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FACULTY OF ENGINEERING
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Project Report
Version 1

CENG 407
Innovative System Design and Development I

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VRelax: Investigation of Relaxing

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Abstract

Anxiety is a crucial disease for the people which is not only a problem that decreasing patients' life quality, but also challenging situation for psychologists who are trying to examine this kind of patients. This project creates an opportunity for psychologists to understand these patients' stressful moments, at the same time, allows patients to relax themselves on their own. Main purpose of this project is to detect participant's stress level, and try to reduce stress with relaxing scenarios. Because of the advanced sense of reality that VR headsets provide, VRelax can comfort participants more effectively than trying to comfort the participant via talking with him/her. Project's main working principle is based on voice analysis process that a virtualized system created in a game engine will use this process to maximize utility, so participant shall be able to interact with the environment with different functional capabilities while analyzing stress. These interactions of participant and scenarios make the created world is more realistic to the participant which with this sense of reality makes reducing of stress relatively easy.

Key words:

Virtual Reality, HTC Vive, Voice Analysis, Relaxing Scenario, Investigation of Relaxing

Özet:

Kaygı insanlar için önemli bir rahatsızlıktır ve sadece hastaların yaşam kalitesini düşüren bir sorun değil aynı zamanda bu tür danışanları tedavi etmeye çalışan psikologlar için de zorlu bir durumdur. Bu proje, bu tür rahatsızlığı olan hastaların stresli anlarını analiz etmek için psikologlara bir fırsat yaratmakta, aynı zamanda hastaların kendi başlarına rahatlayabilmelerini sağlamaktadır. Bu projenin temel amacı ise katılımcının stres düzeyini saptamak ve rahatlatıcı senaryolar sayesinde stresi azaltmaya çalışmaktır. VRelax, sanal gerçeklik gözlükleri ile sağlanan gerçeklik duygusu sayesinde katılımcıyı sadece konuşarak rahatlatmaya çalışmaktan daha etkili bir çözüm sunar. Projenin temel çalışma prensibi, bir oyun motoru yardımıyla oluşturulan sanal bir sistemin, yararlılığı en üst düzeye çıkarmak için ses analiz sürecini kullanmaya dayalıdır. Böylece katılımcı, stresi analiz edip ölçerken çevre ile farklı etkileşimlerde bulunabilecektir. Katılımcının senaryolardaki bu etkileşimleri ve senaryoların kendisi, bu yaratılan dünyayı daha gerçekçi kılarak stresin azaltılmasını daha kolaylaştırır.

Anahtar Kelimeler:

Sanal Gerçeklik, HTC Vive, Ses Analizi, Rahatlama Senaryosu, Rahatlamanın İncelenmesi

1. Introduction

1.1 Company Background

Turkey's radical, visionary and domestic IT software company Mebitech Bilişim was founded in 2012. It has taken its place in the market since the day it was founded and improved itself throughout the time according to the requirements of new technology and market. In the corporate risk management applications, with the internationally accredited cloud (Data Center) located in Ankara and Istanbul, large number of customer services like Business Continuity are also provided by Mebitech.

This project is given to us by Özlem Albayrak who works as principal researcher at Mebitech Bilişim.

1.2 Problem Statement

Stimuli cause strong pressure for patients suffering intense anxiety problem. This pressure makes patients so stressful for psychological treatment, as well as, makes hard for patient to handle these stressful moments on his/her own. This project proposes new aspect to treat intense anxiety problem. This project provides the solution for patients to relax themselves on their own, and assists psychologists to understand patients' stressful moments. One ability of VRelax is detecting of participant's stress level automatically which also eliminates the need of manual intervention by external system or user, and simplifies using of this system. After detecting critical stress interval for participant, VRelax automatically start the relaxation scenario including visual and audio contents.

1.3 Related Work

There are some projects related with both voice analysis and virtual reality interaction, which are used as a guide/contribution/perspective for this project. One of these projects is "Speech Analysis Using Teager Energy Operator" which is also pointed in literature review as: "Teager pointed that analyzing speech signals according to energy required to generate signals." [1]

Another project related with this study is “Speech Stress Analysis based on Lie Detector for Loyalty Test”. This project is also mentioned in our literature review [10]. We have also found products that are directly related with the relaxing VR environment which are Relax VR which uses 360-degree videos to relax users [2], MonarchVR which is a mobile environmental and meditation application that gives the experience of being surrounded by monarch butterflies [3], and Atmosphaeres which are relaxing 360-degree spherical videos that provide relief from stress, anxiety & pain [4].

1.4 Solution Statement

Project aims to develop Unreal Engine VR Application that involves multiple relaxation scenarios to help consultants comfort themselves easily with experiencing their favorite sights and by recognizing their voice; analyze their stress amount and make inferences from it.

The solution for our main problem, stress analysis and reducibility, we will create interactive scenarios that will analyze the stress amount of the participant at the same time. Ability of VRelax is detecting of participant’s stress level automatically that eliminates manual intervention and make opportunity for the psychologists to understand participants stress better.

For the most important difficulties of the project which is creating realistic environment and combining stress analysis structure with these environments, we will search and find realistic objects with low polygons (sacrifice some quality for better performance) and if we cannot find suitable objects or textures, we will create objects and textures with the help of tools like Blender or Substance Painter which we expressed some of these tools throughout this report. Documentations, tutorials and helpful training videos will be useful to apply these solutions.

1.5 Contribution

In our researches we have found no VR application that uses speech recognition and signal processing to measure stress level. According to stress level application makes deductions and suggest suitable actions. It makes relaxing easier and more meaningful with analyzed data. This project could be improved for other psychologic treatments like fears or disorders.

2. Literature Search

2.1 Introduction

VRelax is the virtual reality (VR) project which is developed for patients who suffer exam anxiety. VRelax aims to detect stress level of participant via voice analysis and start the relaxing scenario for stressed participants.

Recent studies -pointed through this review- proved that emotions felt by people, basically, depend on the level of stimuli which indicate the changing of person's emotion. Changing of emotions can be detected by various methods specialized for special purposes. Because, VRelax needs to detect user's voice activity real time; Empirical Mode Decomposition (EMD) is the most appropriate method to detect voice signals. This method -including many different methods- is explained in detailed through this paper.

2.2 What is stress?

In short, stress is the disruption of homeostasis [5]. This disruption can occur for two reasons such as psychological stimuli and physical stimuli. These stimuli can be very different factors around us. High level noise, extremely hot and/or cold degrees can be given as examples to physical stimuli; various emotions and insomnia are examples to psychological stimuli. According to Hans Seyle (2011), stress is divided into three stages:

1. Alarm stage:
   1.1. Body identifies stressor.
   1.2. Adrenaline and cortisol (also known as stress hormone) are produced.
2. Resistance stage:
   2.1. Body tries to handle stress by using its resources.
3. Exhaustion stage:
   3.1. Body's resources are run out [6].

Stress increases muscle tension of all muscles of the body, including vocal chords. Therefore, production of speech is affected directly or indirectly because of tension -which leads effects on physiological microtremor that is present in speech-. Microtremor is, in short, low amplitude oscillation of reflex mechanism, and it controls the tension and the length of stressed muscle. Microtremor occurs because of finite transmission delay between neurons

to/from muscle. With the frequencies of microtremors, stress levels can be classified (such as 8-12 Hz. freq. for stressed person) [6].

2.2.1 Theory of Voice Stress Analysis

There is a basic term for all voice stress analysis processes, which is micro-muscle tremors (MMT). These microtremors also occur in muscles used to generate sound while producing speech. Vibration in 8 to 12 Hz range is valid for every muscle in the body, including vocal chords; and this range points the relaxed (neutral) voice [8]. Analysis process is accomplished by using different databases. The most known database is SUSAS (Speech Under Stress Database). This database includes five domains, consisting of various of stress and emotions. 44 speakers generated 16,000 isolated-word utterances. These five stress domains are:

1) Psychiatric Analysis Data (speech under fear, anxiety, and depression)
2) Talking Styles (fast, slow, soft, angry, loud, question, clear)
3) Single tracking computer response task or speech produced in noise (Lompard effect)
4) Dual tracking computer response task
5) Subject motion-fear tasks (G-force, Lompard effect, noise, fear) [9]

2.3 Similar Works

2.3.1 Speech Analysis Using Teager Energy Operator

Teager pointed that analyzing speech signals according to energy required to generate signals. He also derived a nonlinear energy-tracking operator which is Teager Energy Operator (TEO). According to He, Lech, Memon, and Allen (2008), "The production of a speech signal could be regarded as an effect of amplitude and frequency modulation of separate oscillatory waves in the vocal tract. Therefore, speech signals could be modelled as a combination of several amplitude and frequency modulated (AM-FM) oscillatory components." [1].

