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MASTER THESIS

TITLE: Interactive AR-based tool for Gamification of Smart Touristic Places

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ABSTRACT

Augmented Reality is a computer-generated image technology that transcends the user's view of the real world, thereby providing complex vision, it adds to the real world digital elements depending where the user is looking and how he is interacting with the real world.

One of the main goal is to produce an AR app in "Biblioteca Museu Victor Balaguer", a touristic site based in Vilanova i La Geltru (Barcelona,Spain). An AR application has been built using Android studio and Unity3D platforms evaluated and tested in the Museum going through many 3D modules, videos and images rendered and augmented in the real world of the museum.

Unity, which is the main platform used to build this AR app has different levels of renderings over the real world. It varies from photos to videos rendered upon the real environment passing through 3D modules and animations and 360 degree scenes.AR applications can be built on many devices other than a mobile phone. In this report we will see an implementation of another application on Magic Leap glasses using the Lumin platform integrated with Unity 3D. The output of the same Lumin application was visualized using the Oculus devices to test the result in a virtual reality world.

In this report we will take a look on some current state-of-the-art in AR, describing the work performed in many other touristic places all around the world passing by enlightening the main differences between their project and the project explained in this document. Although the AR field has entered into medical, visualization, military and other technological programs, we will only touch the tourism part of the field. As any other touristic project, this app aims to encourage the touristic domain in some places that are not alive like it should be, which will end by turning back more money and benefits than these sites were earning before. For that we implemented a plan and a business canvas model that explains how these applications will make these changes.

The results shows that the combination of many framework together can lead to a new kind of AR gamification. The interaction between the user and the AR environment is accomplished from one side and between users from another. The mobile game app describes the site of ´Biblioteca Museu Victor Balaguer´ adding some fun for the users in the way of interacting with the real world of the Museum. This app is already programmed and tested on the field. The last stage of our game show an app developed on Magic Leap One that contributes and transmits Point clouds from one site of the Mediterranean to another, providing the user the ability to see and talk with another user at the same time.

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INTRODUCTION

New technologies are rising everyday we pass by, and Augmented Reality is to be considered one of the most important technologies raised in this century, considered as a main fact in changing the future. The field of AR is filled with investors and big company all around the world are interested in this field at all levels [1].

Back in 2019, the year that is considered as the great revival of the AR field where the funding, economical and commercial became strongest in the service of AR, the biggest names in technology, Microsoft, Apple, Google, Facebook and others determined to move forward with projects and researches when the installed user base for AR-supporting mobile devices reached 1.5 billion, and this number is expected, indeed, to increase significantly in 2020 which will be considered the desired year. Thanks to the facts mentioned above, AR has been developed from a science-fiction term to a real technology used in several domains, and it has become a popular term specially in the past few years. AR on mobile phones can be implemented using two ways, which are both used in this project. First we do have the marker-based AR,which is considered as the most powerful technology in AR that uses the algorithms of image-recognition and 3D object recognition to understand and estimate both position and rotation of the marker. Depending on this data, the program will display the desired game object (3D module, video, etc...) in a specific place. The second way, consist of the marker-less AR that is less complicated in terms of algorithms used, works continuously with no object to render depending on it. Thanks to unity using the ground plane features, will give you the permission to display your desired output on any ground surface and the GPS feature to display it on a specific location such as Pokemon GO application [2].

MEDGAIMS is a project that will be developed by a group of partners located in 4 countries on the Mediterranean that aims to demonstrate how entrepreneurship in gamification can be used to increase the diversification of the tourism offer. The MEDGAIMS project develops games not just for fun, but with precise aims: to revolutionize the tourist site experience by gamifying it with both physical and virtual applications, thus increasing tourism flows to the destinations, and creating jobs and startups for game entrepreneurs. The strategy consist of building several touristic game in the country of Mediterranean: Spain, Italy, Lebanon and Jordan. Each partner should develop 10 games,analogue and digital that makes the total presented games to 40 across the Med. This work represents the contribution part of i2CAT in the whole project were the company is responsible of developing AR app in two sites in Spain [3].

From the first stage of this project the tasks were all about the mobile application. When investigating other AR platforms and devices, an idea came by completing this touristic game by adding more life to it using the Magic Leap One process and making a live game between countries.

The main platform used in feeding the program with our 2D markers as painting and images placed in the museum is Vuforia, considered the most accurate platform that Unity3D prefer to work with. Beside the 3D object used as markers in the same site are scanned and fed to the program using the Vuforia Object scanner. Afterward in this context we will explain briefly why this platform was selected naming the basic pros and cons of other platforms. In the second part of the project where the AR App was built on ML-One we did not use any of the platforms mentioned above. Lumin is a completely different platform,

not compatible with Android, and this forced us to change all the regarding the codes, the context and the tracking areas. The basic programming language used is C# in both applications.

The remainder of this document is organized as follows. Chapter 1 introduces the State of the art of possible AR frameworks/technologies and State of the Art regarding current gamification projects in the field of cultural heritage. In this chapter we describe which possible frameworks and technologies we do have and which is selected mentioning the cause of our selection and we will discuss some of the related projects developed in the same field used in our project. Chapter 2 explains briefly the script of the game main platforms and flowchart, followed by an introduction of the main stages of the game and what the user can expect when playing. Chapter 3 contains the implementation of the mobile App game and the strategy of the visualisation for point cloud on Magic Leap device. Chapter 4 describes the result of the implementation and the testing for both application. In Chapter 5, we introduce the Users Experience Journal and an implementation for a business canvas model and what incomes and revenues is expected from our game. This document ends with a conclusion chapter that highlights the technical research programmed and the business investigation characteristics also proposing future works for the applications without missing the sustainability considerations and ethical considerations. The document also includes an annex that describes the physical description of the ”Biblioteca Museo Victor Balaguer” site.

CHAPTER 1. STATE OF ART

In this chapter we introduce the state of art that refers to the AR frameworks and technologies that can be used in the implementation of the project and the current common gamification projects deployed in some sites in the world.

1.1. State of the art of possible AR frameworks/technologies

The AR field is going through a very fast revolution and platforms are being created literally every year. Choosing on which platform the developer and the designer wants to works depends on what it can offers its advantages and disadvantages. For that reason a research led to indicates the pros and cons for all the possible frameworks and technologies well cited in Table 1.1. Most of the AR-app was created using a combination of platforms meaning integrating two or three platforms together to suit the needs and the desired output for the app.

Going through the main platforms used in the field of AR:

Table 1.1 AR Frameworks/Technologies.

Name	**Definition**	**Pros**	**Cons**
ARKIT 2 [4]	Developed version for iOS previously ARKIT	Real depth camera	Only for iOS and the software changes often.
ARCore [5]	Relies on smartphone camera to understand the environment	Motion Tracking	Few support devices
Unity3D [6]	Basic platform for XR, AR, VR building Apps	Integrates with all needed Platforms	Software changes often.
ViewAR [7]	An App where directly you can render objects	Easy to use	Support very small applications.
Vuforia [8]	Common platform for targeting images and objects	Simple and easy to use	A specified number of target allowed.
Lumin [9]	Platform for building on MagicLeap	Very accurate and interactive	New and hard to implement.

Referring to the table above the most appropriate platforms used in AR app worldwide are Unity3D and Vuforia integrated together since these two platforms has many built-in functions and features that suits the needs of the developer. Unity3D image tracking system is easy when using Vuforia because of its simplicity and its wide range of Image

target that you can upload and be used as markers . Reasoning to this and specially for the part of the Android mobile application, these two platforms have been chosen: Unity to be the main platform where the application will be built and Vuforia the portal calling all the markers, 2D and 3D. Back to the second part, Lumin will take the position of the chosen platform to built the AR-ML App, despite the difficulties of this platform it stays the most appropriate one. Lumin will not use Vuforia for the concept of AR Camera to detect it has its own marker detecting integration, but for sure it need to be coded using C# language.

1.2. State of the Art with current Gamification projects

In this subsection we will review some of the current games deployed in the field. In particular, we selected three projects as examples that have some common points as our project.

1.2.1. NosfeRAtu, Slovakia

This is a project that has been accomplished by the Technical University of Kosice based in Slovakia with the Universitat Politecnica de Valencia in Spain. These two groups has been working on an App called NosfeRAtu which its main idea to create a virtual tour in the Orava Castle (Slovakia) where the users are accompanied by a virtual character based on a film personage Nosferatu, and while the game is running the tourist using this app will discover and learn about this place and its history by completing different quests [10].

The project, implemented in 2016 consists on some main stages starting by presenting the historical information of the site using a playful way by implementing specific tools. During the second stage the user will collect some virtual objects that is hidden inside the castle, accomplished by displaying UI buttons augmented in virtual world. The basic objective of the game is to collect these virtual object before being hunted by a virtual vampire. The technical part of this game is based on virtual reality but is considered as a part of gamification in touristic places.

1.2.2. The National Museum of Singapore

In this site developers are running a new project called Story of the Forest. The main idea is to be focusing on 69 images from the William Farquhar collection of natural history drawing which are transformed into 3D model that can all the visitors interact with [11]. What to do is downloading an App and then all visitors will use their cameras to explore the different painting.

Using technology to provide a learning experience adds some fun to it. Like the famous app of Pokemon Go, the visitors of the museum are able to collect, hunt and catch items who are basically plants and animals within the paintings. Once these item has been collected the App shows more information about. This project which has been developed and created by the Japanese digital art collective teamLab has brought drawing to life so visitors can interact and explore the image in a new way.

Figure 1.1 NosfeRAtu Game

Figure 1.2 Story of The Forest

The Story of The Forest game is considered as the best AR/VR game in Singapor. Merging the two platforms in the same game was a new challenge for gamification but the game still has the shape of a traditional one in the interacting process of itself.

1.2.3. Augmenting the Tholos of Delphi

The most relevant media used in this game were texts with specific historical information on each monument accompanied with 3-dimensional video representing the monument, some theatrical acts that had been played on these monuments ages ago and some drawing or photographs of these monuments that describes how it looks like on some specific ages.

Based specifically on the AR and real world, this game, simply as it looks, has improved the touristic side of this site, where an economical study declared the number of tourist has increased by 3 in the same year where this game has been deployed [12].

CHAPTER 2. GAME ARCHITECTURE

In this chapter we will present all the AR tools that will be used in developing the applications. In the followed sections we will introduce the main stage of the mobile game app and what the game will contain as contents and modules. This chapter contain also the architecture of the protocol and framework used to built the application of the point clouds on AR and VR devices.

