

ÇANKAYA UNIVERSITY

# Software Design Document

**Simulacrum: Simulated Virtual Reality for Emergency Medical  
Intervention in Battle Field Conditions**

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# 1. INTRODUCTION

## 1.1 Purpose

The purpose of this Software Design Document is providing the details of project titled as “Simulacrum: Simulated Virtual Reality for Emergency Medical Intervention in Battle Field Conditions”.

The target audience is military personnel in Turkish Armed Forces. Simulation will create opportunities to learn and practice the techniques of first-aid and medical intervention. We aim to provide an immersive environment which includes objects from the real world to make the participant familiar with the events of medical intervention techniques in battlefield conditions.

The purpose of Simulacrum project is to design “Immediate Medical Intervention During Combat” both as a standalone application and a VR system, which shall include realistic scenarios, by taking account of the experience gained by Turkish Armed Forces personnel and their inventories (e.g. tools, materials) that are used for medical intervention. Simulacrum simulation includes two main modes which are training and battlefield modes. In the training mode, participant can interact with these NPCs and get specific information from NPCs related to situation. Participant will be debriefed about first-aid and medical intervention techniques. After the debriefing, participant shall take a quiz about these techniques. If the result of the test is satisfactory, the participant shall be able to practice the techniques. Participant is always able to see his/her previous scores in tests and practices. If the participant is successful in every technique in training mode, participant will be able to attend to practice medical intervention techniques in battlefield conditions. In battlefield mode, participant will start at combat environment. Participant is given ability of firing his/her gun in order to increase the level of immersion of the battle field. Thus, it is easier to give sensation of battle to the participant. When a fellow soldier in battle field gets wounded, a green indicator shall be displayed in front of the wounded soldier. When the participant reaches to this point, event of medical intervention practice shall be started. In this event, participant will try to apply necessary medical intervention technique properly before the given time is up.

HTC Vive is integrated within the simulation in order to increase the level of immersion. HTC Vive includes two controllers for each hand, two sensors for locating the position of the participant and a laser based head mounted display which projects the frames on the computer screen to the participant.

Simulation is designed to be used with both HTC Vive and using keyboard and mouse. Using the simulation with HTC Vive is recommended, because of the fact that using HTC Vive increases the level of immersion of simulation. Head mounted display shall provide a more realistic view to the participant in the simulation and the controllers shall be used to provide interaction between objects in the simulation and the participant. Sensors of the HTC Vive creates a 2 meter-square of field for participant to move around. Participant is able to attend two

different areas. One of them is a spatial area which includes only injured NPC and medical instruments. The other area is a battlefield environment which is designed for putting the participant in a difficult position to practice medical intervention techniques.

In order to provide a better comprehension, this SDD includes various diagrams such as UML diagram of the project, activity diagram and block diagram.

## 1.2 Scope

This document contains a complete description of the design of Simulacrum: Simulated Virtual Reality for Emergency Medical Intervention in Battle Field Conditions.

Unity 3D Game Engine is utilized to create scenes of the simulation and handling all the events in the simulation. Procedures of creating the three-dimensional environment, programming and designing will be performed on Unity3D. Unity3D is a game engine [1] which is used by many game and simulation developers for it is practical. There are various programming languages that can be used within Unity3D such as C# and JavaScript. Xie [2] reports that Unity 3D includes packages like Unity Pro, Android, IOS, etc. It is a powerful cross platform and it is easy to extract to build of the project for Windows, Mac OS X, Linux, Android and IOS. Wang et al. [3] claim that when it comes to scripting, most programmers think that it is slow and limited. But in Unity 3D, script codes are compiled to native code and it is most likely to get a fast iteration time. This makes Unity 3D more attractive to programmers who likes scripting. Because of these facts, we have chosen Unity3D as our development environment.

For designing 3D models, Blender 3D will be used. Blender 3D is an open source and free 3D modeling environment which completely supports processes such as modelling, rigging, simulation, animating, motion tracking and rendering [4]. The reasons why we have chosen Blender as our modelling environment are it is simple to use, User Interface of the program is easy to understand and there are a lot of documentation about possible problems that we could encounter using the Blender 3D.

Scripting part of the project is occurred using C# scripts. C# is a modern, simple and object-oriented programming language which unites features of rapid application development languages with the power of C and C++ [5]. The reasons why we have chosen C# as our programming language are all the members of the group have knowledge of C# programming language and C# is one of the three programming languages which can be used in Unity 3D.

Participant shall navigate through virtual environment and shall interact with object using HTC Vive. Also, the participant is able to attend lectures, take quizzes and practice about first-aid and medical intervention techniques. In the first part of the system, participant shall select a first-aid technique. First part of the training includes non-interactive video. This video gives information about the selected first-aid technique. After participant obtains information from the video, a quiz panel, which includes questions regarding to selected first-aid technique,

shall be displayed. This quiz will contain five questions. Every question has four different choices. These quizzes will be prepared with the professional help from Turkish Red Crescent. Purpose of these quizzes is to determine how much the participant learnt from the video. After completing the quiz, if the result is satisfactory, participant will be able to attend to practice training regarding to selected first-aid technique. The result of the quiz shall not be displayed to the participant yet. When the practice part has ended, the same quiz shall be displayed again in order to determine whether the practice part was helpful to participant or not.

