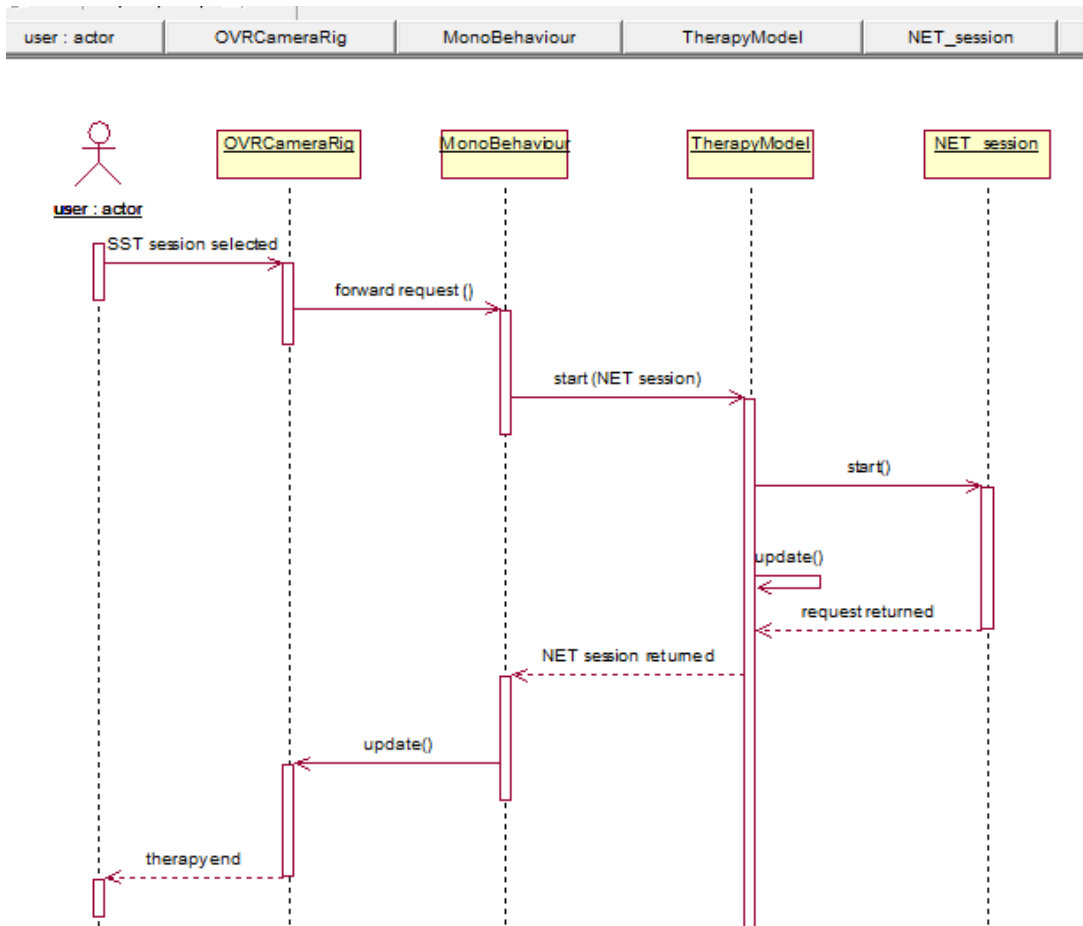
Figure 4-8 Sequence Diagram(Therapy 2)