2.1. Unity3D Process

Unity3D is the most common program used in building AR applications. It contains many features that are helpful in improving any game application and other features can be implemented by the programmer itself to find solutions for the purposes.

In order to accomplish the mission Unity3D needs help from other platforms, mainly C# coding where all the codes that the programmer needs must be written, and Vuforia used for the recognition of the specified marker and targets used in the application. The game is basically built on Android platform and can be also built on iOS platforms.

Unity3D takes care of the following processes:

- Augments the videos and 3D modules in the real world taking into consideration the positioning and the rotation.
- Calls the scripts written via Visual Studio that feed all the rendered items inside the game.
- Merges coding with 3D designs and other rendered game objects.
- Sets up the marker function and the detection process.
- Detects all the errors and specify in which level of detail it is.

2.1.1. Coding

All the coding part of games built in Unity3D are written using Visual Studio and the language used is C#. This language is intended to be simple and object-oriented programming language that adds intelligence to programs and games. In our case many stage of intelligence are added that we will have a deep look on it and how it is programmed in the implementation section.

2.1.2. Vuforia Engine Library

The Vuforia Engine Library consists of many technical stages used essentially to help game programmers with its specific SDK to build AR applications. It supports the main accurate platforms in gaming: Android, iOS , Lumin and UWP. The basics features that

the engine provides for the developers are image targeting, objects and environments recognition. This engine is updated continuously to fit the demands of the programmers mainly the API used for Unity3D, and the Application Programming Interface used in this application is OpenGLES3, since it is the corresponding API software between Unity3D and Android Studio that will allows the communication between these two applications reachable and available [13].

2.1.3. Vuforia Object Scanner (VOS)

To scan a physical 3D Object and use it as a target in Unity, Vuforia has developed a new features added to its existing ones, the VOS. This App will produce an Object Data file to be able to define the object target in the Target Manager [14].

2.1.4. Android Studio

When building application in Unity supported by Android platforms, most of the configuration needed is provided by Unity platform such as the API, SDK and JDK. The Android Studio is connected to Unity via some support libraries downloaded directly with unity that uses the SDK, NDK and JDK of android which connects directly your desire and starts by building your gradle and lint infrastructures and deploy the game on android devices using the specific APK of it. The gradle and the lint infrastructures represents the tools that Android Studio uses to make it compatible with the 3D modules, canvas, videos and images implemented in Unity3D, two main protocols aims to take care of all the desired content built on any android device or platforms, in other words it allows the game to be visible on the device [15].

2.1.5. Android SDK, NDK and JDK

To be able to compile and build the application on android devices the SDK is required that represents the link between the platform you are developing the App and the device. Despite every device has its own SDK, although the compilation of all androids devices is compatible and the desired SDK can be found by plugging the device through the laptop using USB cables. It provides a set of tools and libraries which are convenient with specific platforms (Unity3D in this case) to allow the developer to build and create his own application.

The NDK is the tool set responsible of the implementations of the App in a native code such as C, in other words it allows the developer to program in a specific language for Android devices. The NDK integrate with the SDK to make the process possible [16].

The JDK represents the Java compiler and it is always related to the gradle and the lint infrastructure which permits the user interfaces and the graphic parts of the application to be visible.

2.1.6. Lumin Operating System

Lumin Os is derived from Linux and Android Open Source Project. The main purpose of this design is for spatial computing. The figure below can transmit a better idea.

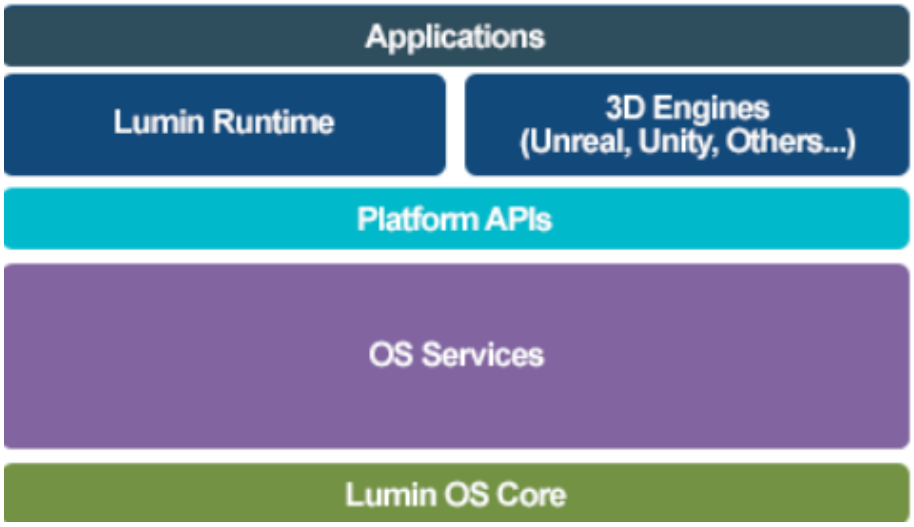

Figure 2.1 Lumin OS

Relating this OS to unity, lumin has some component that are custom-built and Unity3D is one of these components. The main aim of using Lumin is for the implementation of the application on MagicLeap One.

2.2. Game Main Stages

2.2.1. Mobile Game-App

The overview of the mobile game is composed of 6 main stages going from the outdoor stage till the fifth room of the museum. The whole idea of this game despite its technical way, is introducing a secret organisation that many people only hear about it and do not have an idea what is it.

In other words the game objectives in unlocking stages starting from the outdoor of the museum and more specifically from its gate, where many mason codes will be provided and the user have to unlock these secret code room by room to end up by being accepted as a mason mind thinker. In the following paragraphs the main stage will be provided deeply and you will estimate and understand the whole float of the game.

The flow chart in section 2.2.1 will provide more specific idea how the game will be run.

2.2.1.1. Outdoor Phase

In this stage an augmented video will be rendered on the real world explaining the rules of the game and an historical overview of the site. The basic game consist of a quest asked to the users, depending on 4 sculptures on the wall surrounding the museum each one

of the targets on these walls explains one concept of masonry and the question rendered is related directly to the sculpture. When answering the 4 question a 3D module of a HAND will be provided which signifies the mason hand but without any of the 6 symbols of masonry that are Key, Sun, Star, Crown and Lantern.

2.2.1.2. The Beginning Phase

The first room of the museum the place where many paintings and monuments are placed imported from all around the world. These paintings will be the marker used in our application. Based on these markers the rendered objects and videos and quests will be brought to the real world. The game designer chose this room to be considered as EXIT story realized through the paintings by creating 3 stories that starts with a confrontation and end with the exit of your old mind. A KEY symbol will be provided on the 3D module of the hand meaning you are ready to keep on discovering other hidden mason secrets in the building.

2.2.1.3. Egypt Phase

The main character of our game is Victor Balaguer, the founder of the site. As he was a traveller and had already visited many nations in that age of the world, his main objective was spreading his beliefs about the masonry activities and thoughts. In the room specialized to EGYPT in the museum, there is an embalmed mummy dating back thousands of years. Creating a 3D module of this mummy and rendering it over the real world pushed the application to a new level of AR, where the user should finishes his task inside that room and avoid loosing since the mummy and its soldiers will be blocking the road and the user will never escape that room.

2.2.1.4. God´s Phase

Game of 8 possible offers related with different cultures, from Japan to Philippine and Colombia, etc. The user should satisfy the GOD he is interacting with, or the followers of this God will attack. The game of 8 offerings related with different cultures and Gods, the users have to choose which offering is going to make the god happy and will calm down their anger.

2.2.1.5. Meeting Phase

Victor Balaguer has had many of loyal friends hat believed in his thoughts and followed him to spread their point of view regarding masonry, his main supporter being his wife. Inside his marvellous building Victor used to meet his loyal friend in this room, where they discuss and agree and take decision about the future of Villanova. A game based on AR videos will be provided in this stage where the user should interact with the discussion and the agreement and finally help to take the right decision for Villanova.

2.2.1.6. Biblioteca PHASE

The room where Victor used to enlighten himself and his soul. Many books related to masonry could be found in this room. The user in this stage after solving the quests provided using markers and AR components rendered in the real world, he will be able to find the name of the Game ”SURGE ET AMBULA” that means ”Stand and Walk”.

2.2.2. FlowChart of the Game

In this section we will describe the flowchart of the whole game in Victor Balaguer Museum in Vilanova. After each step of this flowchart we will do a description room by room. Fig 2.2 shows the first stage of the game :

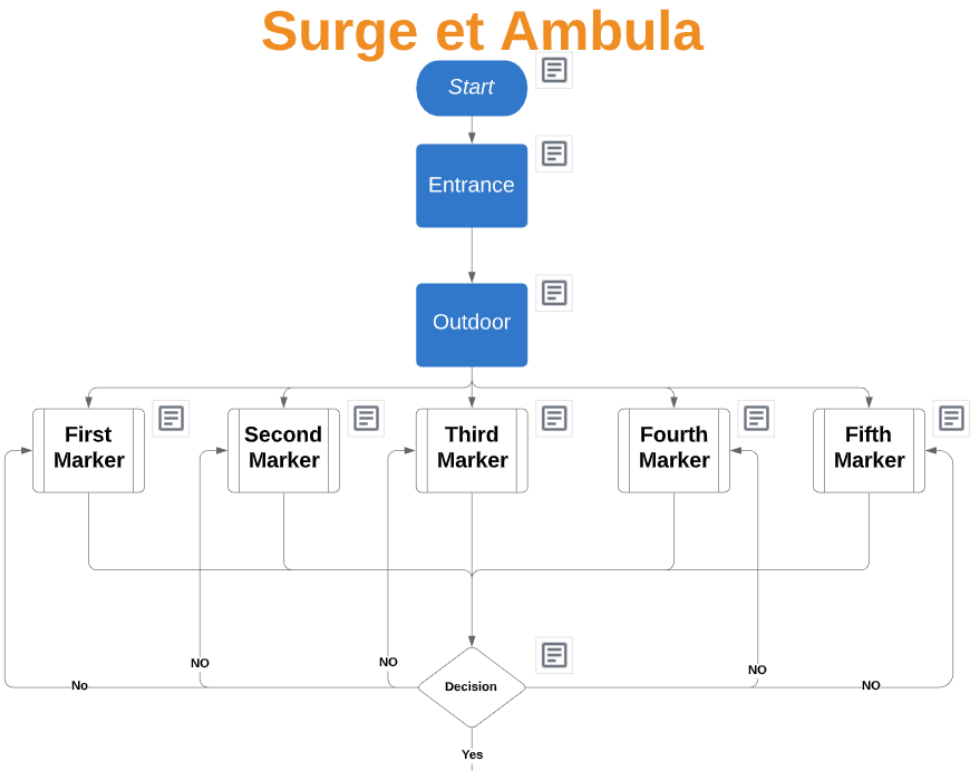

Figure 2.2 Flow Chart Outdoor Stage

- Start: Where the user should download the application and run it.
- Entrance: Whenever the app is run a message will appear on describing what is the aim of this game and leading the user to his first marker. When getting the first marker an AR video will appear describing the whole game and the path that should the user take adding some information about the museum and the secrets hidden inside it.
- Outdoor: In this stage we will have 5 marker outdoor, and the game here will be consisting on quests. The user can interact with these quests and solve it. The quest will include only general idea about the big Secret of this museum that should

be discovered at the end of the game. After getting the 5 markers and solving the quests, a message will appear indicating to the user to head to the main front door of the museum where there is a marker on the floor which will be the starting of the game.