### 1.3 Glossary

<b>Term</b>	<b>Definition</b>
<b>BLOCK DIAGRAM</b>	The type of schema which the components in the system are displayed in blocks.
<b>HEAD MOUNTED DISPLAY (HMD)</b>	It is a display device which is worn to the head.
<b>HTC VIVE</b>	It is virtual reality system with head-mounted virtual reality glasses which has gaze driven technology and provides haptic feedback through controllers.
<b>NPC (Non-player Character)</b>	Characters in the simulation who cannot be controlled by the participant [6].
<b>PARTICIPANT</b>	The user who interacts with the simulation environment. Generally Medical Aid Man, Privates Sergeants, Militant Lifesaver, Commissioned Officer in Turkish Armed Forces.
<b>SDD</b>	Software Design Document.
<b>UML DIAGRAM</b>	It is a modelling language which is used in Software Engineering.

### 1.4 Overview of Document

The remaining chapters and their contents are listed below.

Section 2 is the Architectural Design which describes the project development phase. Also it contains class diagram of the system and architecture design of the simulation which describes actors, exceptions, basic sequences, priorities, pre-conditions and post conditions. Additionally, this section includes activity diagram of scenario generator.

Section 3 is Use Case Realization. In this section, a block diagram of the system, which is designed according to use cases in SRS document, is displayed and explained.

Section 4 is related to Environment. In this section, we have shown the sample frames of environment from the prototype and have described scenario.

## 1.5 Motivation

We are a group of senior students in computer engineering department who are interested in virtual reality technologies and gaming. As a group, we have taken the course of innovative game design for a better understanding in gaming field. We aimed to combine the fields of education, gaming and virtual reality technologies in this project. We have chosen the game engine Unity 3D which all of the members of the group are already familiar to develop our project. Aside from scripting, our project includes visual arts but there are no classes about this field. So in order to increase our knowledge in this field, we have learnt Blender which is a 3D modelling environment and for complicated models that we could not able to design, we have taken help from professional designers. For including virtual reality technologies, we have acquired HTC Vive which is a Virtual Reality headset and we have read documents for how to use HTC Vive in Unity 3D.

## 2. ARCHITECTURE DESIGN

### 2.1 Simulation Design Approach

For developing the project, we have planned to use Scrum which is an agile software development methodology. Scrum is incremental and iterative. In scrum, main work is divided into sprints which should be completed within a certain period of time which could be 30 days on average. Iteration length of every sprint must be equal, because scrum is an agile development methodology. Every Sprint includes tasks which has own story points and risk points. Development team should have a daily meeting every morning which should be maximum 15 minutes. Scrum has three main roles which are product owner, scrum master and development team. Product owner is the person who delivers the requirements, scrum master is the person who manages the development team. Development team is the group of developers who work on the project according to schedule. There are some advantages of Scrum. First advantage is that it is easier to cope with changes because of short sprints and constant feedback. Another advantage is problems can be handled swiftly due to morning meetings. Also, it makes it possible to create quality products in scheduled time [7]. *Figure 1* represents four sprints of the project on the lab board. Sprint is one of the most important feature for Scrum methodology. At the end of each sprint, a part of project has been completed and it has been presented to customer for validation. By taking into consideration of these facts, Scrum is the most suitable methodology for the project.

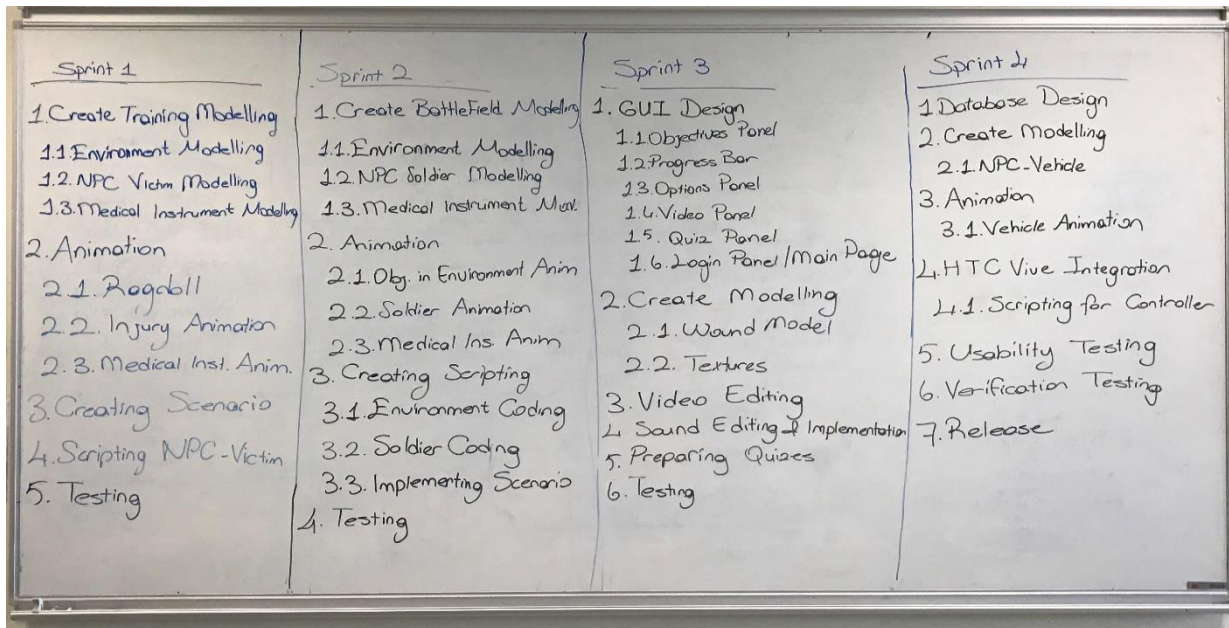


Figure 1 All Sprints of the Project on the Board

We have also used Scrum Board (see Figure 2) in order to complete tasks that are in the current sprint iteratively. Each tasks are written on the story cards which include their own risk points. Scrum board that includes six different phases. “Project Backlog” phase contains all processes within the sprint. “To Do” phase includes which is need to be done with priority. “In Progress” phase contains tasks that are currently being constructed. “In Review” phase represent processes that are being reviewed. “To Deploy” phase includes modules that are ready to be integrated within the main system. “Done” phase indicates processes that are successfully working within the system.