Figure 4-8 shows how user can go to list of therapies available in the application from main menu and how he can select NET therapy from there and how control is shifted back and forth between view and model by controller.
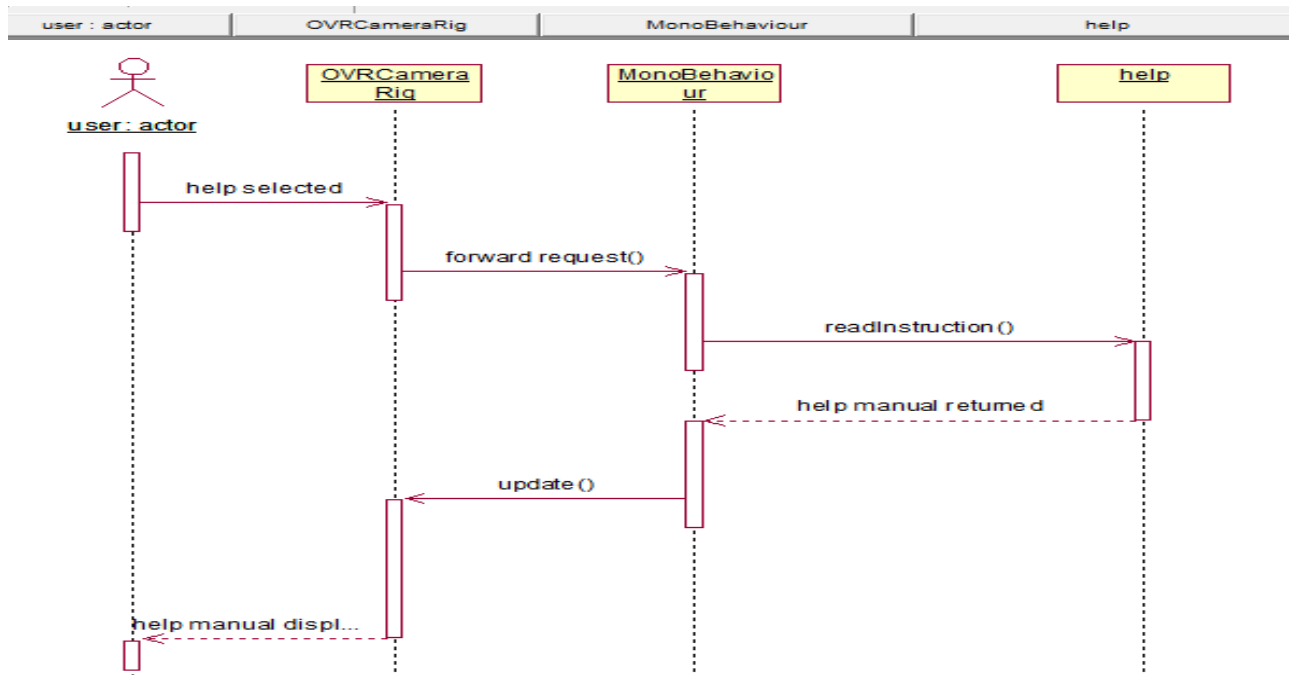
Figure 4-9 Sequence Diagram (HelpMenu)