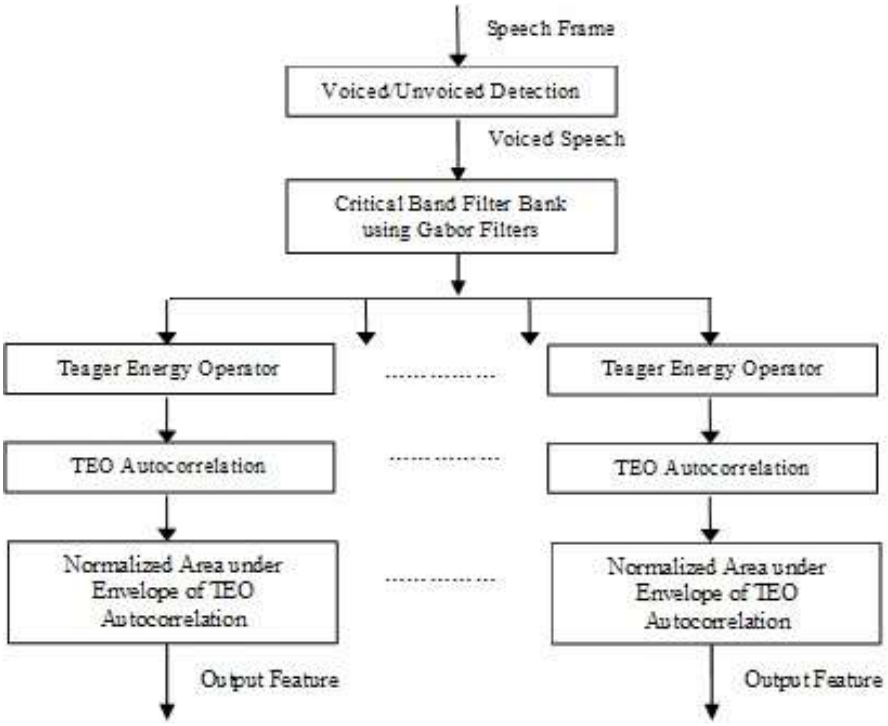

Figure 1: Flowchart of the TEO-CB analysis

2.3.2 Speech Stress Analysis based on Lie Detector for Loyalty Test

Lie detectors are used in especially military-based organizations. Blood pressure, ECG (pulse), EEG, number of eyes blinking per minute, lip movements, leg and hand movements are critical resources to find the result. Software application used for this system is focused on

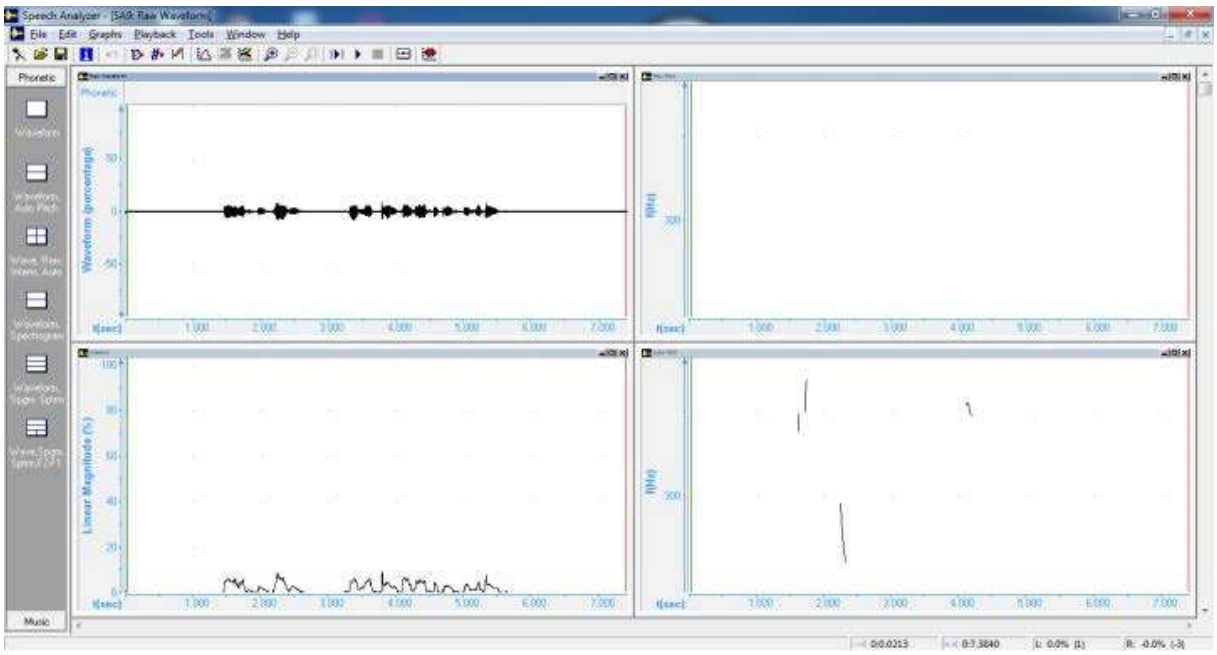

Figure 2: Police Enquiry (Police Voice)

computer network system and neural network of human being [10]. Sample process is shown below:

"Police Enquiry Question: When you plan to rob the cash from the bank? Normal Person: No sir, I came to deposit the cash, in the meanwhile they tried to snatch the cash from the casher. Liar: I was not in the picture." [10]

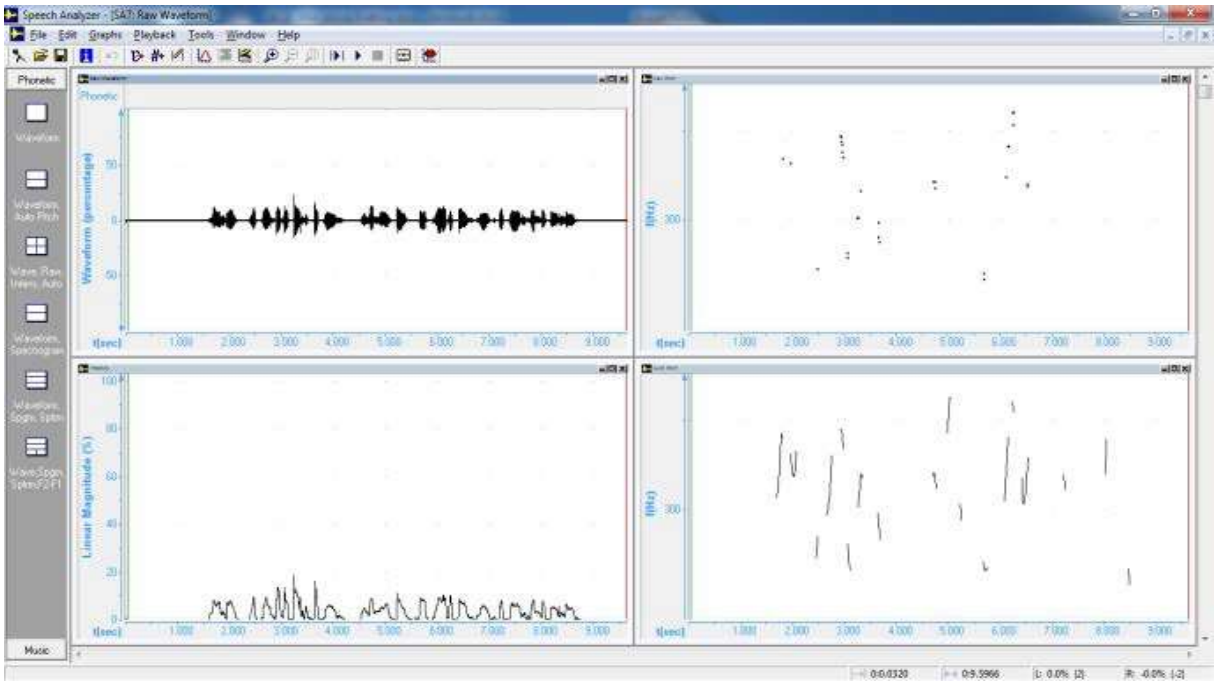

Figure 3: Voice Speech of a Normal Person (Normal Pitch)

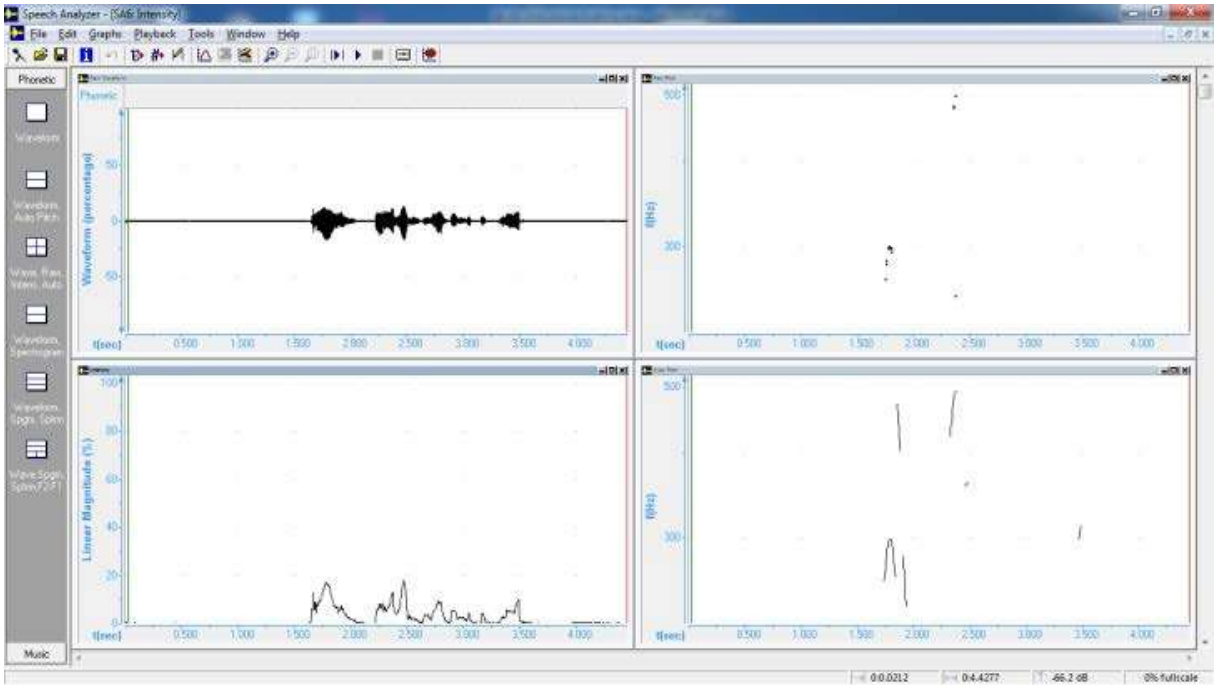

Figure 4: Voice Speech of an Abnormal Person (High Pitch)

2.3.3 Empirical Mode Decomposition

We know that analyzing voice stress is a critical process for various areas like law enforcement and military. While analyzing voice of an individual, we should also consider detection of deception. Therefore, using physiological microtremor with other voice characteristics such as tone and pitch (knowledge of tremors with the signal processing) for VSA (voice stress analysis) products is much more suitable process [6].