Figure 2 Scrum Board with Tasks



Gantt Chart in *Figure 3* includes two parts which are research & documentation and sprints part. This Gantt Chart explains the work to be done with using timeboxes. First approximately 60 days are spent using waterfall for research and documentation which include information regarding project. After documentation, there are 4 sprints which our group specified. Each sprint should be completed within 37 days and has unique tasks. After completing testing and release at the end of each sprint, if there are any tasks which are not completed, 4 extra working days have been reserved for the purpose of completing these tasks. So technically these 4 days are for agile process technical debt. When all sprints are completed, next 10 days will be spent for usability tests.

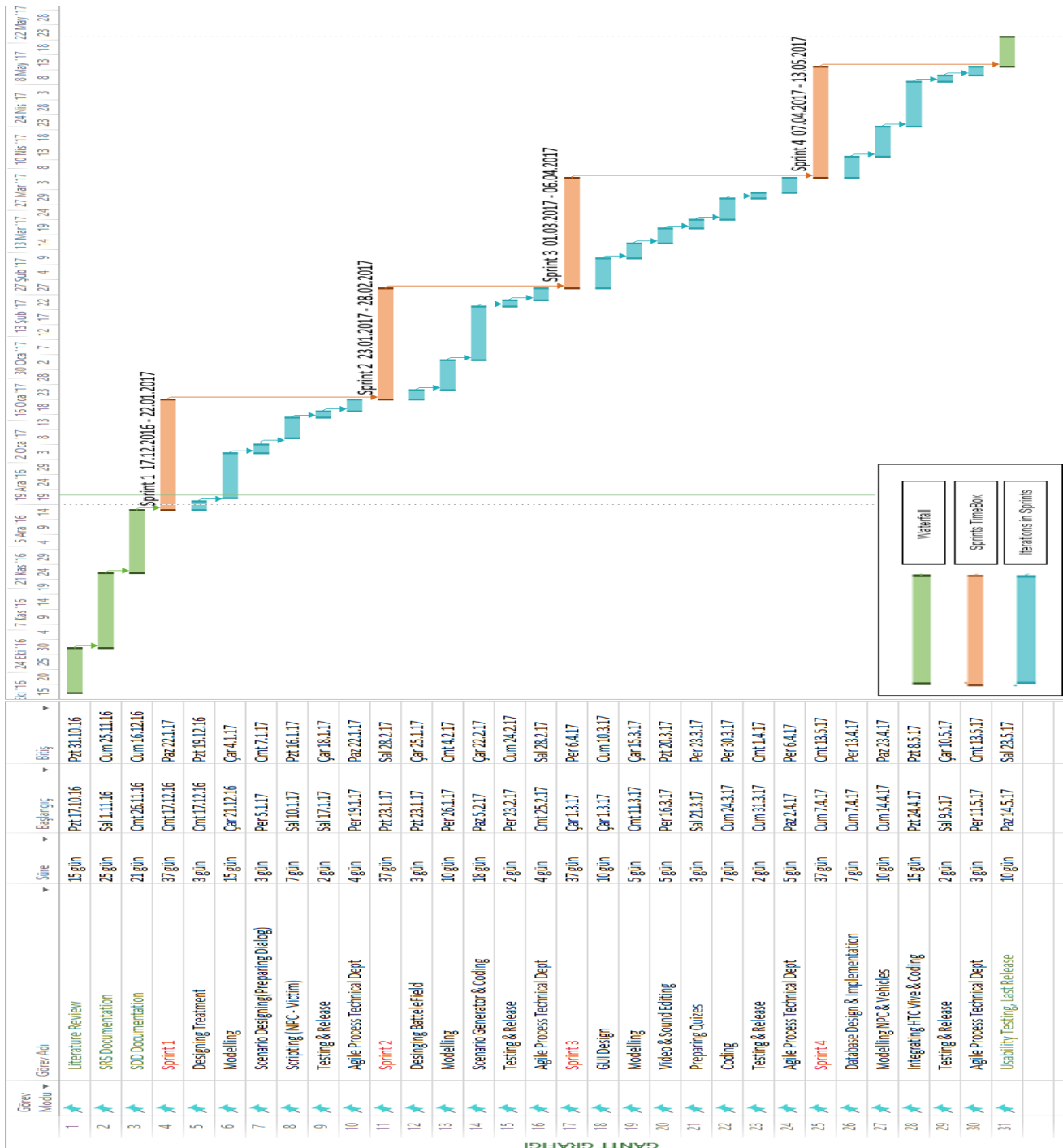


Figure 3 Gantt Chart of Work Plan

## 2.1.1 Class Diagram

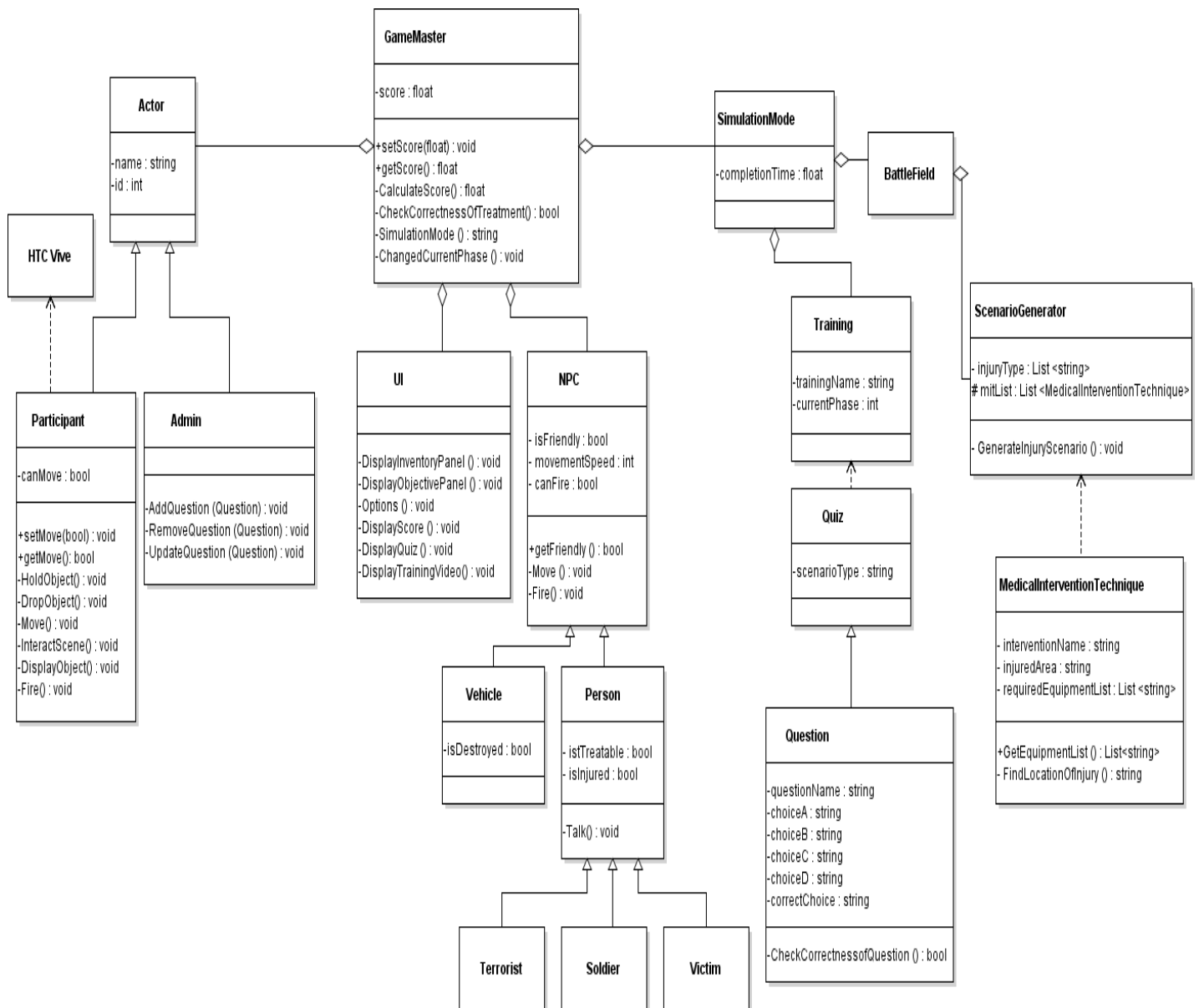


Figure 4 Class Diagram of Simulacrum project

Figure 4 displays information about connections between the systems within the simulation. GameMaster Class is the main system, which contains other systems. It is responsible for connections between other systems such as Actor, UI, NPC and Simulation Mode. Actor class represents all the users who use the system. Participant class is for users who will use the simulation for educational purposes with using HTC Vive. Admin class is for actor which manages the system. UI class represents the User Interface which the Actors of the system will encounter. NPC class represents non playable characters which are used to increase the immersion level of the simulation. Vehicle class that is derived from NPC class represents information about vehicles which is used in battle field