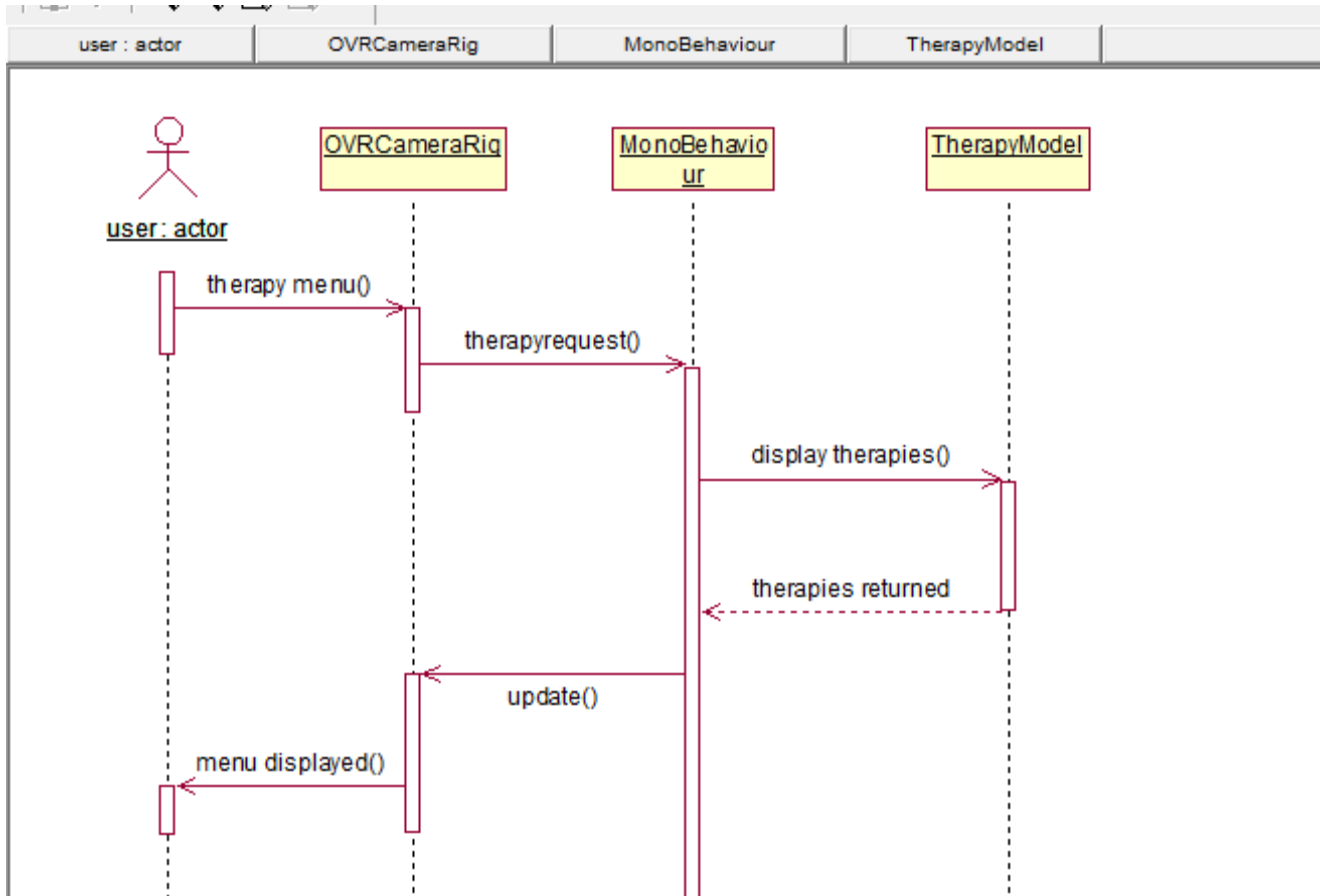Figure 4-9 shows how user can go to instruction manual available in the application from main menu and how control is shifted back and forth between view and model by controller.

Implementation View (Class Diagram)
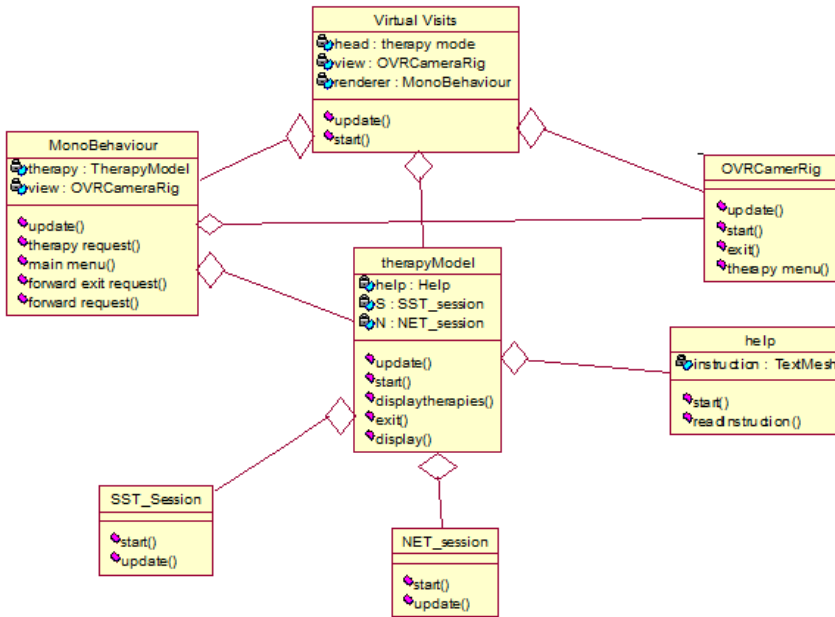
Figure 4-10 Class Diagram

<u>**Class's description**</u>

Name	Description
Aid for Autistic children using VR	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.
SST_Therapy	Social Skills Training. This class contains all the functions that deal with the animations, GUI and physics components of this particular therapy. An exercise that will help children learn some of the important social skills by showing them a virtual scenario of some daily routine activities.
NET_Therapy	Natural Environmental Therapy.This class contain all the function that deal with the animations, GUI and physics components of this particular therapy. It contains a visual representation of an environment and let children learn basic rules of that environment.