EMD (Empirical Mode Decomposition) is based on analyzing physical characteristics of the signal within divided time pieces. These decomposed numerous signals are known as IMFs (Intrinsic Mode Functions). These sets of signals must meet with following two conditions, according to Mbitiru, Tay, Zhang, and Adams [7]:

"1. The number of extrema and number of zero crossings throughout the dataset must either be equal or differ by one at most."

"2. At any point, the mean value of the envelope defined by local maxima and the envelope defined by the local minima is zero."

2.4 Stress in VR Environment

Stress and stress related problems such as fears and anxiety, are most common troubles that people must deal with in their lives. Nowadays, because of the stress that its levels rise for different reasons, the quality of people lives decreases and their personal and professional lives are negatively affected [11]. Virtual reality is used in many therapies in recent years [12] thus it is possible to reduce stress with the use of this technology too [13]. This method is called virtual reality therapy -which is also known as VRET (Virtual Reality Exposure Therapy)- is a kind of occupational or psychological therapy which is used with the technology of virtual reality. In this kind of therapy, patients present in a digitally created environments and complete their special tasks. It is a proved effective way [14] at treating PTSD (Posttraumatic Stress Disorder) as well as widely used as an alternative way of exposure therapy.

Virtual reality therapy has been found useful in many stress related phobias [15] [16] but not all researches met the methodological criteria and it should be noted that none of these studies eliminated stress for all consultant people [17] [18]. Generally, most of them helped to reduce stress and other related anxiety and phobias. According to cyberpsychology science paper [19], people who suffers from PTSD, experience many different simulation stories

throughout the VR therapy session and when participants' traumatic memories triggered, therapists tries to match the virtual environment with the real events. After the examination of which event or stimuli triggered the trauma on the participant, therapists try to calm down the participant and focus the event. With these therapies [19] patients experienced average of %40 decrease on the PTSD that they encounter.

There is a software called "Bravemind" shown in *Figure 5* which is a VR exposure therapy software created at the USC Institute for Creative Technologies [20], consists of several scenarios specifically for post-traumatic stress and distributed to many hospitals, military bases and university centers to produce meaningful reduction in stress related syndromes.

Figure 5: Bravemind Screenshot

There are some ethical and legal problems however according to Yellowlees, Holloway and Parish [24]. Article states that these kinds of applications used in mental health could cause ethical and legal problems due to its different clinical techniques. Treatment standards and ethical guidelines must be applied like that occurring in the real-world. "In any clinical setting, clinicians must follow the laws of their field and other existing guidelines." Security, privacy and confidentiality must be maintained and even if it's a non-real environment and scenario, the patient must be informed of any exception to confidentiality.

2.4.1 Using Game Engine to Create Realistic Environment

Researchers who want to create an environment in VR for the purpose of clinical simulations must deal with some problems [22]. These kinds of simulations require good real-life looking graphics and realistic effects and physics. Creating an entire software platform is hard to do so most of the developers use game engines for creating the world they want. One current engine for VR development that meets all the problems above is Unreal Engine from Epic Games. Unreal Engine is an open source game engine, so developers can edit existing functionalities and create new ones. They can simulate new scenarios or can take a base scenario created by thousands of people on the web.

3. Software Requirements Specification

3.1 Introduction

3.1.1 Purpose

The purpose of this document is describing the VR application which is called VRelax: Investigation of Relaxing. This application aims to reduce stress with relaxation scenarios to help consultants comfort themselves easily with experiencing their favorite sights and by recognizing their voice; analyze their stress amount and make inferences from it to analyze stress better. This document includes detailed information about requirements of the project. It explains user characteristics, software and hardware requirements, interfaces, project development methodologies. This document identifies the concerns of the stakeholders and how users interact with the application.

3.1.2 Scope of Project

Staying calm under effects of strong stimuli is not an easy challenge for patients who suffer intense anxiety problem. This issue makes almost impossible to do psychological treatment under stressful conditions, at the same time, it makes so difficult for patient to maintain these intense stressful situations on his own. This project allows psychologists to understand their stressful moments, and patients to relax themselves on their own.

VRelax aims to detect participant's stress level, and automatically start relaxing scenario. Due to the advanced sense of reality that VR headsets can provide, VRelax can comfort participants more effectively than trying to comfort the participant via talking with

him/her. Because of its advanced technical features according to other VR systems in the market, and its fully functional supportive properties for Unreal Engine; HTC Vive headset is used for this project.

VRelax will automatically detect the stress level of participants via their voice signals. This functionality will eliminate the need of manual intervention by external system or user, and simplifies using of this system. After detecting critical stress interval for participant, VRelax automatically start the relaxation scenario including visual and audio contents.

3.1.3 Glossary

Table 1 Glossary of SRS

Term	Definition
Participant	The user who interacts with the simulation environment. Mostly students in this case.
Stakeholders	Person who contributes anything to the project.
Virtual Environment	Computer-generated, three-dimensional representation of a real world.
Virtual Reality (VR)	A realistic and immersive simulation of a three-dimensional environment which the user interacts.
Voice Recognition	The computerized analysis of spoken words to identify the speaker [1].
Voice Stress Analysis (VSA)	Deception of stress measured in the voice using voice recognition.
HTC Vive	Head-mounted virtual reality glasses with motion sensors
Stimuli	An event or a thing that evokes a reaction in a person

3.1.4 References

[1] Dictionary.com "speech recognition," in Dictionary.com Unabridged. Source location: Random House, Inc. http://www.dictionary.com/browse/speech-recognition. Available: http://www.dictionary.com/. Accessed: November 14, 2017.

3.1.5 Overview of Document

The remainder of this document includes two parts. The second part of the document provides overall description about VRelax: Investigation of Relaxing including development methodology and user characteristics. The third part explains functionalities of VRelax: Investigation of Relaxing. Brief descriptions are provided, and use cases explained in detail with diagrams. This section also includes software system attributes described in technical terms.

3.2 Overall Description

3.2.1 Product Perspective

VRelax: Investigation of Relaxing is a VR application that has the purpose of detecting voice signals, analyzing stress from those signals and reduce stress with scenarios created in virtual environment. Application includes different environments to reduce stress and for measuring stress it uses voice signals. The project can be divided into two parts: stress analysis with voice and reducing stress with simulations in VR. Application measures stress from participants voice and tries to reduce it with built-in scenarios.

3.2.2 Development Methodology

For developing our project, we chose to use Scrum which is an agile development methodology. Scrum is based on short cycle output and feedback generations. It aims developing most important requirements for the project and with this methodology we can easily apply changes needed throughout project development process. In Scrum workload is divided into sprints which is limited to one month or less. Every sprint has a definition of a design and stretchable plan that this plan will lead to next plan and eventually, conclusion of the product. Scrum comes with some responsibilities like development team should have a daily meeting for discussing what they did and what they will do next. Scrum allows teams to stay focus, collaborate and communicate more in fast changing project like ours and with these advantages, it is the best development methodology for developing VRelax.

3.2.3 User Characteristic

3.2.3.1 Participants (Generic User)

3.2.3.1.1 Participant must read English language due to stress analyze database is English.

3.2.3.1.2 Participant is expected to be able to use VR Application.

3.2.3.1.3 Participant is expected to be stressed for application to achieve its purpose.

3.2.4 Operating Environment

The application will operate on Microsoft Windows and will be exported to HTC Vive as VR application. Early production demos and prototypes will be worked on only Microsoft Windows without VR.

3.3 Requirements Specification

3.3.1 External Interface Requirements

3.3.1.1 User Interfaces

The only user interface the application has is the main menu and the GUI in the scenarios. They both will be built-in to the application and will be worked on Microsoft Windows.

3.3.1.2 Hardware Interfaces

Scenarios requires HTC Vive. HTC Vive requires necessary drivers installed for Windows and 1 USB and HDMI port to work.

3.3.1.3 Software Interfaces

There is only operating system to make connection and there is no external software to communicate so there are no external software interface requirements.

3.3.1.4 Communications Interfaces

An internet connection is not required so there is no external communication interface.

3.3.2 Functional Requirements

3.3.2.1 Main Menu Use Case

Use Case:

- Start Voice Test
- Apply Automated Scenario
- Choose Scenario
- Start Selected Scenario
- Change Volume
- Exit

Diagram:

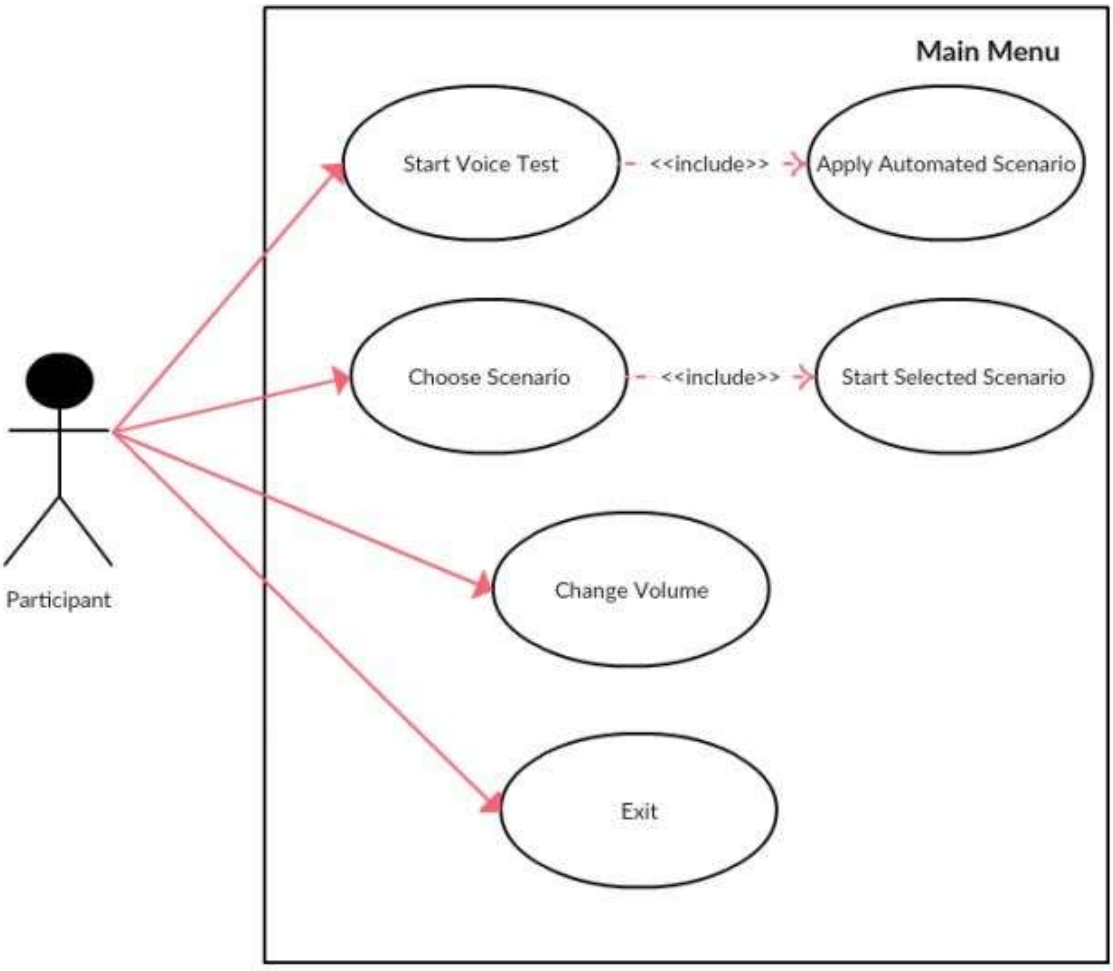

Figure 6: Use Case Diagram of Main Menu

Brief Description:

In the Main Menu Use Case diagram above (*Figure 6*), basic operations -that participant can do- are represented. Participant would choose from four distinct functions (and two additional included function), which are Start Voice Test, Apply Automated Scenario, Choose Scenario, Start Selected Scenario, Change Volume, and Exit functions.

Initial Step by Step Description:

1. Participant shall start voice test to stress analysis.
   1.1. If participant presses Start Voice Test button, then participant shall be redirected to voice test screen.
   1.2. Participant shall apply a scenario that will automatically start if participants stress level crosses the pre-defined level.
2. Participant can choose from two different relaxing scenarios which shall be visible with their thumbnails.
   2.1. Participant shall select the relaxing scenario that s/he desires. Then s/he can start the selected scenario.
3. Participant shall determine the volume level.
   3.1. If participant presses "+" button, voice level shall increase up to maximum voice level.
   3.2. If participant presses "-" button, voice level shall decrease up to minimum voice level.
4. Participant shall exit from the system.
   4.1. If participant presses Exit button, then VRelax: Investigation of Relaxing application shall terminate.

3.3.2.2 Seaside Scenario Use Case

Use Case:

- Throw a Rock
- Show Words
- Hide Words
- Teleport to a Location
- Exit

Diagram:

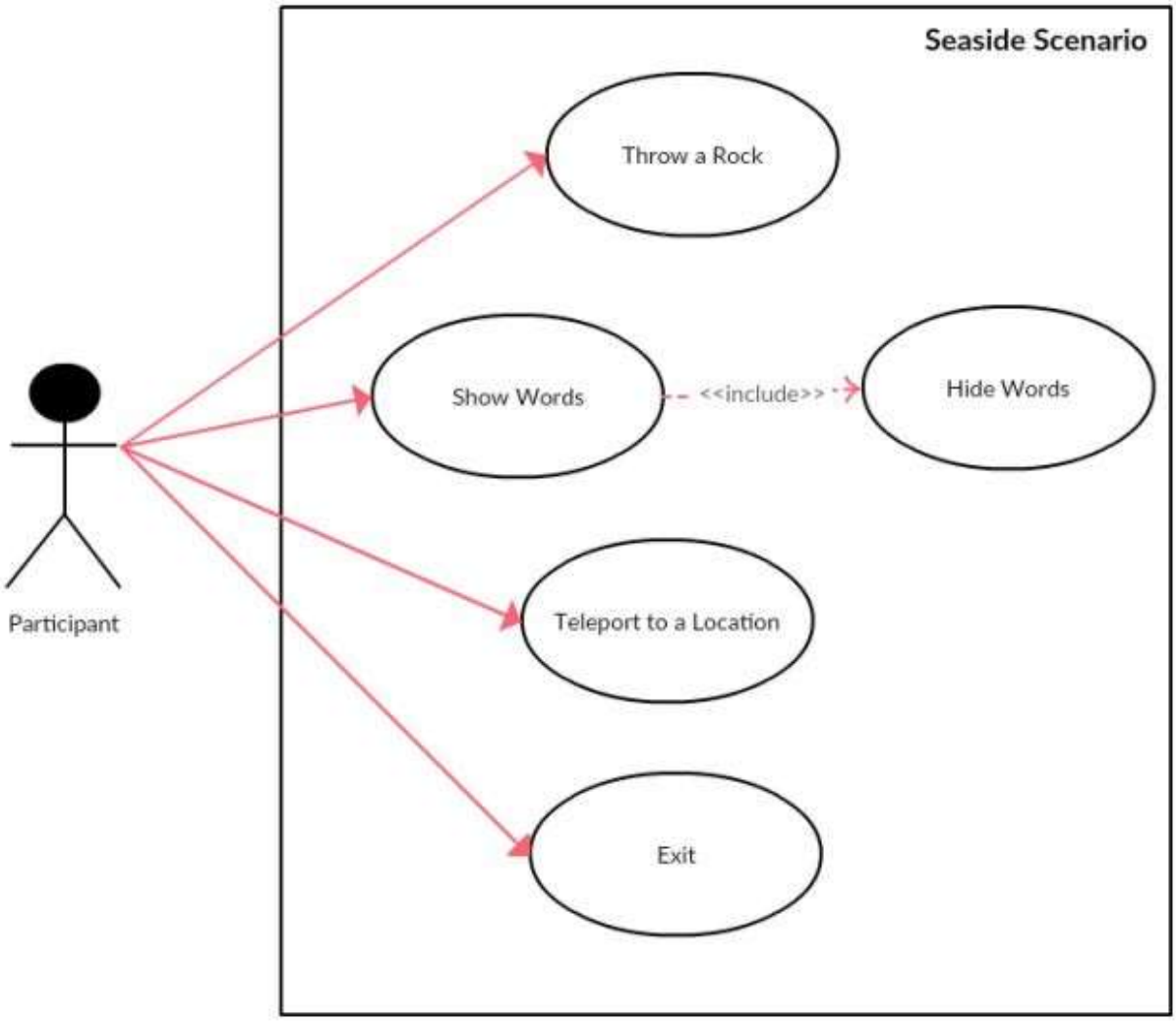

Figure 7: Use Case Diagram of Seaside Scenario

Brief Description:

In the Seaside Scenario Use Case diagram above (*Figure 7*), basic operations -that participant can do- are represented. Participant would choose from four distinct functions (and one additional included function), which are Throw a Rock, Show Words, Hide Words, Teleport to a Location, and Exit functions.

Initial Step by Step Description:

1. Participant shall throw a rock into the sea to interact with the environment.
   1.1. If participant doesn't hold the rock inside his/her hand, s/he shall get the rock by pressing trackpad button.

1.2. If participant holds the rock inside his/her hand, then s/he shall throw a rock by pressing trackpad button.

2. Participant shall show the words that shall be used as stress analysis material.
   2.1. Participant can choose to hide words to continue with opened scenario.
   2.2. Participant can choose to show hidden words to continue voice test within the opened scenario.
3. Participant shall teleport to the location that s/he desires.
   3.1. If participant holds down the trigger button, a teleport location indicator shall be shown on the virtual environment.
   3.2. If participant releases the trigger button, participant shall be teleported to selected location.
4. Participant shall exit from the scenario.
   4.1. If participant presses Exit button, then s/he shall be redirected to Main Menu and opened scenario shall be closed.

3.3.2.3 Creek in a Forest Scenario Use Case

Use Case:

- Collect Fruit
- Eat Fruit
- Show Words
- Hide Words
- Teleport to a Location
- Exit

Diagram:

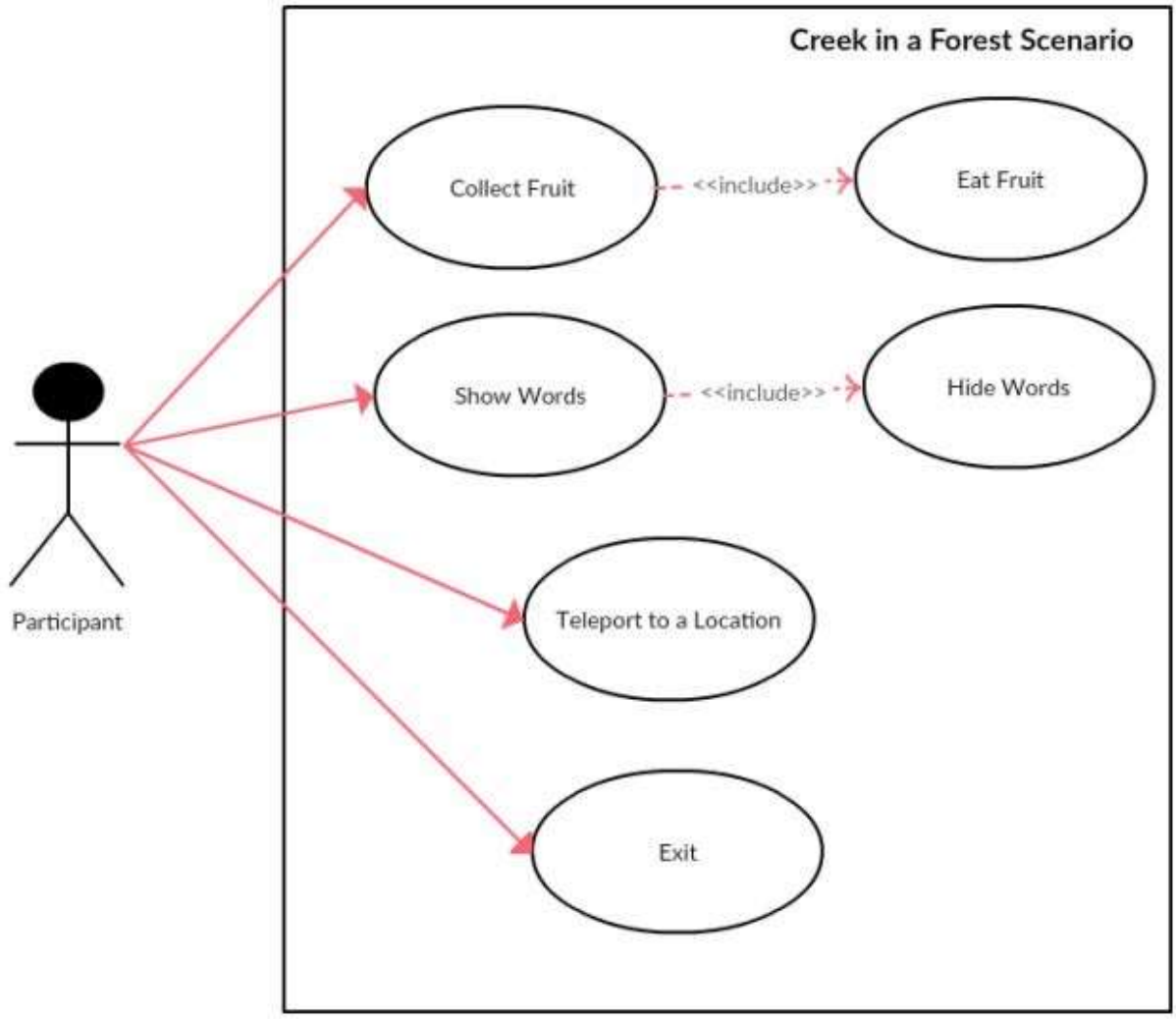

Figure 8: Use Case Diagram of Creek in a Forest Scenario

Brief Description:

In the Creek in a Forest Scenario Use Case diagram above (*Figure 8*), basic operations -that participant can do- are represented. Participant would choose from four distinct functions (and two additional included function), which are Collect Fruit, Eat Fruit, Show Words, Hide Words, Teleport to a Location, and Exit functions.

Initial Step by Step Description:

1. Participant shall collect fruit(s) to interact with the environment.
   1.1. If participant doesn't hold the fruit inside his/her hand, s/he shall get the fruit by pressing trackpad button.

1.2. If participant holds the fruit inside his/her hand, then s/he shall eat the fruit by pressing trackpad button.

2. Participant shall show the words that shall be used as stress analysis material.
   2.1. Participant can choose to hide words to continue with opened scenario.
   2.2. Participant can choose to show hidden words to continue voice test within the opened scenario.
3. Participant shall teleport to the location that s/he desires.
   3.1. If participant holds down the trigger button, a teleport location indicator shall be shown on the virtual environment.
   3.2. If participant releases the trigger button, participant shall be teleported to selected location.
4. Participant shall exit from the scenario.
   4.1. If participant presses Exit button, then s/he shall be redirected to Main Menu and opened scenario shall be closed.

3.3.3 Performance Requirements

There are minimum requirements [23] to run a HTC Vive VR application smoothly:

- GPU: NVIDIA GeForce GTX 1060, AMD RX 480 equivalent or better
- CPU: Intel i5-4590/AMD FX 8350 equivalent or better
- RAM: 4 GB or more
- Video output: HDMI 1.4, DisplayPort 1.2 or newer
- USB port: 1x USB 2.0 or better port
- OS: Windows 7 SP1, Windows 8.1 or later, Windows 10

3.3.4 Safety Requirements

When using HTC Vive there should be an open space in the room to prevent any injuries caused by the obstacles and using a VR Headset for a long time can cause dizziness and motion sickness, so participants should take a break after 45 minutes of use.

The product may trigger epileptic seizures or other symptoms linked to an epileptic condition so participants who has a previous history of epilepsy should consult a doctor.

3.3.5 Software System Attributes

3.3.5.1 Portability

- VRelax: Investigation of Relaxing is designed for HTC Vive using Unreal Engine. The application can mainly be used with HTC Vive but it can work on other VR glasses like Oculus Rift. To do this simple changes and export operations can be integrated to the project with the help of Unreal Engine.

3.3.5.2 Usability

- When the scenario started an indicator will show the stress level in real time.
- In the "Creek in the Forest" scenario, amount of fruits will be limited to 20.
- In the "Seaside" scenario, rocks will be unlimited, so the participant can throw as many rocks as s/he wants.

3.3.5.3 Adaptability

- Acquired stress analysis data and the application itself shall be used in partially bound project KAYYEN [24]

3.3.5.4 Scalability

- Since only one participant uses the system at a time, there is no scalability requirement.

3.3.5.5 Performance

- Stress analysis should be done every second both in scenarios and voice stress analysis test parts of the system.
- Scale adjustments should be done in different locations in different scenarios.
- Level of detail should be changed according to distance for the sake of optimization.

3.3.5.6 Interoperability

- Future implementations of VRelax: Investigation of Relaxing which its interfaces, functions and configurations are completely understood and finished, should be work with bound project KAYYEN.

4. Software Design Description

4.1 Introduction

4.1.1 Purpose

The purpose of this Software Design Document is providing the details of project titled as “VRelax: Investigation of Relaxing”. This application aims to reduce stress with relaxation scenarios to help consultants comfort themselves easily with experiencing their favorite sights and by recognizing their voice. The target audience is people who suffer intense anxiety problem. This issue makes almost impossible to do psychological treatment under stressful conditions, at the same time, it makes so difficult for patient to maintain these intense stressful situations on his own. This project allows psychologists to understand their stressful moments, and patients to relax themselves on their own.

The purpose of VRelax project is to detect participant’s stress level, and automatically start relaxing scenario. Because of the advanced sense of reality that VR headsets can provide, VRelax can comfort participants more effectively than trying to comfort the participant via talking with him/her. VRelax has two main functions which are “Start Voice Test” and “Start Selected Scenario”. When “Start Voice Test” function is selected, participant shall be redirected to voce test screen to analyze his/her voice via making him/her read the specific words. If participant’s voice is considered as in the critical anxiety level, then -selected or default- relaxing scenario shall start. This auto-transition feature supplies participant/psychologist freedom that s/he does not have to manually start relaxing scenario. Moreover; this feature of determining participant’s stress helps psychologists to understand patient’s reactions to multiple stimuli. When “Start Selected Scenario” function is selected, participant shall be redirected to selected -or default- scenario. According to selected scenario, participant will be able to interact with the environment with different functional capabilities. In the Seaside Scenario; participant can throw a rock to the sea, show or hide words, teleport to the desired location, and exit from the scenario. In the Creek in a Forest Scenario; participant can collect fruit, show or hide words, teleport to the desired location, and exit from the scenario. These interactions of participant and scenarios make the created world is more real to the participant which makes participant easy to forget the stimulant(stimuli). With this sense of reality, relaxing participant becomes much easier.

This application will operate on Microsoft Windows and will be exported to HTC Vive as VR application. HTC Vive fully supports Unreal Engine. Moreover; its wide angle and technical specifications give advantage to HTC Vive according to other VR brands.

For better understanding of this application, this SDD paper include activity diagram, UML diagram, and block diagram.

4.1.2 Scope

This document is a written description of the design of VRelax: Investigation of Relaxing. It contains all relevant information about designing this application.

Creating an entire software platform from scratch is a hard work to do. Especially if it is a system that is a 3D environment including different functions. To create a such thing, developers must create models, animations, physics of objects, AI of characters and also, they have to manage memory and threading processes manually. Game engines satisfies these needs to save the developers a huge workload, and project management becomes easier with fewer code writings. It facilitates the production of the game with the easy user interfaces. In our project we chose Unreal Engine [1] because it's an open source program and it can create immersivity beautiful environments with its built-in shadow rendering. It supports C++ programming language, so we will be using those two to create functions, environmental elements and interfaces.

For 3D models, we will use Blender 3D because it is an open source modeling tool and it has an easy to use interface, it supports rigging, simulation and animation creation [2]. We will also use free assets and models from internet as long as models harmonize with the intended environment.

For creating materials and painting objects to create realistic look we may use substance painter. It is not essential to the project because of a limited time but with substance painter objects could look gorgeous to eyes.

Coding is a part of our project which we will use C/C++ languages to implement voice stress analysis tool into our scenarios and to do that we will use MATLAB and Visual Studio development tools. We will follow algorithms and techniques and use SUSAS database both

mentioned on literature review. Participant will read the shown words in the app (can both be in scenario or voice test sections) to determine stress level.

Lastly, the VR system which we will be using is HTC Vive. Participants will use dedicated buttons in HTC Vive controller to do some actions. Before implementing the project to VR, we will create a Windows application then export and test it on VR to adjust scale of objects and optimize it to avoid unintended actions.