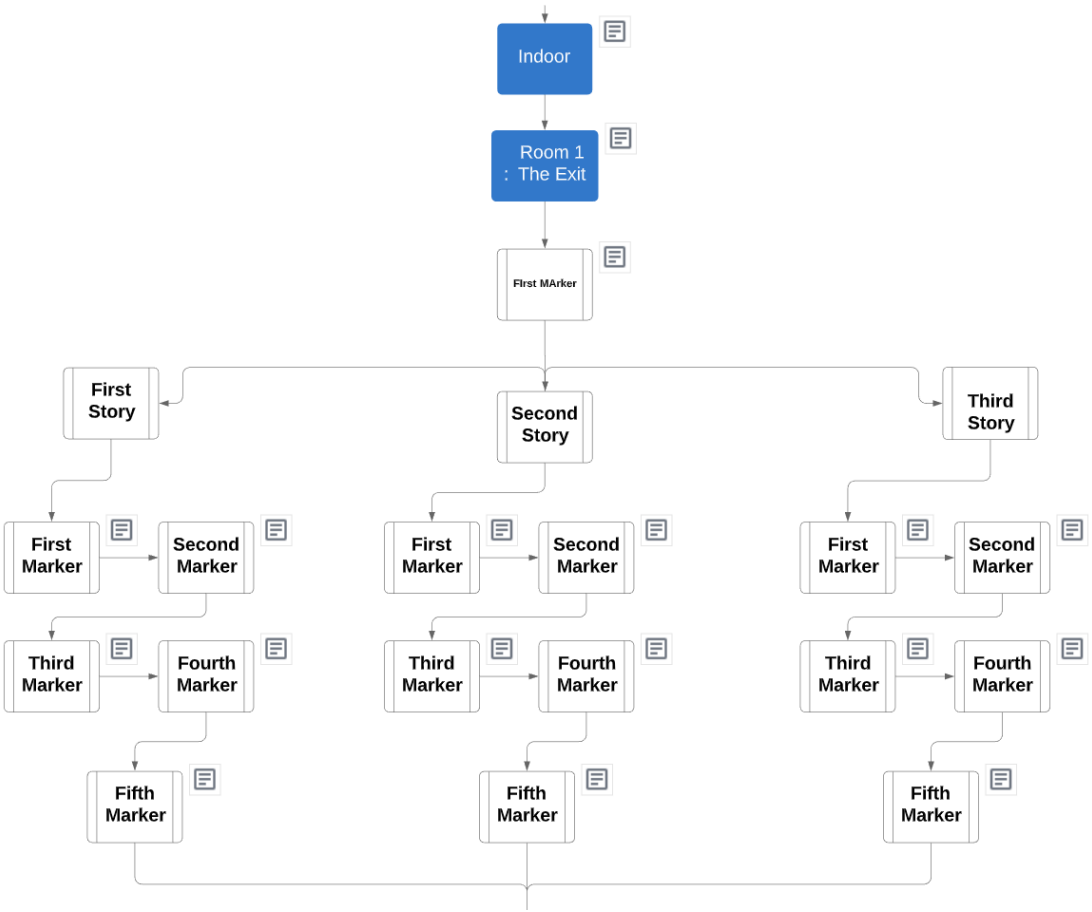

Figure 2.3 Flow Chart First room

The name of the room is THE EXIT, Fig 2.3, where we assume that the user will have some knowledge about our secret where he should open his mind and start learning what Victor Balaguer did ages ago. After finding his first marker users will be able to choose between three stories, whatever story he chooses, it will lead him to the next stage. The three stories are about the Secret of the museum and moving from marker to another marker the story will continue as texts rendered in the real world. After finishing the story (any of these three) the user will receive the same hand that he got on the entrance of the museum but a logo will be added to it like a reward, the logo is KEY and from here he will start understanding what he should do at the end (filling the five finger of the hand by logos). After the Key Logo, a message will appear leading the user to the next room.

The second room of the indoor is the room of Egypt, Fig 2.4, since all the content in it are shipped from Egypt. In the first stage of this room we have our first marker that will display an AR video explaining somehow the content and the instructions of this room. The game in this room will include on its first two target a quest game of multiple choices. After answering the two multiple choice quest users will interact with a 3D module of an animated skulls talking to him/her, asking a question and with augmented reality buttons

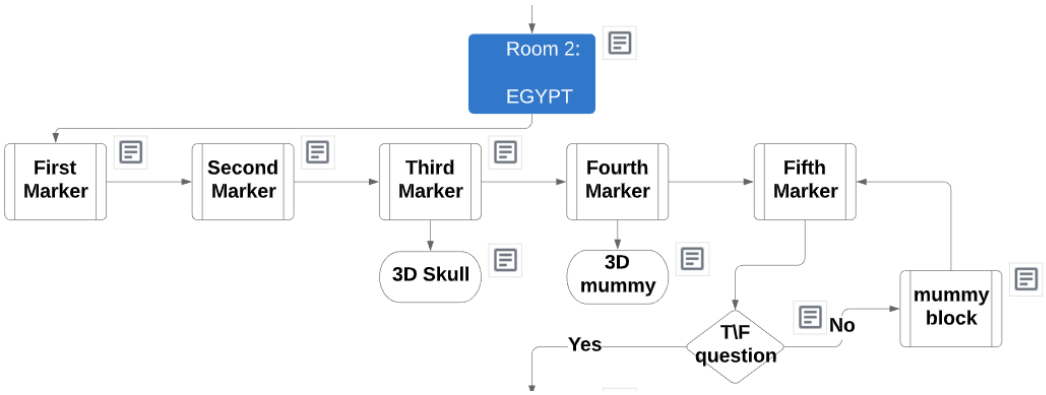

Figure 2.4 Flow Chart EGYPT Room

he/she will be able to answer on the skull question. If he answers right he will move to his next target where he/she will be able to see a full 3D module of a mummy near the mummy inside that room talking to him/her and giving him/her instruction about what to do and where to move. In the last stage of this game the user will have to answer a TRUE/FALSE question asked by the mummy, if he/she answers right he will be able to move and get the hand animated again with its second logo the SUN and if not two armed mummy will block his road and he/she must answer again the question but the user will loose points.

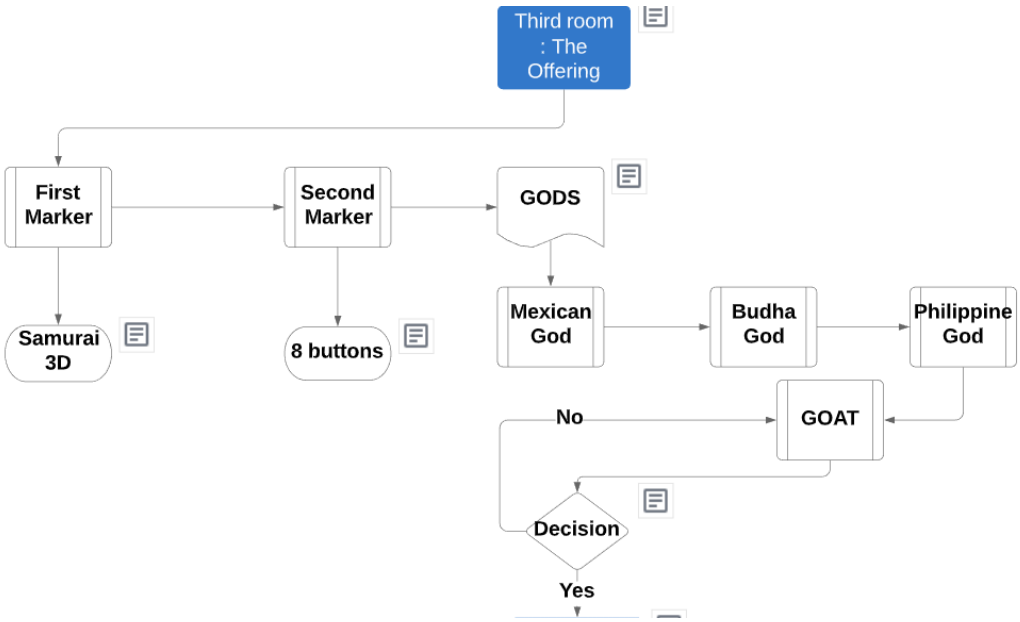

Figure 2.5 Flow Chart GOD´s Room

The Offering room is our third room, Fig 2.5, where we have inside a lots of GODS presenters as Buddha, Philippine's Gods, Mexican´s Gods. The basic idea of this game is how to make the gods happy. In the first stage a video will be displayed to explain this to the user after a 3D module of a samurai will appears to give the user the instruction. In the following marker the player will get 8 buttons (AR) and moving through Gods you have to choose which of these buttons will satisfy the God. In the last stage of this room users will find a 3D module of a "GOAT" and have to choose which Gods will be satisfied with the

GOAT. Finishing this stage, the animated hand will reappear again and the third logo will be on it which is the STAR.