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.
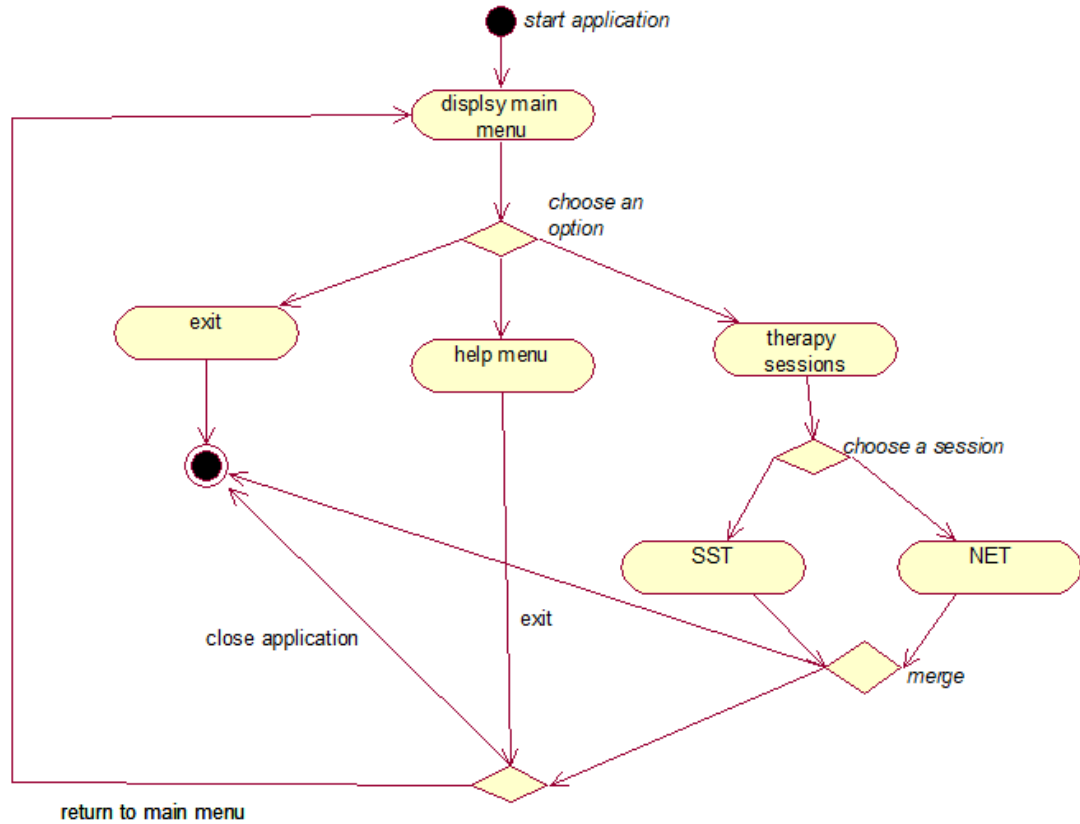
Figure 4-11 Activity Diagram

State Transition Diagrams (Logical view)

In this section, state transition of application is shown and how flow changes to other states.
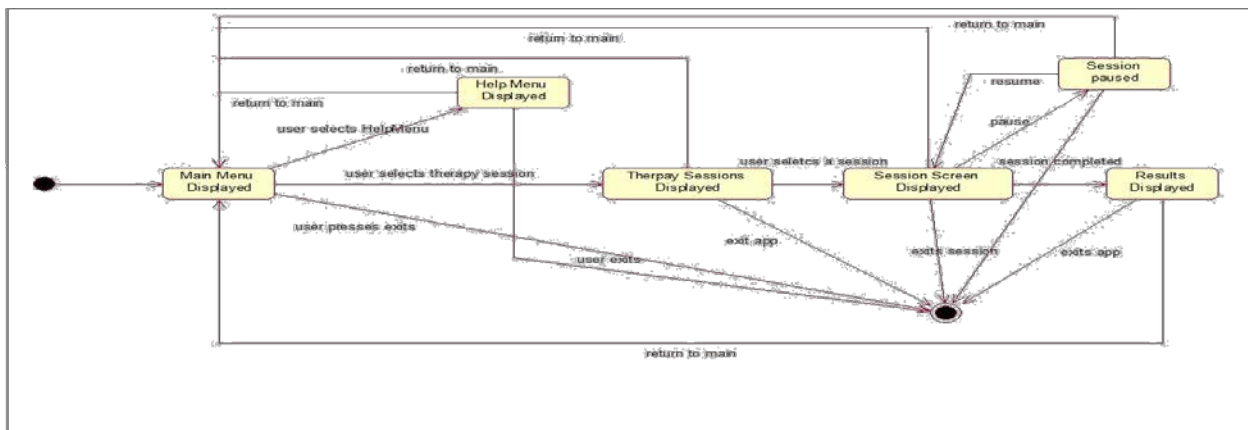
Figure 4-12 State Transition