4.1.3 Glossary

Table 2 Glossary of SDD

Term	Definition
Block Diagram	Schema that components of the system categorized and shown in blocks
HTC Vive	Head-mounted virtual reality glasses with motion sensors
Participant	The user who interacts with the simulation environment. Mostly students in this case
SDD	Software Design Document
MATLAB	Program to calculate mathematical operations and functions
Virtual Environment (VR)	A realistic and immersive simulation of a three-dimensional environment which the user interacts.
Stimuli	An event or a thing that evokes a reaction in a person.
GUI	Graphical User Interface
AI	Artificial Intelligence

4.1.4 Motivation

We are two senior students in computer engineering who are interested in serious games. Our aim is to create combination of VR environment and voice analysis process. We both worked on a project called KAYYEN [21] which is like a preliminary project to our project and we both have taken the innovative game design course to understand gaming field better. In our

internship we have worked on Unity Engine which is another game engine, used Blender and Substance Painter which we will make good use of them. Due to our ability to work on these texturing and modeling tools, we aware of the virtual environment objects which gives us to prepare our work more realistic. From time to time, we will also get support and consultancy from Mebitech which is the proposer company.

4.1.5 Overview of Document

The remainder of this document includes five parts. Section 2 is the Architectural Design which describes use cases in terms of conditions and basic sequences and priorities. Also, it contains class diagram of the system to understand variables reside in the system. Additionally, this section includes activity diagram of the entire VRelax application.

In the Section 3, a block diagram of the system displayed and explained briefly according to systems and sub-systems.

Section 4 is related to human interface design. In this section, we have shown user interfaces of menus and scenarios. Also, we briefly explained which functions can be accessed in these user interfaces.

Section 5 is references, and Section 6 is appendices to provide supporting details.

4.1.6 References

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4.2 Architecture Design

4.2.1 Class Diagram

Figure 9 displays information about connections between the systems within the VRelax project. VRelaxDecider Class is the main system, which includes -has access to- other systems. This class is responsible for connections between other systems, as well as, deciding the system’s flow by determining participant’s stress level. Participant class stands to represent the

user of this system, who shall have the HTC Vive required for using the system. Participant shall have different functions in different scenarios which is shown via two separated classes

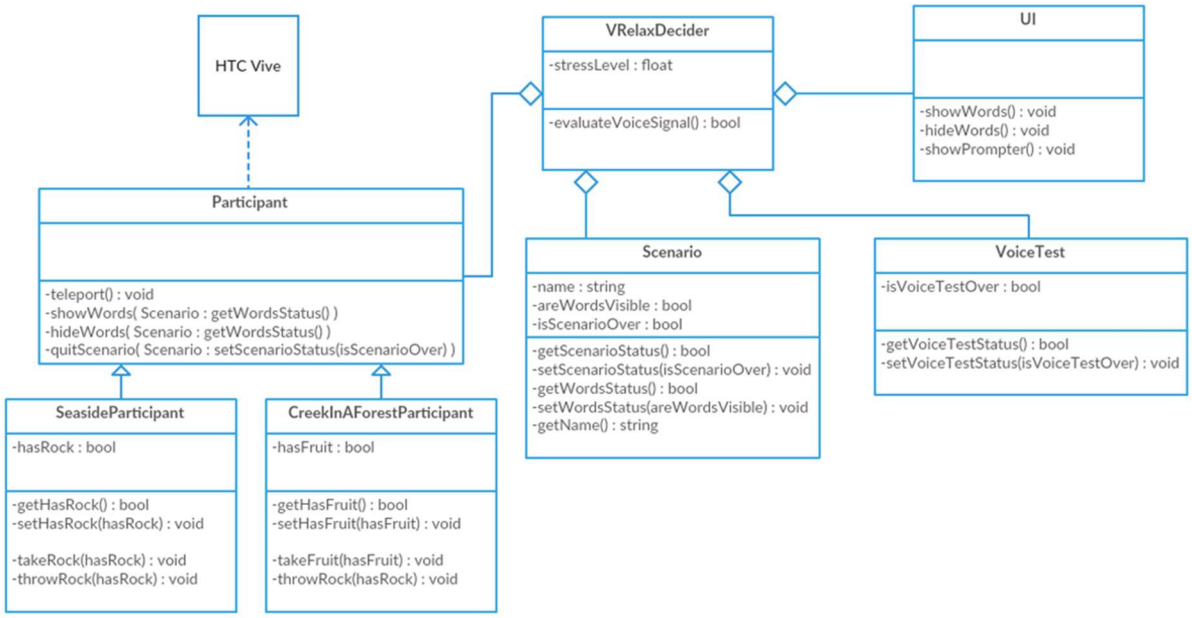

Figure 9: Class Diagram of VRelax

which inherited from Participant Class SeasideParticipant and CreekInAForestParticipant. UI Class represents the simple functions -affecting user interface- that user shall do in anyone of three scenes which are either scenarios or Voice Test screen. Scenario Class represent functions of all scenarios, deciding the scenario status, words visibility status; and contains the scenario's name. VoiceTest Class is identical to Scenario Class according to functionality of deciding Voice Test status.

4.2.2 Architecture Design of VRelax

4.2.2.1 Main Menu

Summary: This system is used by participant. Participant can start voice test, apply automated scenario, choose scenario, start selected scenario, change volume, and exit from the system.

Actor: Participant

Precondition: Participant must run the application with appropriate devices.

Basic Sequence:

1. Participant can start voice test by pressing “Start Voice Test” button from main menu. Participant shall "Apply Automated Scenario" to start analysis. Applied scenario will automatically start if participants stress level crosses the pre-defined level.
2. Participant can choose the scenario that s/he want, by pressing “Choose Scenario” button from main menu. If participant do not choose the scenario, then default scenario is considered as selected. Participant, after choosing the scenario, can start selected scenario by pressing “Start Selected Scenario” button which will be visible after choosing the scenario.
3. Participant can change the default volume level by pressing “Change Volume” button from main menu.
4. Participant can exit from the system by pressing “Exit” button from main menu.

Exception: None

Post Conditions: None

Priority: Low

4.2.2.2 Seaside Scenario

Summary: This system is used by participant. Participant can throw a rock, show words, hide words, teleport to a location, and exit from the scenario.

Actor: Participant

Precondition: Seaside Scenario must be started automatically or manually.

Basic Sequence:

1. Participant can get the rock by pressing trackpad button, if s/he does not hold the rock inside his/her hand.
2. Participant can throw a rock by pressing trackpad button, if s/he holds the rock inside his/her hand.
3. Participant can teleport to a location by using the trigger button: if participant holds down the trigger button, teleport location indicator will be shown on the virtual

environment; if participant releases the button, then s/he will be teleported to the selected location.

4. Participant can hide analysis words by pressing “Hide Words” button if words are visible.
5. Participant can show analysis words by pressing “Show Words” button if words are not visible.
6. Participant can go to main menu by pressing “Exit” button.

Exception: None

Post Conditions: None

Priority: High

4.2.2.3 Creek in a Forest Scenario

Summary: This system is used by participant. Participant can collect fruit, eat fruit, show words, hide words, teleport to a location, and exit from the scenario.

Actor: Participant

Precondition: Creek in a Forest Scenario must be started automatically or manually.

Basic Sequence:

1. Participant can collect the fruit by pressing trackpad button, if s/he does not hold the fruit inside his/her hand.
2. Participant can eat the fruit by pressing trackpad button, if s/he holds the fruit inside his/her hand.
3. Participant can teleport to a location by using the trigger button: if participant holds down the trigger button, teleport location indicator will be shown on the virtual environment; if participant releases the button, then s/he will be teleported to the selected location.
4. Participant can hide analysis words by pressing “Hide Words” button if words are visible.

5. Participant can show analysis words by pressing “Show Words” button if words are not visible.
6. Participant can go to main menu by pressing “Exit” button.

Exception: None

Post Conditions: None

Priority: High

4.2.3 Activity Diagram

Figure 10 shows how the entire VRelax application works as an activity diagram. When the application starts, participant shall have three options to choose, which are starting the voice test, selecting the scenario, and changing the volume level.

If participant chooses to start the voice test, the s/he shall be redirected to the voice test screen. In this screen, participant shall read the analysis words which shall be chosen according to specified analysis database. If participant’s stress level is in the critical stress interval, then s/he shall be informed about his/her stress level which is followed by that selected (or default) scenario shall be started. If participant’s stress level is not in the critical stress interval, then s/he shall be informed about his/her stress level and s/he shall be prompted to choose that if s/he wants to continue with the voice test or not.

If participant chooses to select the scenario, the s/he shall be redirected to the selection screen which contains the two relaxing scenarios. S/He then can start the selected scenario manually.

If participant chooses to change the volume level, then s/he shall be redirected to the volume option screen which includes the buttons to adjust the volume level. When s/he submits the volume level, then s/he shall be redirected to the main menu.

After the activation states “Scenario shall be started automatically” or “Participant starts the selected scenario”, selected (or default) scenario shall open. This scenario can be either “Seaside Scenario” or “Creek in a Forest Scenario”. When one of these scenarios is opened, analysis words shall be hidden in default.