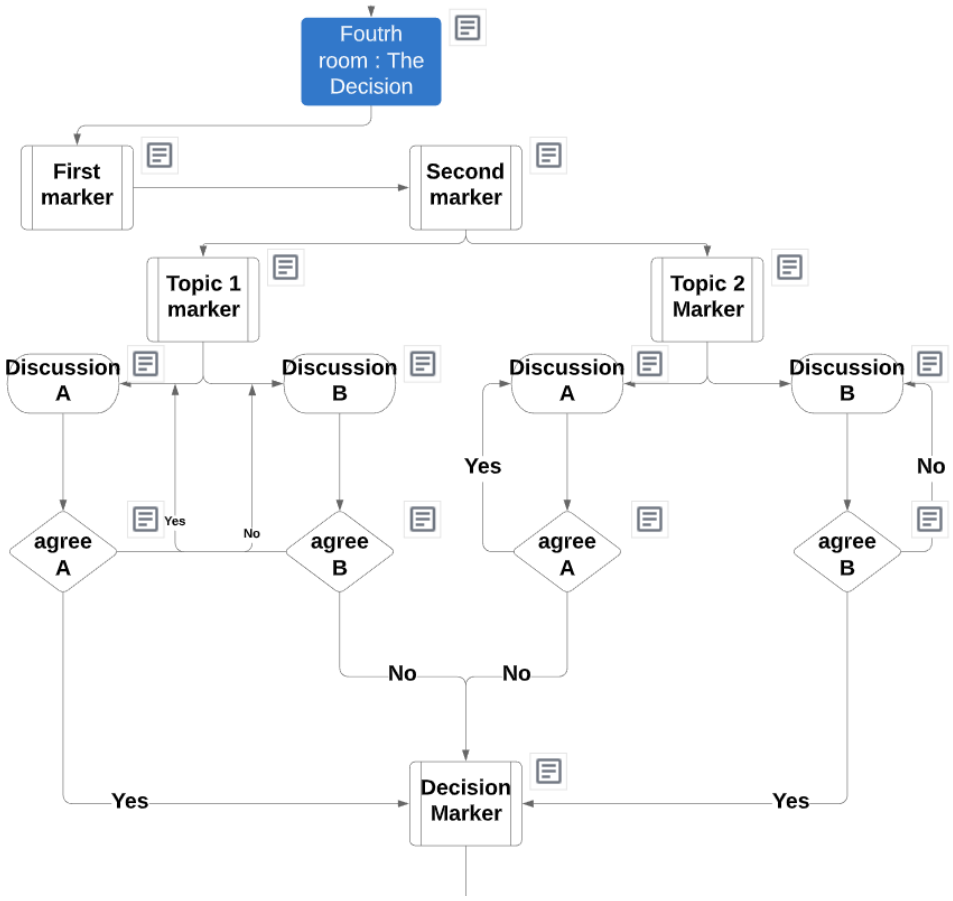

Figure 2.6 Flow Chart Meeting Room

The fourth room, called The Decision,Fig 2.6, deals mainly in the meeting room where Victor Balaguer used to meets with his colleagues. While in any meeting room the criteria that happened is choosing a topic, discuss it then after the discussion they usually make an agreement about that topic to end up by a decision. And that is exactly what we are offering in this room. The user will be able to choose between two topics after displaying for him a videos that will help him to choose and at the end our user should make the right decision that is convenient with the secret party that our story talks about. As we can observe in the flowchart the user in one of the two topic and after the discussion must agree with Victor Balaguer and his colleagues, and the second topic user should not agree with victor Balaguer and the others (like a tricky question would be). After this stage the people in this meeting will decide if you can move on and continue to be one of them or you should repeat your test to learn how to be. Also the Animated Mason Hand will appear again after this stage to show the fourth symbol on the hand which is the CROWN.

In the ´biblioteca´, Fig 2.7, the majority of the secret will be found as at the end of this stage the user will get the name of the application which is ”Surge ET Ambula”. So in describing this stage the fifth room name the Mason Code, the user should find 3 markers in the room and each marker will lead to one of the 3 words. But the words will be written in the mason code, that consist of symbols and each symbol represent a letter from A to Z. After getting the three words a video will be shown explaining the meaning of these expression then the

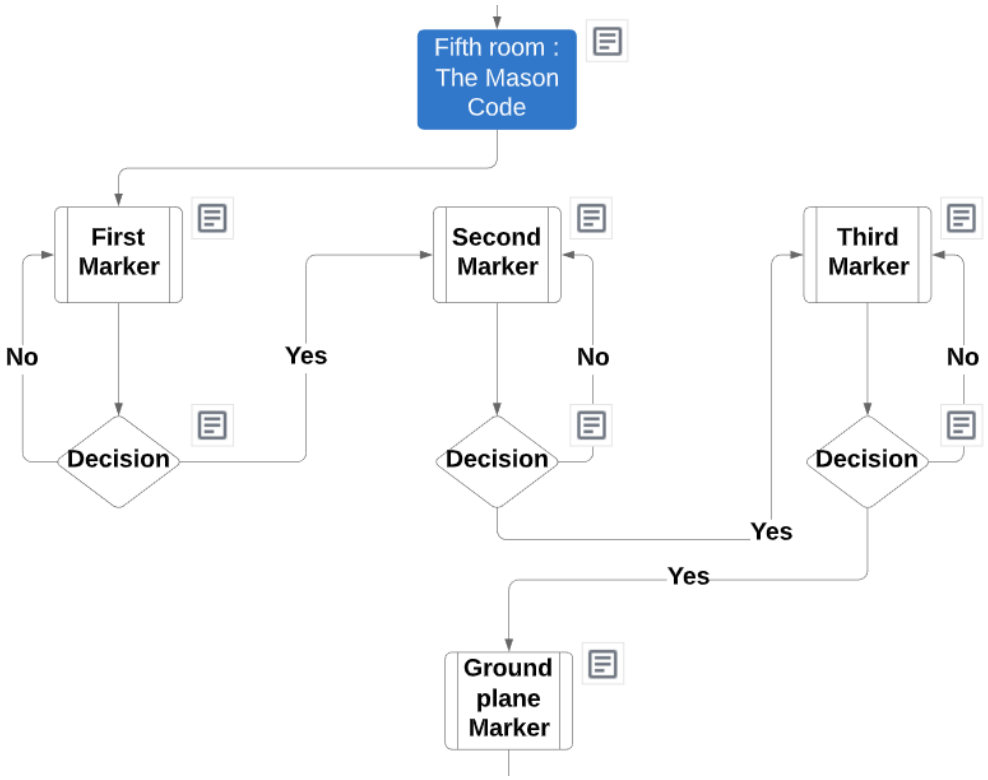

Figure 2.7 Flow Chart Biblioteca Room

mason hand will appear again showing the full symbols on it and specially the one of this room which is represented by LANTERN.

Figure 2.8 END of the Game

At the end of this stage, Fig 2.8, the user will get the hand with the 5 symbols plus the one EYE inside which means that you became a Masonite.

2.2.3. Magic Leap One Lumin

Magic Leap One considered and named as the killer of screens for the future it holds for the XR and AR. It is a new technology released in the US of America with a lot of researches was running around this technology. Building applications on ML is still as baby-born projects, simple AR and XR games were built and the investigation all around the world is taking the technology more seriously [17].

As mentioned before this app games created for MedGAIMS, consist in encouraging the tourism between all the countries of the Mediterranean, from Spain and specially i2CAT we took the challenge in bringing the real world of other country to here and vise-versa.

The main idea is making an interaction between tourists in the four countries mentioned by sharing at the real time and real visualisation the experience they had in these touristic sites.

Figure 2.9 Magic Leap One

2.2.3.1. Concept of Materials

This applications is a combination between Lumin and Intel® RealSense™ camera, Fig 4.7, together integrated into Unity3D that compile the outputs and inputs of both devices and instruments. The Intel® RealSense™ [18] depth camera offers high quality depth regarding its wide field of view, considered one of the best cameras for the applications that uses augmented or virtual reality. The range of this camera can vary up to 10m. The phenomen uses its Intel RealSense SDK 2.0 and cross-platform support. According to ML1, considered as ”futuristic pair of augmented reality (AR) glasses”, it is designed to enhance the real world in augmenting objects and modules that can be interacted from the side of the user.

Figure 2.10 Intel® RealSense™ Camera

2.2.3.2. Concept of the Application

The main idea comes from sending and receiving point-clouds of the user at the real time to make an AR experience between the four countries. At the last stages of the AR game in any of the four countries, the user will be able to share his experience about their touristic experience in the sites he played in with another user in another site at the same time. In the following chapter the implementation will be shown in more details.

2.2.3.3. Point Cloud Multi-points Control Unit (PC-MCU)

The PC-MCU is a program that i2CAT is developing which aims to send and receive multi point clouds data via online servers to achieve a real time communication between multi users. The whole study consist of recording PC via real-sense cameras visualised using Unity3D platform and displayed on AR and VR devices. The process of sending and

receiving these PCs is done using online servers where the frame-bits per second of the points should be considered as a high propriety for this application to avoid delay and error issues. To minimize the latency, a parallel work is done where the sending and receiving processes runs at the same time on each frame, the program starts to decode the package before it is received completely and send the next package before decoding the previous one completely. In our project, PC-MCU is the responsible of the sending and receiving process of the PCs using the servers. Mentioning that this protocol will work in parallel and the two processes of sending and receiving will work at the same time. Fig 2.11 shows the architecture of the MCU, we can observer that the process from collecting the PC data from the camera till the receiving PC data to the smart glasses is done by the MCU.

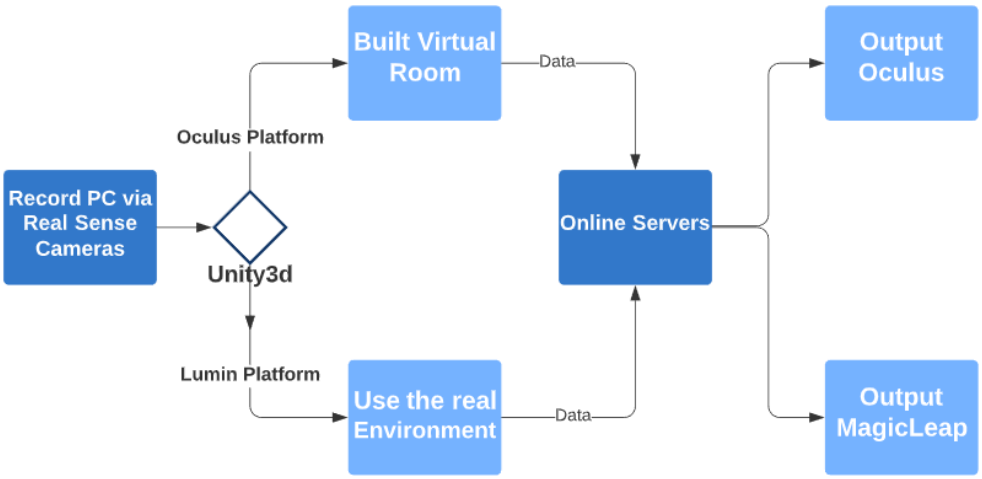

Figure 2.11 MCU Architechture

CHAPTER 3. APPLICATION IMPLEMENTATION

In this chapter we will introduce the implementation of both applications by mentioning the main steps followed and the programming intelligence deployed in the platforms.