Work Breakdown Structure
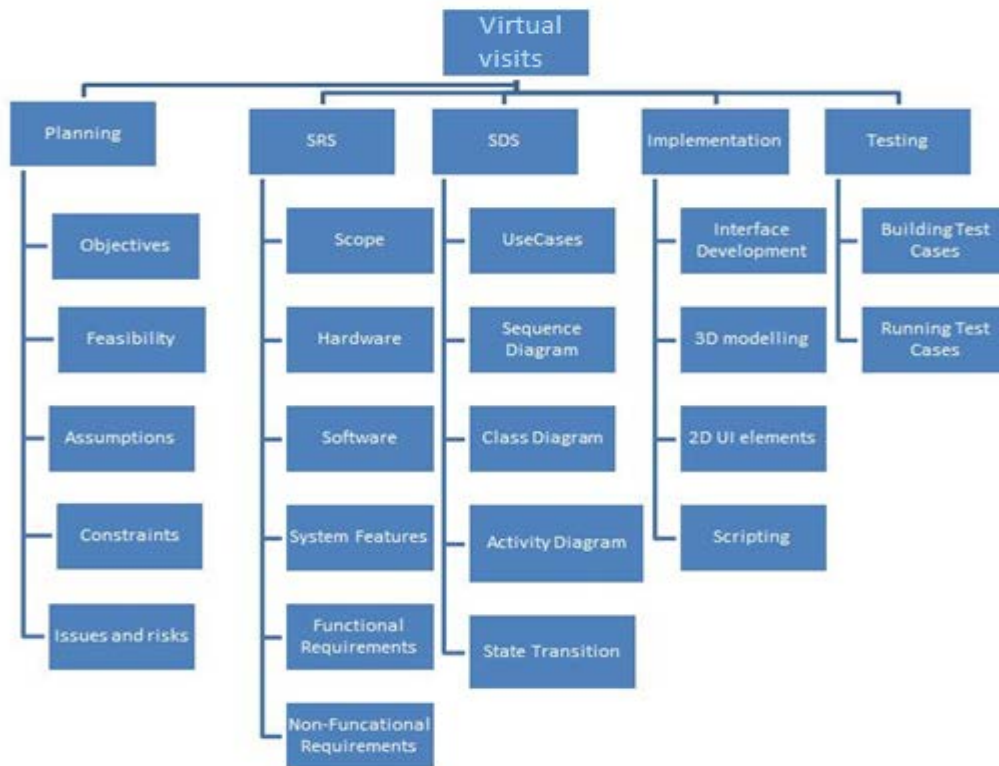
Figure 4-13 Work Breakdown Structure

Work Breakdown structure of our application has been shown in Figure 4-13. It shows in what phase's application has been developed and sub phases required for its completeion. Figure 4-14 shows the structure chart of the application that we've developed.

Structure Chart
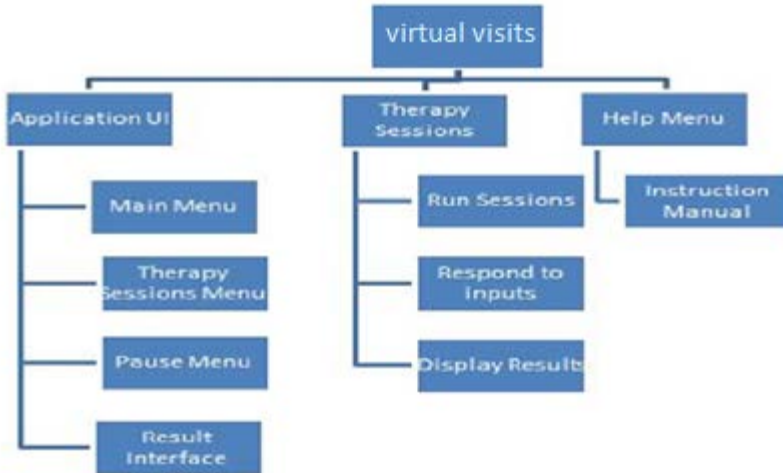
Figure 4-14 Structure Chart

4.4.2 Detailed Description of Components

This section describes in detail all components of Smart therapy system powered by 'Aid for Autistic children using VR' 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 and head 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 .