conditions whereas Person class represents the people that are in the battle field. Soldier, Victim and Terrorist classes are derived from Person class. Simulation Mode is the base class of Battlefield and Training classes and is used to represent the current mode of the simulation.

Training class includes Quiz class which includes questions that are asked to the participant of the simulation. Battlefield class is a base class of ScenarioGenerator. ScenarioGenerator class, which is generating scenarios randomly, includes MedicalInterventionTechnique class.

## 2.2 Architecture Design of Simulation

### 2.2.1 Profile Management

**Summary:** This system is used by participant and admin. Participant can login, register, and update personal information and exit from the system. In addition to this, admin can delete an account, approve participant accounts and add a new admin.

**Actor:** Participant, admin

**Precondition:** User must run the program.

#### **Basic Sequence:**

1. User must register if s/he doesn't have an account.
2. User shall login to the system by entering his/her username and password.
3. User can update his/her personal information by selecting update button from user menu.
4. Admin can delete a user account by selecting delete button from admin menu.
5. Admin can approve a user account which is registered recently by selecting approve from admin menu.
6. Admin can add a new admin by selecting add new admin button from admin menu.
7. User can exit from the system by selecting exit button.

**Exception:** Database connection can be failed.

**Post Conditions:** None

**Priority:** Low

### 2.2.2 Options Menu

**Summary:** Participant can pause and continue the simulation, change volume settings, display instructions and exit from the system.