3.1. Mobile-App ”Surge et Ambula”

3.1.1. Unity Data model

For this work we will use Unity3D to manage all the data that this application will consist of. Unity3D was chosen as mentioned in previous chapter because it is easily implemented and can adapt a large number of platforms and integrate them together. An important detail is the version of Unity used, in our case we used the Unity 2019.2.21f1, mentioning there is no reason for this version but whenever the process starts in developing using Unity it is recommended to stay on the same version. The Data combined in this platforms needs to be validated by the other platforms (Android or Lumin) to prevent any compilation error in Data receiving into Unity3D. The Data models are in form of coding (C#) ,modelling (3D), pixels (Camera) or images (Vuforia).

Obviously, it is important to remind that the Game has many features that will be listed in the following subsections, all these features are programmed using C# coding and integrated with Unity to come out with the best UI modelling app.

3.1.1.1. Game Languages

The main characteristics of the Game is its languages deployed in the main 3 languages used in Catalonia, English basically for non-local tourist, Spanish for country-local tourist, and Catalan for locals in Catalonia. Using a specific feature that Unity offers building the same app but with differed languages can be done using the ”PlayerPrefs”, a very useful process where depending on which language the user will choose the texts and videos and all the scripts of the game will be called in the desired language. An example of how this code is implemented is mentioned in this paragraph (data model 3.1).

From the first script of the game the user will be able to choose between the three languages as 0 is English, 1 is Spanish and 2 represents Catalan. The main advantage of using the PlayerPref is the saving method from scene to scene, the code will be fed by the language the user is using and this will be applied to videos and 3D text also.

```
"languages":
  {
    "PlayerPrefs.SetInt"("userLanguage", 0),
    "PlayerPrefs".Save(),
    "SceneManager.LoadScene"("username"),
    "PlayerPrefs.SetInt"("userLanguage", 1),
    "PlayerPrefs".Save(),
    "PlayerPrefs.SetInt"("userLanguage", 2),
    "PlayerPrefs".Save(),
```

```
      }
```

Data Model 3.1 Schema of floating the Languages

3.1.1.2. Game videos

The game uses almost 20 video and each video is repeated 3 times depending on its language subtitles mentioning that the video were filmed in the museum by professional actors where they played the role of Victor Balaguer and some of his friends leading and helping the users how to move inside the museum and to follow the chart of the game on its different stages plus some information about the historical side of the museum an of Victor Balaguer himself. One basic challenge was on displaying the videos depending on the languages chosen, in this code we can observe the process (data model 3.2).

```
    "videos ":
      {
    "VideoPlayer videoPlayer" = gameObject.GetComponent("typeof(VideoPlayer)") a
    "videoPlayer.clip" = videoSource[PlayerPrefs.GetInt("userLanguage")];

      }
```

Data Model 3.2 Video Languages source

And from here we can observe that the video flow using the playerpref getting it from the userlanguage displays the necessary video according to the desired language.

3.1.1.3. Game Points

As it is a game it will be important of mentioning some kind of motivation for the user by deploying a pointer where whenever you answer or you react wrong to your quest in the game, the user will loose points. The main challenge in here is following the counter from scene to scene and from button to button which also is applied by a piece of coding mentioned here (data model 3.3) .

```
    "POINTS INFO":
      {
 "PointController".ReducePoints();
 "GameObject[]" gos;
 gos = "GameObject".FindGameObjectsWithTag"("pointtext")";
gos[0]."GetComponent"<Text>().text="POINTS:" +"PlayerPrefs".GetInt("UserPoints");
      }
```

Data Model 3.3 Points Body

3.1.1.4. Marker Manager

Unity3D combined with Vuforia relies on detecting markers and targets and following the position rotation and scale of this target, we can render our objects or videos or messages.

Taking into consideration that we have many markers in the museum, a new fact should be considered in a high priority which is indicating to the users where they can find markers (data model 3.4) and informing them when they detect a target but for now it is not activated and they should unlock it with previous markers.

```
"MarkerManager":
  {
  "public" GameObject[] targets,
  "public" int currentTarget = 0,
  "public" void CheckMarker(int marker),
  "if" (marker == currentTarget) ,
       // Show Marker Content,
 targets[currentTarget].GetComponent<EventAction>().OnTrackGood.Invoke(),
   "else" ,
       // Find another marker,
targets[currentTarget].GetComponent<EventAction>().OnTrackBad.Invoke(),


  }
```

Data Model 3.4 Marker Manager Body

3.1.1.5. Scene Controller

The game consist of scenes and each room is one. That behavior should rely on a script written to take the control of the float of it which mean a code that feed the game on how moves from marker to marker and when to activate and deactivate a message, a module or a video. We attached below a piece of code explaining how to activate and deactivate game objects, image targets, videos and 3D modules (data model 3.5).

```
"parameter":
  {
     "public" GameObject[] quests;

// Start is called before the first frame update
"void" Start()
{
    "for" (int i = 0; i < quests.Length; ++i)
    {
        quests[i].SetActive(false);
        "if" (i == 0) quests[i].SetActive(true);
    }
}

"public" void Activate(int num_quest)
{
    "for" (int i = 0; i < quests.Length; ++i)
    {
```

```
        quests[i].SetActive(false);
        "if" (i == num_quest)
         {
    quests[i].SetActive(true);
    "if" (quests[i].GetComponentInParent<EventAction>() != null)
              {
gameObject.GetComponent<MarkerManager>().currentTarget = quests[i].GetComponent();
              }
           }
       }
   }
     }
```

Data Model 3.5 Scene Manager

3.1.1.6. Wrong Marker

Since our game has a flow the users will be moving from marker to another. A new intelligence is implemented in the coding of the game which aims to indicate when the users will detect a marker but it is not on its right time, a wrong marker message will appear. This code (data model 3.6) shows how to implement it :

```
    "Wrong Marker Manager":
      {
      "public" void "PlaceWrongMarker"(Transform markerTransform) {
        markerTransform."SetParent"(gameObject.transform);
        markerTransform."localPosition" = new Vector3(0,0.1f,0);
        markerTransform."localEulerAngles" = new Vector3(0, 0, 0);
    }


      }
```

Data Model 3.6 Wrong Marker Manager Body

3.1.1.7. Look to Camera

Tracking markers and target can be done from many angles. This could cause problems for the texts and 3D modules that we want to be always facing the user, more specifically when the user detects a markers the rendered object will move with the user and always look to the camera (data model 3.7).

```
    "Look to Camera":
      {
"Vector3" forward = "Camera".main.transform.forward;
 forward.y = 0;
 "forward" = forward."normalized";
```

```
 "Quaternion" rotation = "Quaternion".LookRotation(forward);
"transform".rotation = "Quaternion".Lerp(transform.rotation, rotation, velocity);
    }

    }
```

Data Model 3.7 Look to Camera Body

3.1.1.8. 3D Design

In this part and using the help and knowledge of a 3D design student, Quim Colabrans Ramirez, we designed several 3D modules implemented in the game. The schema needed to generate these assets is the following:

The process of modeling:

- 3D Blocking: Generate basic 3D shapes with simple geometry.
- Sculpting: Create complex geometry based in the 3D Blocking.
- Re-topology: Remake the geometry with as less polygons as possible, but without losing the shape.
- UV: Create the 2D interpretation of all the faces of the 3D mesh.
- Texturing: Use the UV generated to give the mesh it's texture (Color, Roughness, Reflections, etc.)

The process of animation:

- Rigging: Create the "skeleton" of the mesh and the points used to move the "bones".
- Skinning: Generate the relation between the "skeleton" and the polygons of the mesh to make the geometry move as the skeleton does.
- Export to engine: Unify every element to have the final asset.

Examples of 3D module built shown in Fig 3.1 and Fig 3.2.

3.1.2. Game Script

The game chart was created by the game designer, Xavi Socias Perez, owner of the CheapFilms company based in Vilanova. Writing this part which is one of the most important stage of the game took many continuous meeting between us and Xavi to end by writing the whole game script that was followed for building the application.

The main idea is creating the most interacting AR game with the visitors and tourists that will attend to this museum. That is why there is a need for a game designer who has an experience in writing game scripts and knowledge about the history of the museum referring to the monuments and painting that exists inside needed a wide investigation.

Figure 3.1 Victor Balager Module

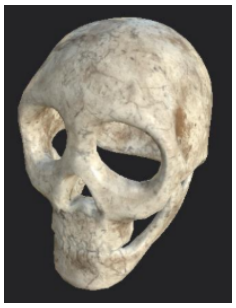

Figure 3.2 Egyptian Skull Module

3.2. Lumin Implementation

3.2.1. Point-Clouds PC

The idea as mentioned before is sending and receiving the PC of the user when finishing the AR mobile game that will render his PC and send it to another site where the AR Applications are established to make an interactive information sharing between tourists in the indicated countries.

The PC is a huge number of data points recorded and scanned using special camera as RealSense [19] or Kinect Azure [20]. When starting the process of scanning the laser scan records the necessary number of data points depending on the surfaces of the area you are scanning and the depth of field of each camera. The field include walls, human, windows, doors, etc. In our case we should take into consideration that we need only the PC of humans, so the field we are scanning the PC from it should include the person only.

These PC will be sent using online server from one static point to the other ones. In other words from Spain (Museu Victor Balaguer) to the touristic site in Italy, Jordan and Lebanon. After highlighting the main idea about this part of the project, here it comes my task, visualising the PC on the AR devices and more specifically Magic Leap One.