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 gestures).

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

'Aid for Autistic children using VR' 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

'Aid for autistic children using VR' 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

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time which directly affects the experience of the target user besides this, poor designs make testing and maintenance activities difficult.

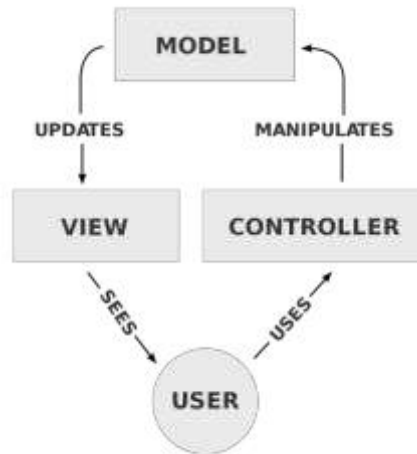MVC pattern will be used for the implementation of this application. General behavior of MVC is shown below.

Figure 4.15 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 "Aid for Autistic children using VR". The test plan will ensure that project 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.   User shall be able to exit the session and move to main menu when required
7.   Choosing Help Menu option shall show Instruction Manual.
8.   All therapy sessions shall be working correctly
9.   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 the project 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	Main 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	Main 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.Natural Environment Therapy 2.Social Skills Therapy 3. Return to main menu 4.Exit

Status	PASS

5.7.6 Therapy 1

Test Case ID	**TC 6**
Description	This will test whether Natural Environment therapy works correctly, i.e. therapist 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 Therapy 1 from Therapy Sessions Menu.
Expected output	Shopping Mall scenario will be displayed and user (Autistic child) will be able to observe the environment. Once he's comfortable with it he'll more to the next level introducing more things to the same scenario.

Actual output	Shopping mall scenario is displayed and therapy game is working fine.
Status	Pass

Table 5-6 TestCase6

5.7.7. Therapy 2

Test Case ID	**TC 7**
Description	This will test whether therapy 2 works correctly, i.e. therapist is able to control his gestures with controllers in game and is comfortable with the scenario being displayed on the VR screen.
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 therapy 2 from Therapy Sessions Menu
Expected output	Social skills therapy scenario is displayed on screen in a virtual environment with a time limit; user(Autistic child) shall get comfortable with it over the time. It shouldn't be expected that the child will be comfortable in the first session. It may vary.
Actual output	Social skills therapy is displayed and therapy game is working fine
Status	Pass

Table 5-7 TestCase7

5.7.8 Return to Main Menu Feature

Test Case ID	**TC 8**
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 5-8 TestCase8

5.7.9. Pause/Resume

Test Case ID	TC 9
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 5-9 TestCase9

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.

Chapter 7. Conclusion

By utilizing the modern technology features, we have developed an application addressing the diverse needs of autistic children focusing on improving their behavioral symptoms and social skills. It was designed and evaluated with the collaboration of autistic children, their therapists and parents having hands on experience in dealing with Autism, to ease them in the times when they are overwhelmed by their environments as well as to calm them down. The preliminary results of application evaluation showed the promising effectiveness of developed application in advancing in the overall improvement of the interaction with people and environment of Autistic children which otherwise took long and caused harm and difficulty for children and their caretakers.

The initial evaluation yielded that both the user interface design and learning content structure of application fulfills the elicited requirements of autistic children .Since the application implements the real life scenarios in the virtual environment, therefore it is expected to prove as an efficient and cost-effective technology-based therapy system, affordability and accessibility.

Appendices

Appendix A: Glossary

1. **APP:** Application
2. **GUI:** Graphical User Interface
3. **SDS**: Software Design Specification
4. **SRS**: Software Requirement Specifications
5. **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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