**Actor:** Participant

**Precondition:** Participant must be logged in and selected options button.

**Basic Sequence:**

1. Participant can pause the simulation by selecting options button.
2. Participant can continue the simulation by selecting continue button from options menu.
3. Participant can change volume of the simulation by selecting change volume settings from options menu.
4. Participant can display instructions by selecting display objectives button from option menu.
5. Participant can exit from the system by selection exit button.

**Exception:** None

**Post Conditions:** None

**Priority:** Medium

### 2.2.3 Training Mode

**Summary:** This system is used by both participant and admin. Participant can select a first-aid technique, display score, display options, take quiz, answer questions, attend practice technique, hold and drop objects. Admin can add, delete and update questions of the quizzes in this system.

**Actor:** Participant, admin

**Precondition:** User must be logged in, chose a first-aid technique.

**Basic Sequence:**

1. Participant can select a first-aid technique from the list of techniques.
2. After selecting a technique an educational video regarding selected technique shall be displayed to the participant.
3. Quiz panel which includes questions about selected technique shall be displayed to the participant.
4. If the result of the quiz is satisfactory, a training environment shall be created for the user.
5. Participant can hold and drop object in training environment.
6. Participant can display options by selecting options button.
7. Admin can add, delete and update questions regarding selected technique.
8. Participant and admin can display score regarding selected technique.

**Exception:** Database connection can be failed.

**Post Conditions:** Changes made by admin will be saved within related table. Final score of the participant shall be updated within related table.

**Priority:** High

#### **2.2.4 Battlefield Mode**

**Summary:** This system is used by participant and admin. Different from the training mode, this mode includes war ambiance, includes medical intervention techniques and injury scenario.

**Actor:** Participant, admin

**Precondition:** User must be logged in to system and selected battlefield mode.

**Basic Sequence:**

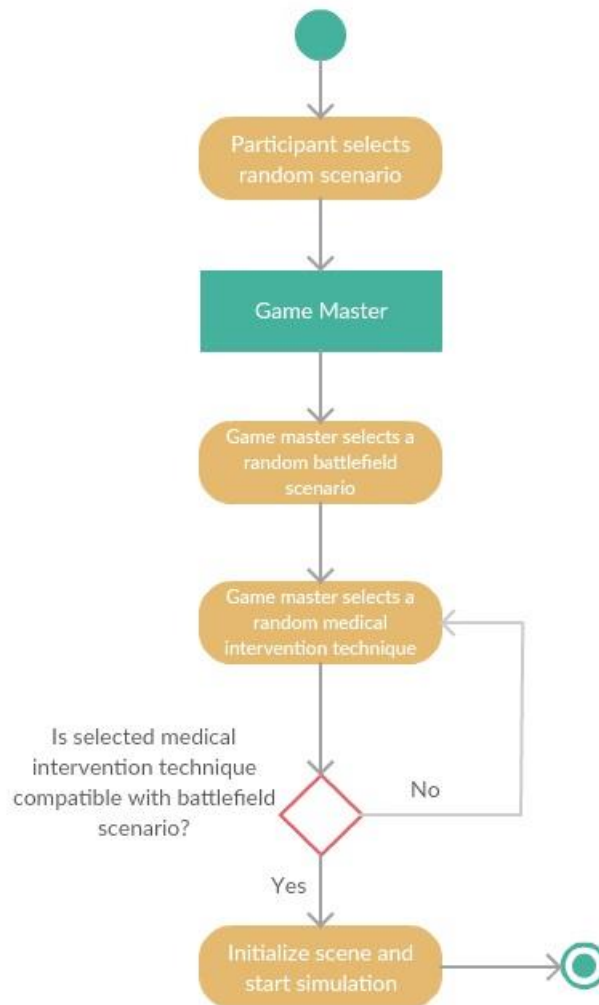
1. Participant can select an injury scenario from list of injuries.
2. After selecting an injury scenario, Participant shall select a medical intervention technique.
3. An environment is created depending on the selection of participant.
4. Participant can move around the environment with keyboard's w-a-s-d buttons and HTC Vive Controllers.
5. Participant can hold and drop objects which are in this environment.
6. Participant can fire a gun with mouse's right click or HTC Vive controller.
7. Participant can display Progress Bar by selecting progress bar button.
8. Participant can view items in his/her inventory by selecting inventory button.
9. Participant can display objectives panel by selecting objectives button.
10. Participant can display options by selecting options button.
11. Admin and participant can display score regarding selected medical intervention techniques and injury scenario.

**Exception:** Database connection can be failed.

**Post Conditions:** Final score of the participant shall be updated within related table.

**Priority:** High

## 2.3 Activity Diagram



*Figure 5 Activity Diagram of Scenario Generator*

*Figure 5* shows how the scenario generation works as an activity diagram. When the participant selects random generation choice, Game Master object will run random scenario generation function. First of all, in this function, a battlefield scenario shall be selected randomly according to the algorithm. After that, a medical intervention technique shall be selected. Then the compatibility between these scenarios shall be checked. If the medical intervention technique and battlefield scenario is compatible, the scene shall be initialized according to these scenarios and the simulation shall be started. If they are not compatible, then another medical intervention technique shall be selected randomly again.