3.2.2. Magic Leap One Implementation

Receiving and Sending the PC is done through a protocol derived in i2CAT called PC-MCU. A PC Multi-Point Control Unit developed by the Media team in this company, regarding all the software and code used for ML1 a different process is implemented to visualise the PC. First step is being able to visualise a static PC on the ML1, a recorded and saved PC used in this process was the testing period before moving to the real time recorded PC. When being able to render the PC using the ML1 next step is being able to fix the positioning of the PC in the real world. To accomplish this task an image tracking code were used to always show the PC in front of the user.

```
"ITML1 ":
  {
"_trackingBehaviour" = GetComponent<MLImageTrackerBehavior>();
    "_trackingBehaviour".OnTargetFound += OnTargetFound;
    "_trackingBehaviour".OnTargetLost += OnTargetLost;
    "_trackingBehaviour".OnTargetUpdated += OnTargetUpdated;

  }
```

Data Model 3.8 Image Tracking ML1

The implementation of the Image Tracker on Magic Leap one will allow us to detect a 2D image and use it as a source for our rendering and place the PC content based on its scale, position and rotation. Feeding the program when the image is Lost or tracked what should display.

Image tracking detects two-dimensional planar images from a custom-defined target set and then continuously tracks the images' locations and orientations as you or they move in the setting. With image tracking you can place authored content based on the presence of a physical image.

The main phases of the implementation is cited below:

- Calling the PC generated by the Real Sense Camera using its URL and following the Corresponding API.
- Playing on the Lumin platform of Unity.
- Establishment of the Image tracking process to visualise the PC on the specific place in the real world [21].
- Using the online server to make the connection between the two sites available.

All these functionalities and processes are offered to the other entities of the Lumin platform. More specifically, one of the users will act at the same time as a receiver and sender of the PCs with other users that will act the same. It is important to recall that the PC-MCU is the platform from where the paralleling and recording the PC is established on.

3.3. Oculus Implementation

The Oculus, Fig 3.3, is a virtual glass where virtual games and applications have been deployed on it [22]. In our project, we made a virtual conference room and we aimed to place the PCs in specific places of this room.

In this section we will talk about a VR implementation related for the MCU application, where the same procedure is followed only differing the platform from Lumin to Oculus and without integrating the Image tracker. Regarding the API used, Oculus to be able to communicate with unity use the Auto Graphics API to get rid of the Vulkan one that will cause an error in the app built since Oculus cannot communicate with.

Oculus Integration Pack, downloaded from the Package Manager from Unity3D contains OVRPlugin that provides built-in editor support and many additional features. It is released to ensure compatibility with the package from one side, and with the built of the application from the other side

The PCs will be displayed in a virtual room designed by the media team of i2CAT, aiming to a communication between users visualized in that virtual room. Unity3D and after receiving the PCs packages from the servers, render it on a specific position in the virtual room to fit each PC on a chair.

Figure 3.3 Oculus VR Device

CHAPTER 4. TEST OF THE GAME

In Chapter we will describe the tests applied to both applications, including the results we accomplished and providing some pictures of the apps. Moreover, we will test the visualization part of the rendered objects in the museum as 3D modules, videos and texts and testing the intelligence implemented as for the scenes flow and the markers managing orders. The test of the PCs app will take three stages, two with AR and one with VR implemented using the Oculus device explained in the previous chapter. The AR tests will include the results for the static and the real time PCs shown using the Magic Leap One device and the VR results will be shown using the Oculuc device using a virtual room.

4.1. Android app Test

The mobile application with all its content and technical parts is tested and runs on its proper way. The game was built on an android device (Samsung S8) and is eligible to all other android mobile phones and tablets. Keep in mind the testing includes only the technical part of the game, meaning only the intelligence applied with the codes written and shown in this report. The 3d modules used in this report for now are the testing 3D modules, all will change before launching the application.

The Figs 4.1 and 4.2 show the running process in Unity3d where we can observe the version of Vuforia used and the availability of the image targeting procedure.

These console results describes how we are managing our markers in the scene where every marker appears with an ID. We can observe if an image target in found or not with its specific id (r1s14) is the name of one image target. All these console result are run before the tracking begins so we as developers we can notice if any marker or scene will fail before building the game. Each marker is created using the intelligence implemented with an ID assigned when the game is running. The program will know where the user is in term of time and action using these intelligence. Since its a built-in game without the interference of internet we will gave no latency neither delays problems.

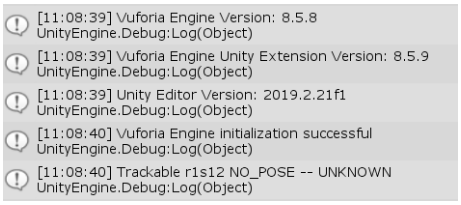

Figure 4.1 Unity3D and Vuforia Engine availability

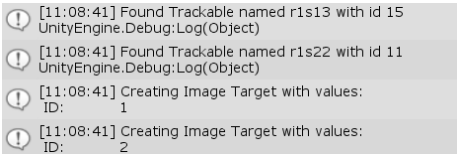

Figure 4.2 Image target ID process

The game was tested several times in the Museum and on many iterations going through the whole museum including all its rooms and showing the main script of the game how it will look like as shown in Figs 4.3 and 4.4.

This AR game was built as a motivation process for tourists to approve the levels of services provided by the museum to its visitors. As shown in the previous pictures, the AR world was implemented from its technical side. Visitors can nearly examine the APP with

Figure 4.3 On Marker Rendering

Figure 4.4 Markless Rendering

all its beautiful design once it is provided.

In the experiment environment we will feed all these 3D modules (Figure 4.4), videos (Figure 4.5) and texts (Figure 4.6) to the real world. To test the performance of the application some users had played the game and were satisfied even before ameliorating the 3D modules which for instant are the testing modules. The goal is to make the flow of the game goes smoothly and the user enjoy the game while playing without any interruption or boredom. Meanwhile, the mobile application is technically done but not released and company will improve all the 3D modules and may change the content of the game (texts, some videos, etc..) but the technical part from Unity3D to Android and the coding will behave in the same way as mentioned in the implementation chapter. Eventually we ended-up by activating all the paintings in the museum as markers and targets that will become our wide gate of the AR world.

Figure 4.5 Video Rendering

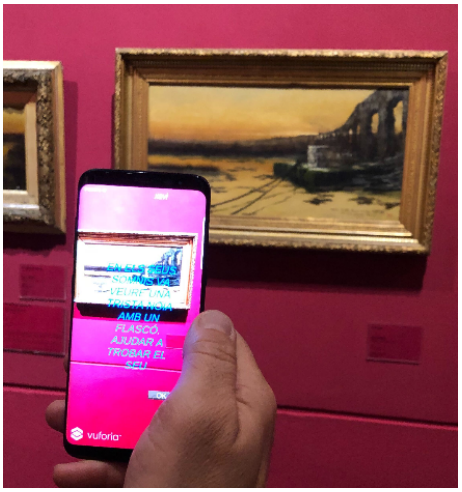

Figure 4.6 Text Rendering

4.2. Static Time PC

The Static time Pc is the first testing phase for the visualization on MagicLeap. We used a prerecorded PC and visualized it on the magic leap using the wire bridge between the computer where the program in Unity3D is processed and the ML1. In Fig 4.7 we can observe its process.

Figure 4.7 Static PC Process

In this test we tested the visualisation of ST-PC recorded by one partner of i2CAT on the ML1. The real field of view from the glasses of the users will be the output of the application where as shown in the figures the PC is quite visible in the Lab demo (Figure 4.8) and in the real world (Figure 4.9). Since these PCs are static and without using online or local servers , the delays of the visualization is quite small and the PC is shown with no latency neither interruptions. These facts will change when moving to real PC and servers.

Figure 4.8 Demo Visualisation

Figure 4.9 Real Static PC

The process of collecting all the points recorded and the data built of this PC needed an implementation of some codes and specially the position where the output (PC) should be rendered. In this stage the PC is rendered in one meter from the user always, it is static, not rotated and with no interaction neither audio sources. Regarding one of the main fact that should be highlighted in this experiments, the small amounts of references that could be found on the process of visualising a PC on the ML1, since for now this technology has been released just two years ago.

The delays that follow this test is very small to a point the user will not even feel it so the time that it takes to compute all the points and combine it together for reforming the shape (Lady in Red) is an average of approximately 0.12 seconds. Going from Figs 4.9 and 4.8 the data flow of the points time only is reduced by the facts of using a static PC, in other words the PC is acting like an object rendered (a cube or a sphere, etc...).

4.3. Real Time PC

The RL-PC system works in an other way of the static PC as mentioned in the previous section. The static PC acts like any object rendered taking into consideration that its a point cloud and the positioning and the rotation of this object must be implemented in a proper way. The Fig 4.10 shows the process of the Real Time PC.

Figure 4.10 Real Time PC Process

The basic idea here is rendering the RL-PC of a user in the output field of another user and vise-versa. Placing the PC on a specific position and rotation using an image marker fed to the program. When the ML1 tracks the image targets it will start receiving the frames from the online server using its specific URL and the rendering process begins. This system works by processing many iteration through the online server. Each iteration will change the number of frame per second as shown in Fig 4.13, where the frame per second varies between 32,2 fps to 32,4 fps. The fps varies due to the number of points per cloud and that affects directly the latency, so in these many iteration shown in Fig 4.11 and Fig 4.12 we can notice that as we increase the point per cloud the fps will decrease which leads to a higher delay. The main point here is to increase the fps as much as we can and since our PCs are only for human the testing criteria gave us a conclusion that with 10K points per cloud is more than sufficient. The goal will be achieved by the recording process from the Real Sense camera. As the console result shows, the best fps is accomplished when using the 10K points per cloud option. When using the 100K points per cloud the fps varies between 9.6 fps to 10.2 fps which means the data coded and decoded will be in a slow process, the latency appearing in this figures is the latency between the SubReader and the PCDecoder which will not vary and stay the same in all the scenarios. Table 4.1 shows the different results obtained using different number of points per cloud and there we can observe that the latency varies a lot. We observe that when we reduce the points per cloud we will ave a better latency and the delays will not be as higher as we increase the point per cloud. The byte per packet results shows that we will use more packets to deliver the PC, therefore a human PC does not need a lot of point per cloud leading to a lower bytes per packet. These latency numbers are provided by the Media team of i2CAT that was responsible of the protocol. The latency observed in the following table

represents the delay between the receiving data and the visualisation of the PC on the glasses, as the points per cloud increase this latency will increase and cause a bigger delay on the visualization process. The whole point cloud recorded sent via the online servers is carried by a packet that can handle a specific number of bytes. The minimum size is defined by the IP packet size and the frame frame size.