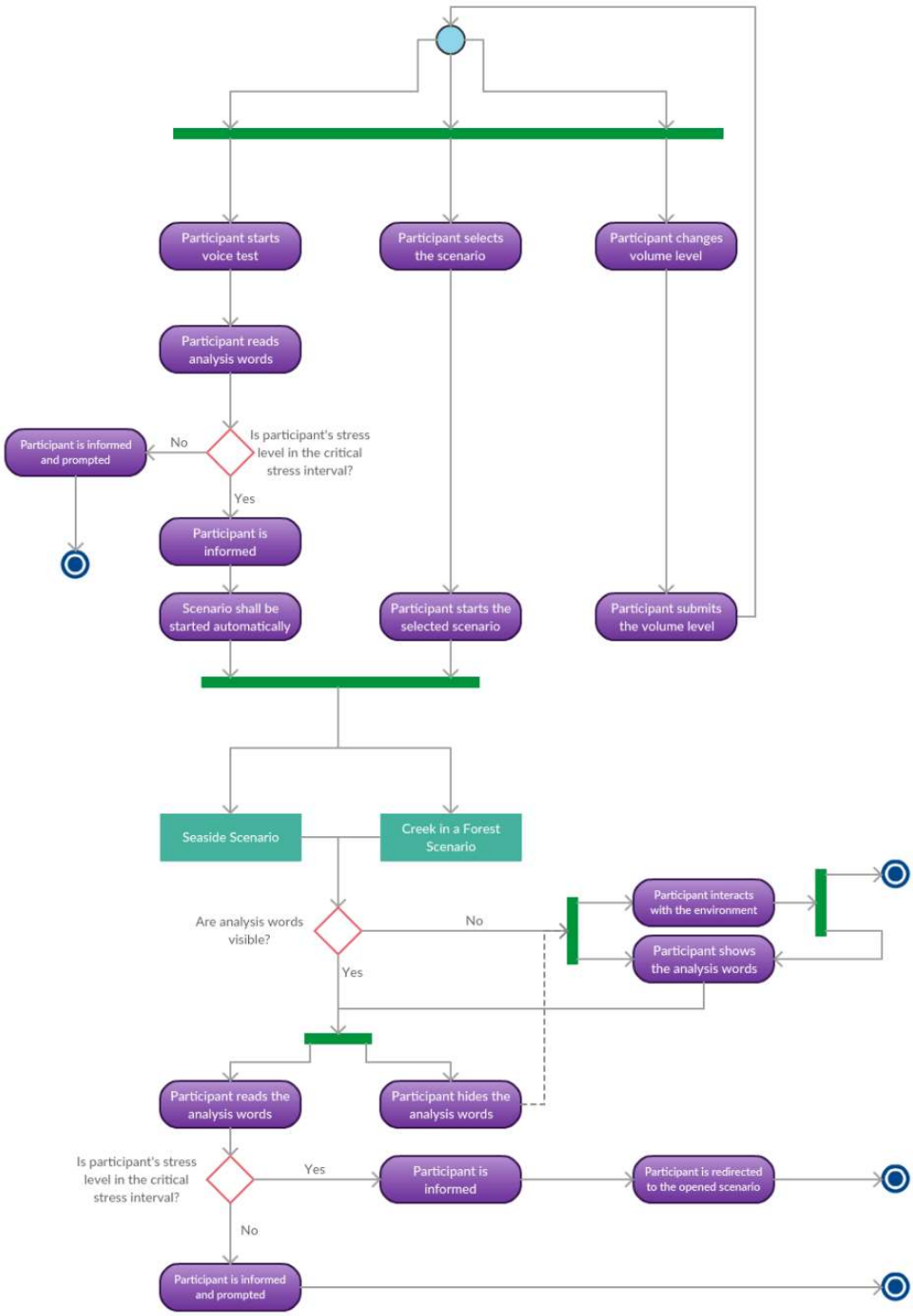

Figure 10: Activity Diagram of VRelax

If participant chooses to interact with the environment, s/he shall have two options. One option is (theoretically) to interact with the environment forever. Other option is to show the word to continue with the voice analysis. This option could be chosen after interacting with the environment.

If analysis words are visible in the scenario, then participant shall have two options. One option is to hide the analysis words which shall take the participant to the step after negative answer of the nearest (previous) question. Other option is reading the analysis words which shall end with re-evaluating the participant's stress level. If participant's stress level is in the critical stress interval, then s/he shall be informed about his/her stress level which is followed by that selected (or default) scenario shall be started. If participant's stress level is not in the critical stress interval, then s/he shall be informed about his/her stress level and s/he shall be prompted to choose that if s/he wants to continue with the scenario or not.

4.3 Use Case Realizations

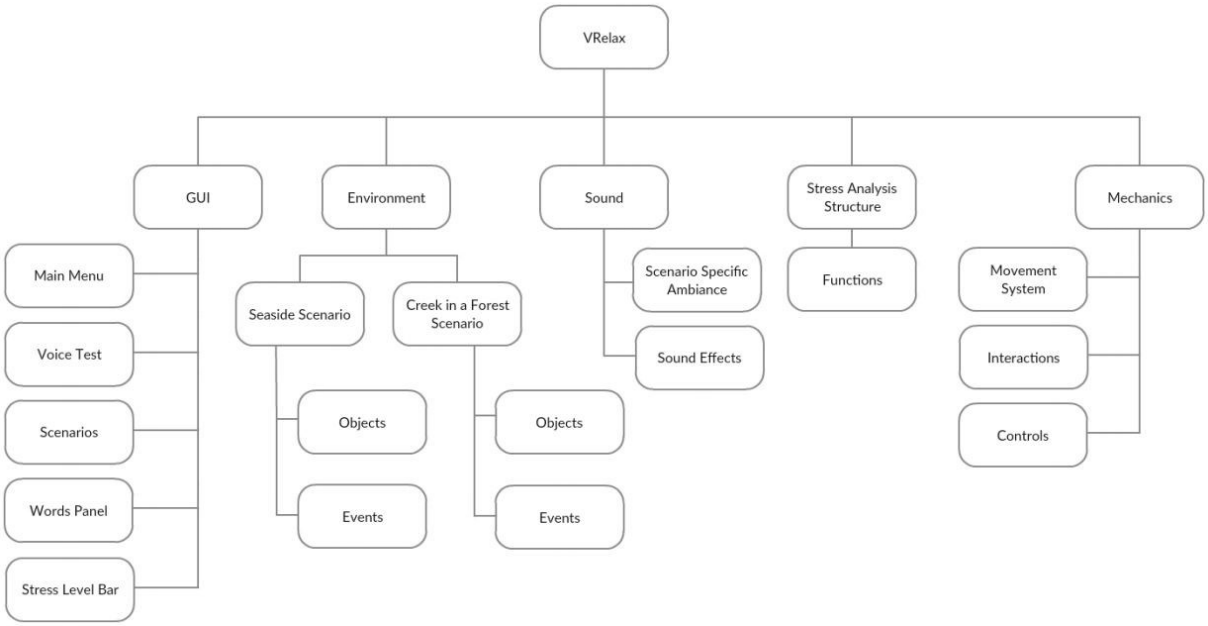

Figure 11: Project Components of VRelax

4.3.1 Brief Description of Block Diagram

Components of the VRelax Project are shown in the *Figure 11*. There are five core components of the system. These main components have sub-systems of their own and these components are shown as block diagram in the figure.

4.3.1.1 GUI

GUI design necessary for actors to interact with the system functions. There are five sub-system for GUI component which are Main Menu, Voice Test, Scenarios, Words Panel and

Stress Level Bar. Main Menu is the start page of the system. In Main menu participant can start a voice test, choose a scenario, adjust volume level or exit from the system. In the voice test screen, participant can start a voice test and analyze his/her stress level. There will be also scenarios list to select a scenario in the voice test menu and open it when the participants voice is stressful. In the scenarios menu thumbnail of the scenarios will be shown and participant can start a scenario that s/he desires. Words panel will be shown both in scenarios when s/he wants to show the words and in voice test page to analyze stress with those pre-defined words. Finally, a stress level bar in the voice test page will give feedback to the participant about stress amount of the participant. Participant will use HTC Vive headset and a controller to access these menus. In the earliest demos that before VR implementations, keyboard and mouse is required to access these menus.

4.3.1.2 Environment

Environment component is responsible for user interactions with the objects and events in the scenarios. There are two different scenarios and they have different Objects like fruits or rocks and beach or forest and both scenarios have events like throwing a rock to the sea or eating collected fruits. The participant can do these actions and participate these events with controller of the HTC Vive.

4.3.1.3 Sound

Sound is an essential component for this application because of relaxing purpose. The sound component is responsible for all sounds in the system which includes Scenario Specific Ambiance like music and Sound Effects like sea waves sound or tree leaves sound.

4.3.1.4 Stress Analysis Structure

This sub-system of the VRelax application responsible for the analysis of the voice. The sub-system of this component Functions which will operate in the background of the application, will calculate stress amount of the participant.

4.3.1.5 Mechanics

Every game system has mechanics, this module of the system is responsible for the mechanics of the VRelax. There are three sub-system which are Movement System,

Interactions and Controls. Participant can move around the environment with teleport function, interact with the scenario specific objects or events using HTC Vive while background controls sub-system will handle actions. Controls is one of the core mechanics of the system due to frequent use of this module.

4.4 Human Interface Design

4.4.1 Scenario Environment

In our VR application, we have two different scenarios which means two different environments. They include materials, 3D models and objects. Seaside Scenario which is shown in *Figure 12* has materials like sand and sea and environment objects like rocks, grass, terrain. Participant can throw a rock to the sea or walk around in the environment with the teleport function which allows participant to move freely in the seaside.

*Figure 12: User Interface of Seaside Scenario**

Participant can exit anytime and return to main menu using Exit button and with Show Words / Hide Words button show or hide the words which application uses them to analyze stress with voice. This user interface of buttons applies both scenarios which they have the same functions.

*Figure 13: User Interface of Creek in a Forest Scenario**

Creek in a Forest Scenario which is shown in *Figure 13* has materials like wood and leaves and environment objects like rocks, grass, trees. Participant can collect fruit from specific trees and eat it or walk around in the environment with the teleport function which allows participant to move freely in the forest.

4.4.2 Overview of Other User Interfaces

The representation of main menu shown in *Figure 14*. From this screen participant can access all main functions of the system. All options except “Change Volume” which is shown in Figure 16 will redirect participant to the new page to access sub-functions. Change Volume option will open a volume bar with “+” and “-” buttons to adjust volume of the application.