### 3. USE CASE REALIZATIONS

#### Simulacrum Project

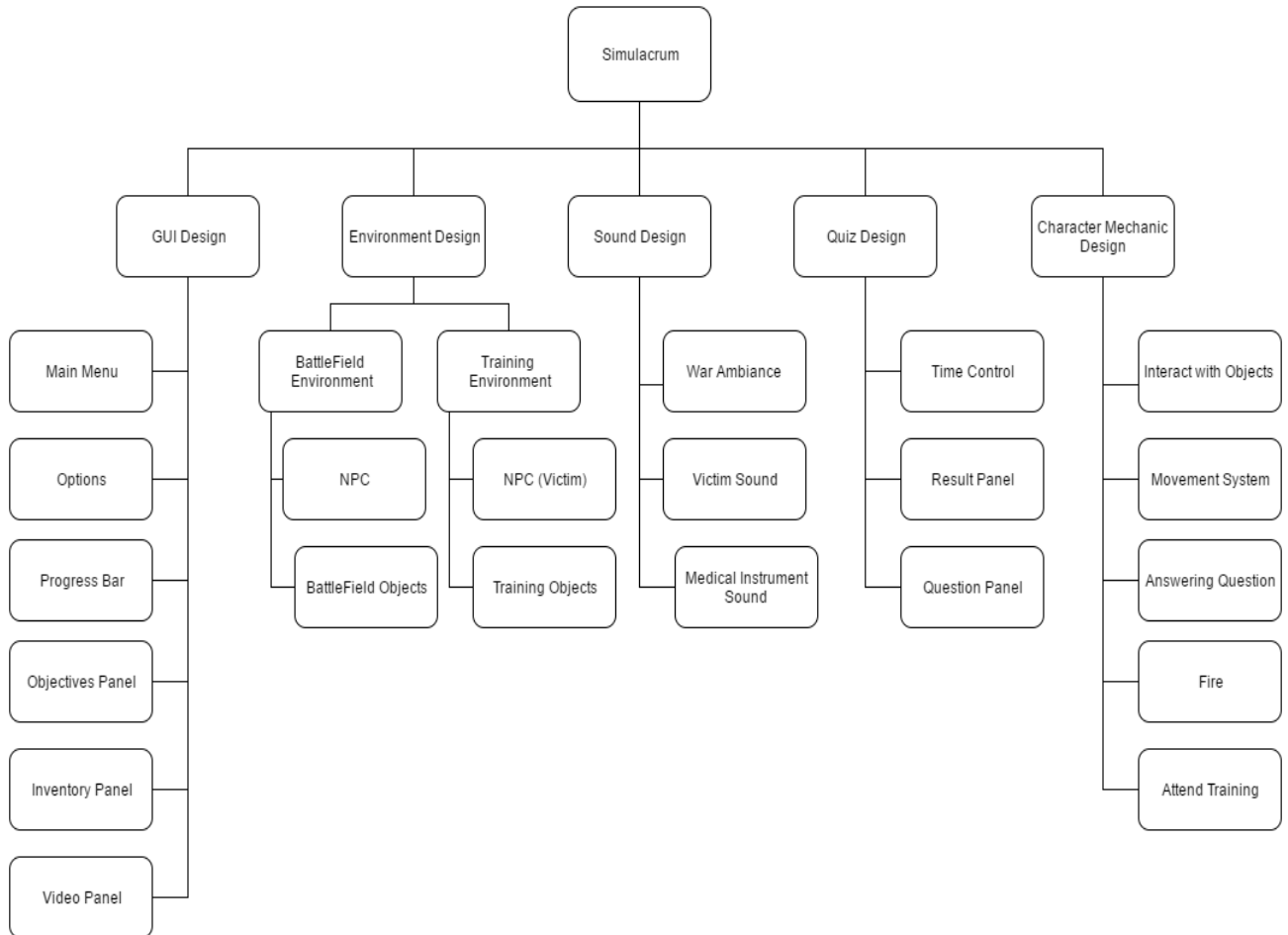


Figure 6 Project Components of Simulacrum

#### 3.1 Brief Description of Figure 6

Components of the Simulacrum Project are shown in the *Figure 6*. All designed systems of the simulation are displayed in the block diagram in the figure. There are five main components of the system which have their own sub-systems.

##### 3.1.1 GUI Design

GUI design is responsible for interaction between the actors and the system. There are six sub-systems in this design which are Main Menu, Options, Progress Bar, Objective Panel, Inventory Panel and Video Panel. Main Menu is a start page, participant can register, login, display the information about how to use the system, and logout from the system. There are two different ways to access the options menu. First of all, if HTC Vive is connected to the system, participant shall access options menu by activating the panel on the tip of the index finger of

left hand with using right hand. Secondly, if HTC Vive is not connected to the system, options menu can be accessed by clicking esc button from keyboard. Participant can reach the progress bar from both simulation modes. Progress bar indicates the achievement of the participant. Objective panel can be reached from both simulation modes by clicking “O” from keyboard or can be accessed by activating the panel on the tip of the middle finger of the left hand with using right hand. Objective panel displays current objectives. Inventory panel can be accessed from both simulations. This panel is located on top of the screen. Inventory panel indicates participant’s inventory that contains medical instruments. Video panel is shown from both of simulation modes. It will give information about first-aid and medical intervention techniques.

### **3.1.2 Environment Design**

Environment Design is responsible for managing environment which the user interacts with objects. There are two types of environment in the system which are battle field and training environment. Training environment is more focused on education whereas battle field includes objects which are related to battle. Both of the environments includes NPC objects such as victims, soldiers, tanks, etc. to increase the level of immersion of the simulation.

### **3.1.3 Sound Editing**

Sound design module is responsible for all audios which are used in simulation in order to increase the realism of the simulation especially for battle field mode. This system includes War Ambiance, Victim Sound and Medical Instrument Sounds.

### **3.1.4 Quiz Design**

This sub-system manages all the question that are asked to the participant. This sub system includes Time Control, Result Panel and Question Panel.

### **3.1.5 Characteristic Mechanic Design**

This design module is used for determining the participant’s abilities. Participant can interact with objects using HTC Vive, move around the environment, answer questions in the quizzes, fire guns and attend trainings.