Table 4.1 Evaluation of different Point per Cloud

Points per Cloud	**Frame per Second**	**Latency**	**Bytes per Packet**
10k Points per Cloud	Varies between 32,2 and 32,4 fps	150 ms	27k
50k Points per Cloud	Varies between 16,1 and 16,2 fps	280 ms	90k
100k Points per Cloud	Varies between 9,6 and 10,2 fps	460 ms	145k

The first user that will be considered as the first terminal, will use the online server to send the corresponding data and on the parallel process will receive the data for the the other user considered as the second terminal. This outputs are done by the PC-MCU prototype but these facts affects the visualisation on the device, from the delay gate where once the image is tracked the PC-MCU start coding and decoding the data files and more starts paralleling the processes of coding and decoding at the same time.

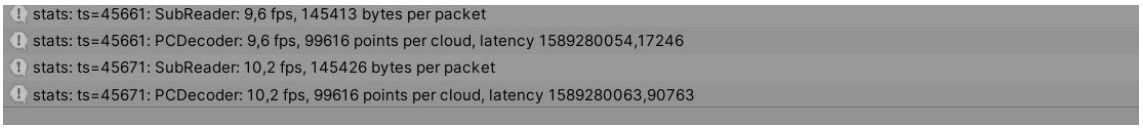

Figure 4.11 Console Result 100K Points per Cloud

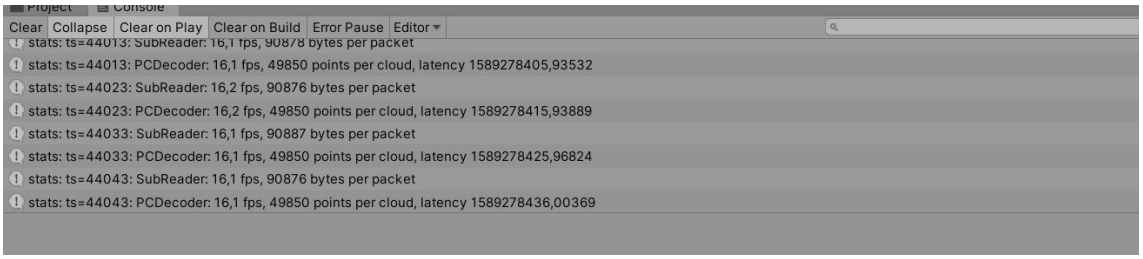

Figure 4.12 Console Result 50K Points per Cloud

For now we are able to visualise PC on the ML1 on a real time using the two types of servers, local and online. Figure 4.14 shows the PC of one team mate in i2CAT sending his PC via online server, and Fig. 4.15 shows another team mate sending it via local server. The range of the ML1 regarding the field of view is quite bothering the process, it is not large but it is the best in the field for now so this fact was also well considered in the process that displaying the PC should be in at least one meter from the user.

Each one of these two scenario has its characteristics concerning the fps and the latency and more important the points per cloud. The RealSense camera has a range from 5K

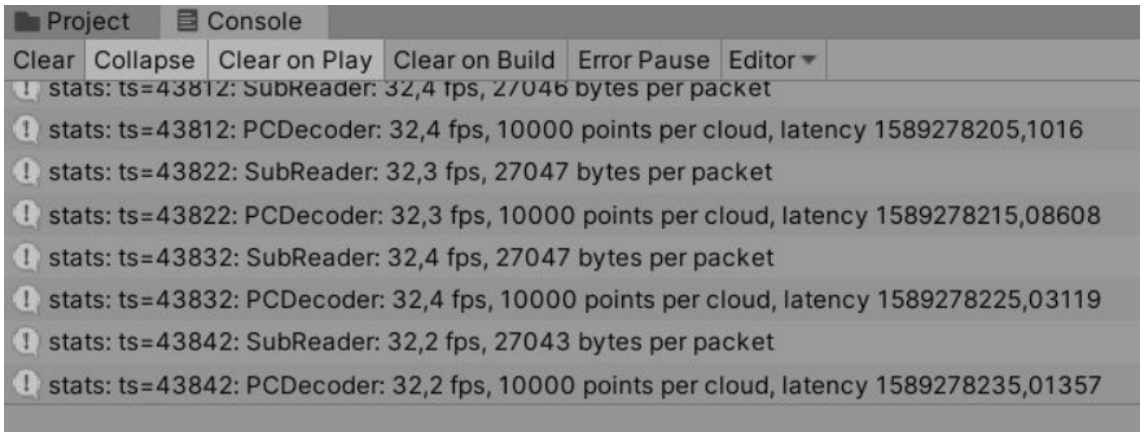

Figure 4.13 Console Result 10K Points per Cloud

Figure 4.14 PC from Online Server

Figure 4.15 PC from Local Server

points per cloud up to 25K and in this prototype we used 10K since we have to implement two cameras that each one will send 10K. The process in the MCU will be 20K, it works in parallel of sending and receiving and to avoid any failing in the system the PC must be in the range of the camera to be able to send this frames to the MCU.

These PC rendered in Unity3D are called from a specific DLL for the servers and well rendered in the real world as demonstrated in the figures mentioned on this section. Keep in mind that to be able to see the received point cloud as in front of the user an image tracking process is implemented and acts like the gate of activation of the visualisation of the point cloud.

What is achieved is well noted in the following:

- Render a static PC in the real world called from a specific dll.
- Visualise a real-time PC in the real world for two pilots (users).
- Render the Point clouds depending on an image target as an activator for the process.
- The PC will be seen as sitting in the front.

We can notice that the resolution of the PC using online or local server does not differ much and this result comes from one behavior that we are implementing only 2 users, every user will send its PC once and receive 1 PC from the other user. Therefore when implementing many user the result theoretically will change a lot and it will affect the fps for our program.

4.4. Real Time PC on VR World

The results shown in the Fig 4.16 represents the visualization of the real time PCs recorded with the RealSense camera implemented in a virtual world.

Figure 4.16 PC Oculus device

The factors that should be considered in this test is the positioning of the PC to fit in the virtual chair in the room. The same codes are used in the VR as the AR tests but excluding the image tracker system since here we do not need it.

CHAPTER 5. BUSINESS-RELATED POINTS

5.1. Users Experience Journal

The unique goal of this game is encouraging tourism in Spain and specially in the site mentioned in this report. That's why it is quietly important to mention our expectation after the release of this game and how the process will be accumulated.

For this we will discuss many phases of expectation of the experience of the users in the near future.

- Search phase:

  In the first phase the user's goals are to find all possible gamification in the sites they are going to visit and also find a solution for the boredom that follows some local and foreigners tourist stays in Spain, to improve their tourism experience.

  At first they will search for some existing games in the field and they will definitely find some fields and sites that provides AR gaming like in this case our game. On the other hand tourist guides and companies will suggest and recommend for them sites where AR games are deployed.

  In this phase customers/patients feel hope and excitement about maybe finding the way to improve their tourism experience.

- Evaluate phase:

  In the experiment phase, the customer goals are:

  – To compare what kind of gaming fits best with his or her desires. Some might prefer only visiting sites and exploring the place physically without any interference of technologies and other, which represents our targets of users, feels more comfortable and enjoy the technological way of exploring sites.
  – To evaluate which approaches best work with themselves.

  To perform those activities, our customers interact with us through the following touch-points:

  – Internet: To get information about specifications of the game and where to play it. However finding this game online will be easy after only searching for the site because the game will be recommended by the cite of the museum.
  – Tourists Guides Offices: Here the customers get informed about what options this specific game have and to have a general idea what is waiting for them in the museum.

  Because of how these interactions take place and the information available we believe that the customer satisfaction at this stage is medium to poor so as he is then being left alone in the decision process. We see opportunity then here to provide more security on the process maybe in the form of conferences with some users that had already played the game and guiding the prospective customers in their experimentation phase.

- Purchase phase:

  For the purchase, the main goals of the customers are the following:

  - Online tickets for the game.
  - To have a good services and priorities at the entrance of the museum.
  - Become a member of the museum once buying the game.

  In order to perform these goals our customers will interact with us through the following touch-points:

  - Online website with a lot of information to ensure the customer about the game.
  - Emails about new update
  - The tracking of the game stages.

  All along this step, the customer can pass through these different feelings and thoughts:

  - Skeptical: Will it really be a fun me?
  - Optimistic: This will really provide me a new tourism experience

- Support phase:

  The most important subject of customers is enjoying their visit while using our game, mainly we can notice that most of previous ways was not using technology and more specially AR, tourists nowadays search for a new experiments in touristic sites. An AR game easily played might be the best solution for them, interacting with rendered objects in the real world from the mobile camera may creates for them that new experiments and rendering a point-cloud in front of them to make an AR meeting with other tourists in other places will create one of the best experiences they had in touristic sites. In this application, big data analysis can be exploited to discover daily or weekly pattern whether users plays the game better or more than others even clustering each experiments feeling for users into different categories according to their outcomes. In this case the data points would be delivered to online servers after playing the game. Costumers needs always to have the game as the description we did and this is the aim goal of us, delivering them the best way for new experiences in touristic sites.

  Additionally, we can identify that the customer would go through the following touch-points:

  - Setting Expectations: educate on AR,and devices such as ML1
  - Stay up to date: Follow the new versions of the game, also the PC will always have an updated version.

  In this phase the users have taken all the decisions already from using or not the game or opting to manage their touristic experience only in standard ways. As a result, they are satisfied with the game as they are able to examine their new experience.

Table 5.1 Customer's Experience Map

User Phases	**User goals**	**Touchpoints**	**Feeling experience**
Search	Find a new touristic experiments	Internet and Touristic guides	Hope and excitements.
Evaluate	Ascertain if this game is a good option or no	Internet and Forums	Frustration: if the game matches the descriptions provided or not
Experiment	Compare which are the existing games and if it suits them	Internet and tourism offices	Solitude is felt as the user feels alone to explore
Purchase	Getting tickets for the game easily, becoming a member	Websites, mail and call center	Sceptical about the result
Support	Description must be as the output	Setting expectations and keep up to date	Happiness for having a new satisfied touristic experiment

5.2. Business Canvas Model

The BMC (Figure 5.1) is an implementation of the plan before the quick-off for the project [23], to highlight the most relevant elements that this canvas includes and providing the investors a very clean point of view for the project by only mentioning the basic points and the keys for the game.