*Figure 14: User Interface of Main Menu**

*Figure 15: User Interface of Change Volume**

In the “Start Voice Test” page shown in *Figure 16*, participant will choose a scenario and apply it to automatically start it when his/her stress level crosses the indicated level. SUSAS Database Words [25] will appear when the participant applies the scenario, while the

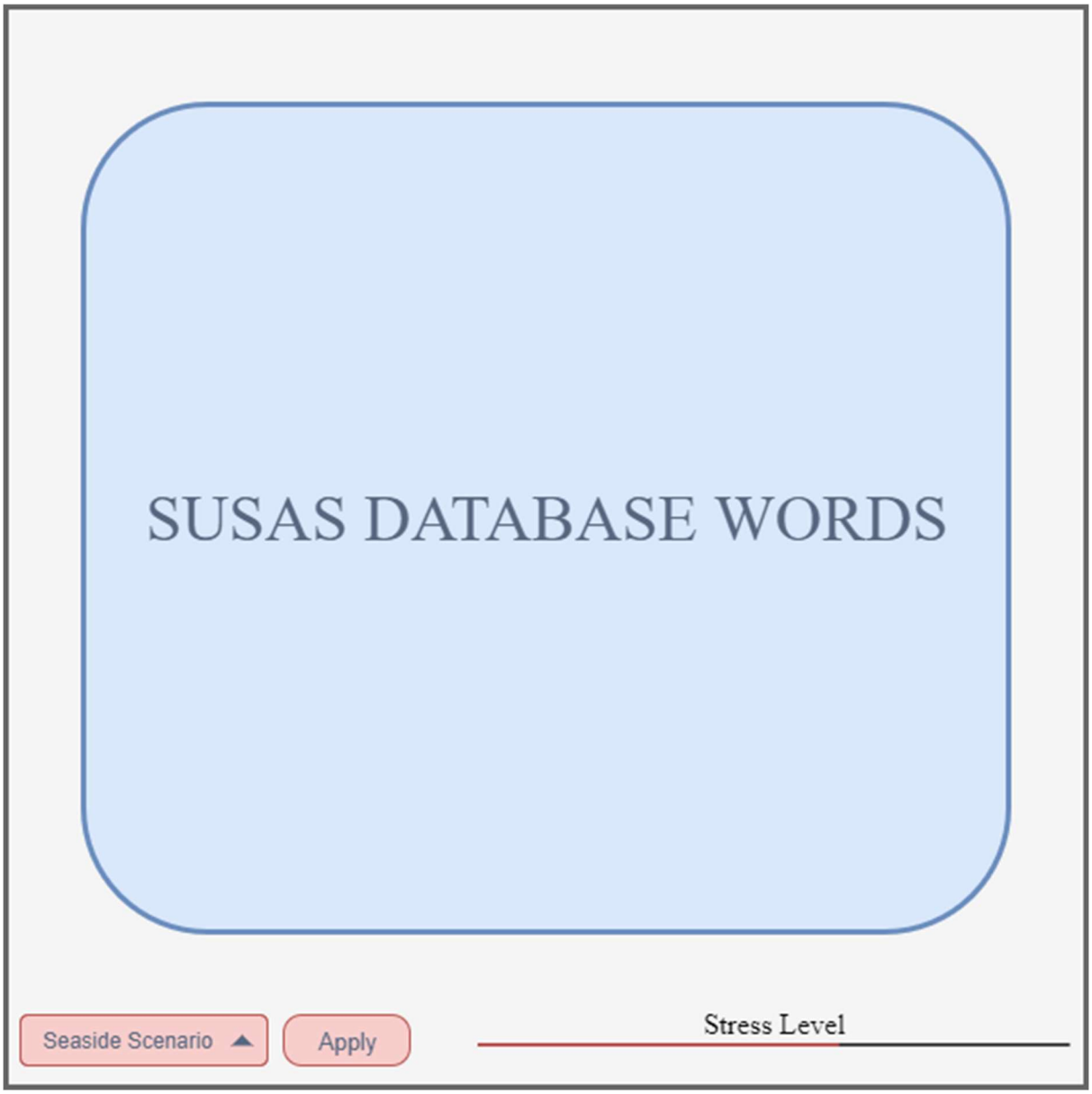

*Figure 16: User Interface of Start Voice Test**

participant reads the words, application will analyze the voice and give a feedback about participant’s stress level with the stress level bar.

Finally, Choose a Scenario screen which is shown in *Figure 17* includes thumbnail images of the available scenarios and a start button to start the selected scenario. Selecting a scenario is indicated with a red border in this case.

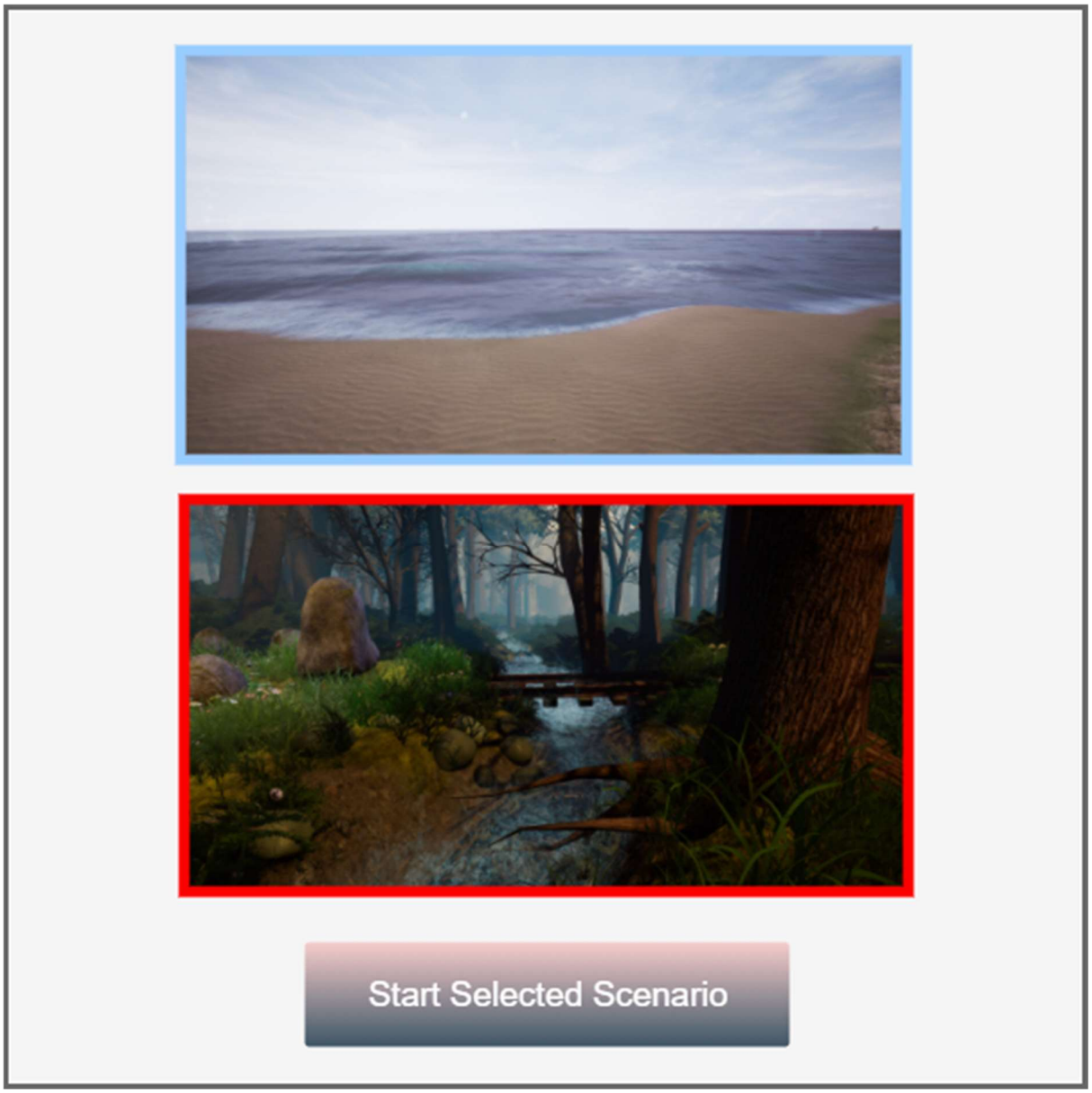

*Figure 17: User Interface of Choose a Scenario**

5. Conclusions

This report includes detailed information about VRelax: Investigation of Relaxing. In this project, we have aimed to analyze stress with voice and reduce it with relaxing scenarios. We have planned to use HTC Vive for the VR system because of advanced technical features compared to other VR headsets and its compatibility with Unreal Engine.

To develop VRelax, we have made a lot of research about stress analysis, usage of VR technologies and similar works. We have analyzed different documents and projects to understand how to analyze stress with voice and learnt Unreal Engine fundamentals to get

started for scenario implementations. After our research finished, we have determined the requirements of the project with both our supervisor and proposer company Mebitech. According to these requirements we have prepared a SRS document. In order to determine the design of the project we have prepared a SDD document for explaining design structures.

Our researches show that there are not many applications about this topic and they don't have a stress analysis tool like ours. In the future, we will implement voice analysis structure and create immersive environments for our scenarios according to our SRS and SDD documents. We will revise the documents while developing the project, so these documents are not final version. There will be some disadvantages and difficulties for the developing project. Most important one is creating realistic environment. VR applications are demanding in terms of system requirements so using most realistic objects and textures will reduce performance and even could make the project unplayable. Another problem is that there is no example of implementing a voice analysis structure into the unreal engine environment, so we must combine them without destructive code approach.

In conclusion, while researching for our project and preparing these documents we have learned many things and we will continue to learn.

Acknowledgement

We are grateful for the help and guidance that we have received from our advisor Dr. Faris Serdar Taşel and co-advisor Assist. Prof. Dr. Murat Yılmaz. We improved both the project and ourselves thanks to their valuable comments and advices. We are also grateful to our proposer company Mebitech for giving us this opportunity. This work couldn't have been possible without the help received from them.

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Appendices

** All images used in this document does not reflect actual product and can be found in https://www.artstation.com/. User interfaces and scenario environment screens could change in the future. These images are used only for draft purposes which enlighten us about how we should proceed when we start creating user interfaces and scenarios.*