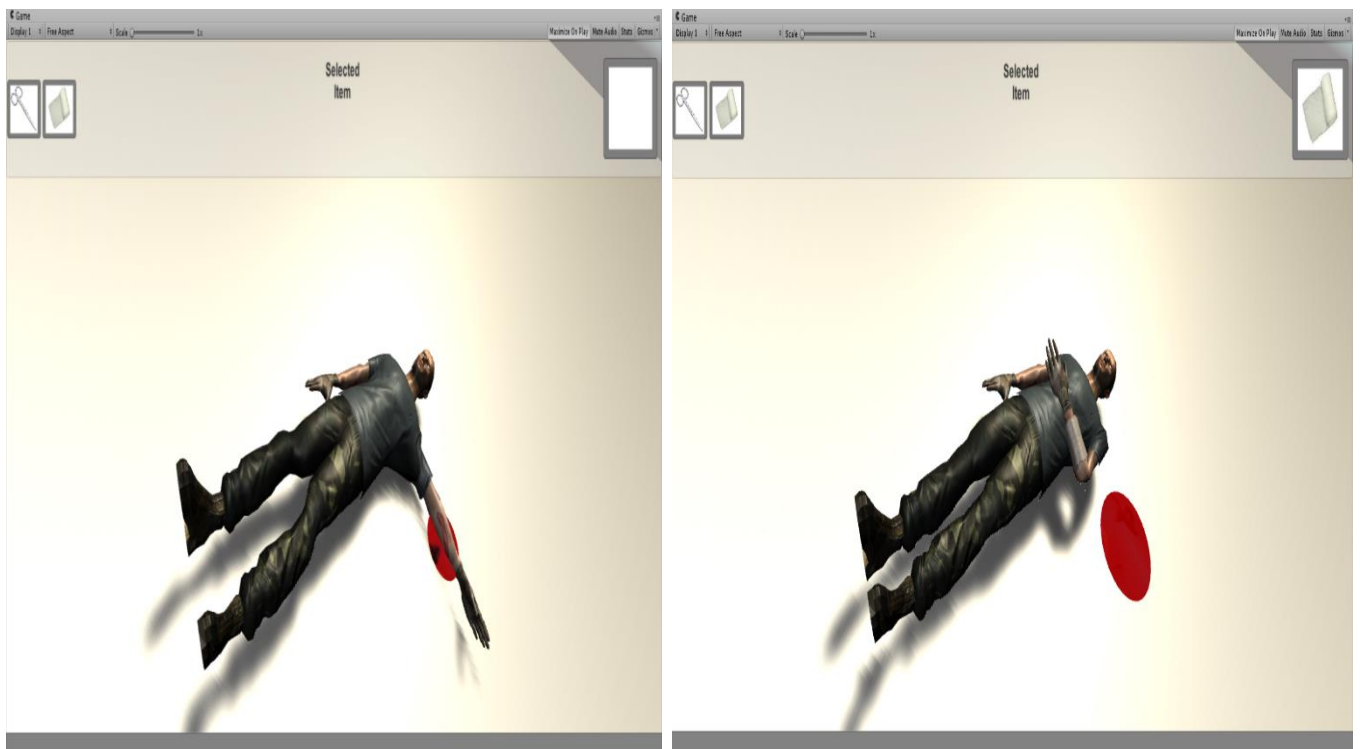


## 4. ENVIRONMENT

### 4.1 Modelling Environment

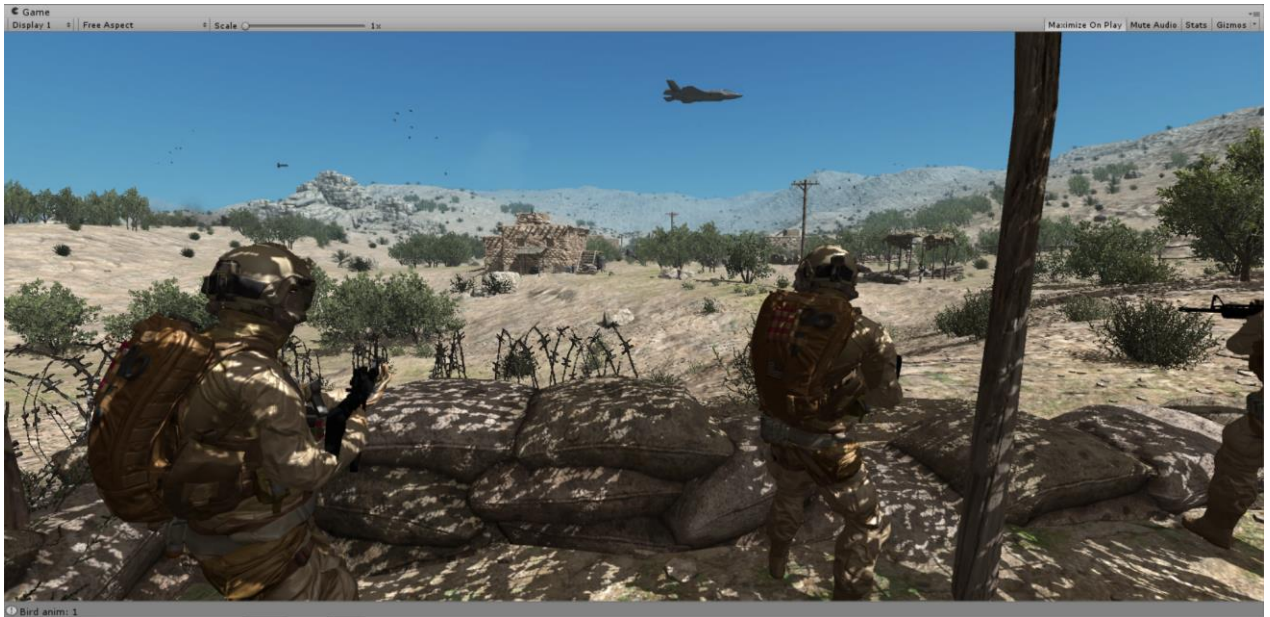
In this project, 3D image-based modeling technique is used to create virtual environment in Simulacrum. Objects in real life are modelled virtually using modeling tools such as Blender and these models are transferred into Unity3D project. Unity3D is capable of recognizing 3D object with extensions of FBX, OBJ, etc. [8].