The BCM consist of nine elemnets, we will go through each one by introducing its functions:

- Key Partners: In this element we focus on what should be avoided to achieve the main goal of the game.
- Key Activities: Introduce the unique propositions implemented in the game.
- Key Resources: Mentioning the unique strategic assets that the business have to compete.
- Value Proposition: Indicate the reasons that will motivate the users for using this Application and play the game.
- Customer Relationship: The strategy that will insure the interaction between the developers and the users.
- Customer Relationship: Who are our targets,more specifically for whom we are developing this game.

- Channels: Describing how and where to play the game.
- Cost structure: In which field we will spend money,who are the specialist that will work on this App.
- Revenue Streams: The main goal,how to make money from this App.

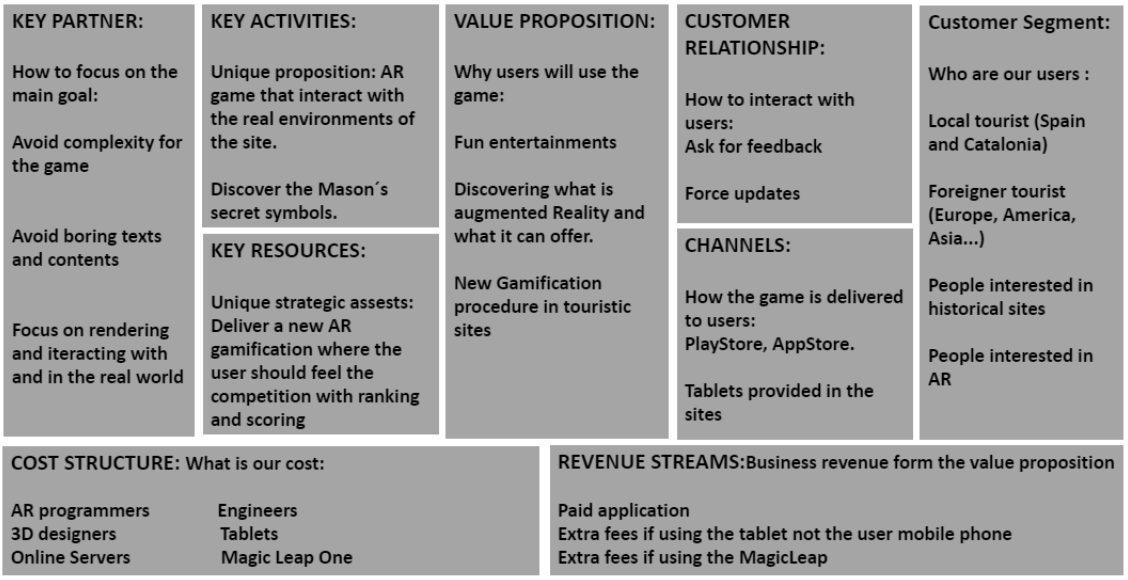

Figure 5.1 Business Canvas Model

The number of visitors per year to this museum varies from 25K up to 33K, after providing this services we can theoretically say that this number will pass through an increment since we are targeting almost all types of tourists and visitors, local and foreigners.

CHAPTER 6. CONCLUSIONS

In the last chapter of this document, we will provide a conclusion about the technical and the economical measures that are programmed and evaluated in the report. Proposing future work for this study is also well noted in this chapter and mentioning the sustainability and ethical considerations.

6.1. Conclusion

Our work presents a new behavior of augmented reality and confirms that deploying such kinds of games in touristic and historical sites has a high impact on the tourism and the experiences of the visitors were they will always remember the sites thanks to these applications.

The applications implemented in this study is a part of gamification projects around the Mediterranean which its main goal is to improve the tourism in some of touristic and historical sites located in 4 countries : Spain, Italy, Lebanon and Jordan.

The project aims to connect the Mediterranean world and to provide knowledge between the local and tourist about other cultures and historical stories and sites. It also aims to the convergence of views between the countries mentioned to what impact it has on better relations in the future. We have made a new behavior of gaming consist of connecting 4 sites in the Mediterranean world from Spain/Vilanova to Lebanon/Beirut to Jordan/Amman and Italy/Alghero. Tourists will have an experience that has not been deployed before travelling between these 4 countries and playing these AR games with discovering secrets and unlocking tasks.

This study focused on how gamification can improve touristic sites, more specifically AR gaming. Developing a mobile application and a Magic Leap One application were used to accomplish this job. From here on and as many sites of the world have been deploying such kind of games without providing to the users the fact that they can interact with the augmented reality world has been for showing new experiences as far as the AR is becoming well known between people and developing a game where the user will be able to feel this world by interacting with it is necessary.

Back to Spain, the game described in this report that consist of two main stages, mobile game and AR-Glasses application has been developed and soon will be released in the first site of ´Biblioteca Museu Victor Balager´.

To the best of our knowledge, and compared to other projects, this project will be considered so far a well developed AR application in touristic places in Spain. The combinations used and all features of augmented reality deployed with all possible components as videos, images and 3D modules are rendered in many scenes. The most accurate difference is the development of magic leap application where the live experience of the users will enhance the game to a new level of gamification comparing with other similar projects. The opportunity that the tourists and users has in communicating with other users in other sites where MEDGAIMS deployed these AR applications will encourage a lot the tourism domain so far, any new experiment that combine technology and fun and history for tourists will encourage,ameliorate and enhance the tourism.

Concerning the results we achieved, mentioned in the previous chapter, the mobile app results has shown a new programming features in terms of saving time for developing games for the implementation of the markers and scenes intelligence. In the PC app, the PC-MCU was responsible about reducing the latency and managing the cloud and frames errors, and the program implemented using Unity3D achieved the desired goal for the visualization of the PCs using a new behavior of image tracking and positioning in the real and virtual world.

From another point of view, the site mentioned in this report ”Biblioteca Museu Victor Balager” welcomes per year around 30k visitors from locals and foreigners, the assumption made in this report indicate very clearly that after the deployment of the game the visitors number theoretically will increase on its first year to touch 50k, which means that this kind of Gamification are going to be in the near future one of the main features that all touristic and historical sites will offer. This number is supposed to increase year after year when ameliorating the game itself and updating it.

More generally, AR will have a high impact on Gamification in tourism and in other fields like video gaming and mobile gaming. Everyone will feel curious about knowing the new technology related to this field which is considered of the most ones that investors are interested in from the part of incomes and revenues that will give it in return.

6.2. Future Work

One main task should be took into consideration, that for now a marker can be used only for one action in one scene to avoid changing the scene in order to render different object with this marker a new logic should be behind it,so as for future tasks we will be able to track where the user is in time and space in reality and in the course of the game.

Implementing the audios in the mobile game will be proceeded in the near future where usually audios gives life more to the game, we will only synchronize the audio with headphones to not disturb any other visitors in the museum.

Concerning the point clouds part, a new part is going through the proposals where we will try to implement up to 4 users, to make the connection between the 4 countries involved in MEDGAIMS project at the same time which need a new development for ML1 to be able to visualise 4 real time point cloud at once.

To improve the incomes, the need of ameliorating the game from its technical point of view is necessary and publishing the game through well-known platforms as GooglePlay and AppStore may increase the publicity and make the game more famous.

6.3. Sustainability Considerations

These apps aims to improve economical sector and specifically the tourism one, but it is necessary to mention that the PC app will save time and could be used in several domains, specially for conferences and family meetings or even may be used the education sector can be done using such apps.

6.4. Ethical and Security Considerations

The game developed will allow tourists and users to be connected in a secure process, there will be no data retrieve from their mobile phone when downloading the game and all the rights will be reserved.

ACRONYMS

AOSP	Android Open Source Project
AR	Augmented Reality
BCM	Business Canvas Model
DLL	Dynamic Link Library
FC	Flow Chart
FPS	Frame per Second
JDK	Java Development Kit
ML1	Magic Leap One
NDK	Native Development Kit
OS	Operating System
PC	Point Cloud
PC-MCU	Point cloud Multi-points Control Unit
RT-PC	Real Time Point Cloud
SDK	Software Development Kit
ST-PC	Static Time Point Cloud
UI	User Interface
VOS	Vuforia Object Scanner
XR	Mixed Reality

ANNEX 1: DESCRIPTION OF BIBLIOTECA MUSEU VICTOR BALAGUER

In this annex the site of the 'Biblioteca Museo Victor Balager' is introduced, going throught its location and the description of the inside-outside of it and proposing some technological idea of the game.

Figure 6.1 Biblioteca Museu Victor Balager

Historical Preview:

'Biblioteca Museu Victor Balager' was founded in 1884 by Víctor Balaguer [24], as a thankful gesture for the political support received from the citizens of Vilanueva y Geltrú. The myst says that the body of Victor Balaguer have been buried under the Museum and that was the plan of Victor himself. This explains that the building was designed and built in the form of a coffin and also refers to the famous phrase written at the entrance of the building "Surge ET Ambula" that signifies get up and walk which is considered on of the Mason's code that Victor Balaguer belonged to this secret organization.

Architechture of the Museum:

1-Indoor basic room of the Museum

The Museum includes 5 main room, and each one has its own historical character. First room that consist of paintings (Figure 6.2) describes the history of the city and some other painting representing the history of all Spain. This room will be considered as the first stage of the indoor room of the application.

The second room has another character derived from the middle East and specially from Egypt (Figure 6.3), where many antiques have been shipped from this country in addition to a Mummy of a person that was embalmed from decades.

Third room named as the room of Gods, contains many monuments and antiques imported from all over the world, specially from Philippine, Japan and Colombia. Inside we find a huge integration of religious combats arms and historical resources of this countries back

Figure 6.2 Painting's Room

Figure 6.3 Egypt Room

to hundreds of years ago.

Victor Balaguer has assigned an area in his museum for his meeting with popular faces from Vilanova y Geltrú, a room where he and his loyal friends and politicians used to be reunited in purpose of taking decision about their secret programs (Figure 6.4).

The last stage of this building is the 'biblioteca' (Figure 6.5), where all the books written by Victor Balaguer or books imported from the country that he used to travel too exist. A large collection of books related to Illuminati and Masonry can be found in this room.

2-Outdoor of the Museum

The outdoor area of the Museum was very complicated to understand, the walls that surround the whole building contains sculptures and carving that represent in one sense or another, a brief explanation of history not only for Spain but for the whole world.

Some sculptures represent the history of God's of Greece, other talks about the astronomy and masonry as well. Every single detail in this Museum has a hidden part and a purpose that pushed Victor Balaguer to deploy it serving the main goal that he had in mind "Masonry".

Figure 6.4 Meeting Room

Figure 6.5 'Biblioteca'

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