In our simulation, we have two different environments which include 3D models. First environment is training scene which includes 3D models of NPC (victim) and medical instruments. In *Figure 7*, a victim who is injured in training environment can be seen. In this moment, it is expected from the participant to examine the wounds of the victim and start treating that wound correctly using items in the inventory panel. Inventory panel contains all the items in the possession of the participant and these items are displayed in grid view on the left side of the panel. If the participant would like to use an item from the inventory, s/he will click on the button of that item and that item will be displayed on the right side of the panel. It can be observed that the wounded victim is treated in the image on the right side by selecting an item from the inventory and using it upon the victim.



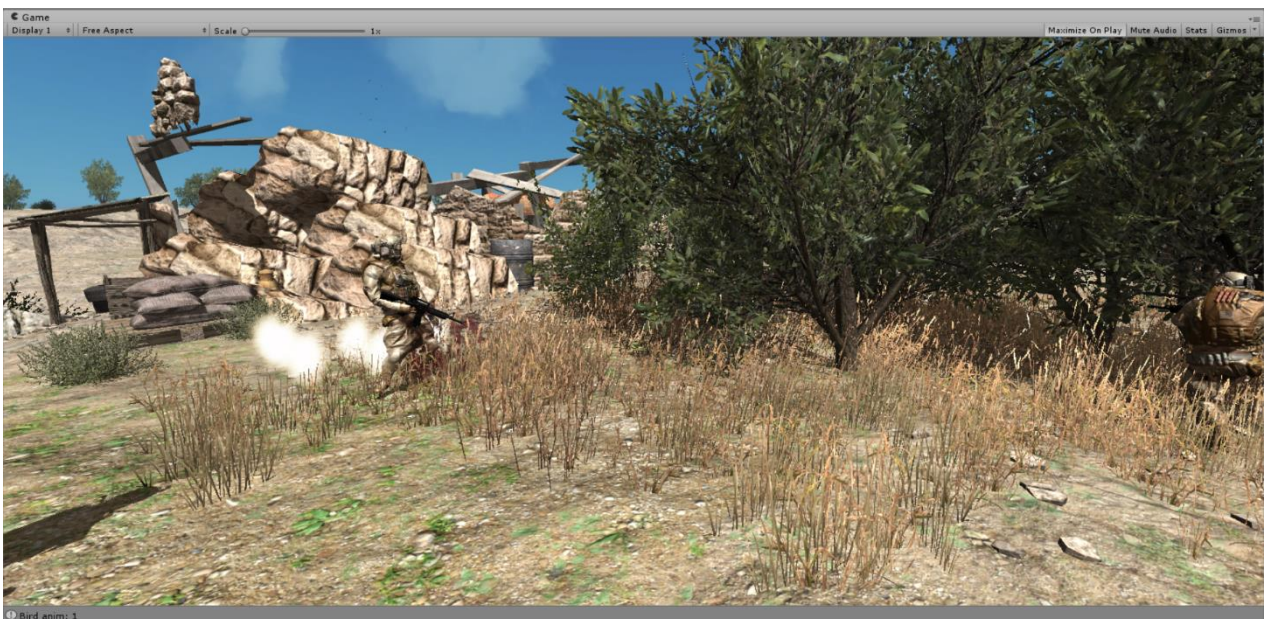
*Figure 7 Wounded Person in Training Environment*

Second environment is a battlefield. Apart from including NPC and medical instrument models, this environment also includes a terrain, tree, grass, armored vehicle, house and fighter jet models.



*Figure 8 First Scene of Battlefield Environment*

As it can be observed in *Figure 8* the participant shall start in a battle field along with his/her military unit. Initial objective of the participant is to neutralize every terrorist and secure the village in the *Figure 8*. Until any of the fellow soldiers are wounded, the participant shall act as a proper soldier as s/he is expected to fight with the terrorists using his/her gun.



*Figure 9 A Fellow Soldier Getting Shot Scene of Battlefield Environment*

In *Figure 9*, it can be observed that it is the moment of a fellow soldier is getting shot by a random enemy. In a certain part of the scenario, this event is planned to occur. To allow participant to practice medical intervention techniques, this event will always occur in some part of the simulation. In this case, it is expected from the participant to stop fighting and start performing necessary medical intervention technique immediately.



*Figure 10 Wounded Soldier Scene of Battlefield Environment*

In *Figure 10*, as it is expected from the participant, s/he gets closer to the wounded soldier in order to perform medical intervention technique. In order to perform this technique, participant must get to the indicator which will appear next to the wounded soldier. After reaching to this indicator, functionalities such as fighting and moving of the participant shall not be used in this part. Instead, medic bag which belongs to the participant shall appear and it will be expected from the participant to perform necessary medical intervention technique by selecting required items from this bag.

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