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**Development
of an User Interface
for Virtual Reality**

MASTER DISSERTATION

Yesica De Pontes

MASTER IN COMPUTER ENGINEERING



UNIVERSIDADE da MADEIRA
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Yesica De Pontes
MASTER IN COMPUTER ENGINEERING

SUPERVISOR
José Luís Silva

CO-SUPERVISORA
Karolina Baras



Development of an User Interface for Virtual Reality
Yesica De Pontes Romero

Constituição do júri de provas públicas:

Diogo Nuno Crespo Ribeiro Cabral, (Professor Auxiliar da Universidade da Madeira),
Presidente

Filipe Magno de Gouveia Quintal, (Professor Auxiliar Convidado da Universidade da
Madeira), Vogal

Karolina Baras, (Professora Auxiliar da Universidade da Madeira), Vogal

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SUMMARY

This project aims to create a head-mounted display (HMD) prototype interface for improved user interaction in virtual reality environments. Nowadays, this virtual reality technology is covering more areas of the market, among which are the Hospitality and Tourism. At present, some hotels have implemented this technology in their services. Based on the existing "Guestly" system [1], a mobile and web platform that allows hotel guests to see the characteristics of the hotel, development of a prototype for a more immersive user interaction in virtual reality environments is proposed, thus offering an innovative solution. The developed prototype is structured by its characteristics and options, facilitating maintenance and use of the system that is going to be developed. A preliminary evaluation was carried out with users who achieved the initially established objectives. This new application is an innovative scope in technology, offering a solution to improve the scope of the existing "Guestly" system [1]. For the realization of future developments, it can be analyzed that other resources or additional functionalities can be explored for their development and, in this way, expand the scope of the current project.

Keywords

Virtual reality
Head tracking
User interface
User experience
Tourism
Technologies

RESUMO

Este projeto visa criar uma interface de head-mounted display (HMD) para melhorar a interação do utilizador em ambientes de realidade virtual. Hoje em dia, esta tecnologia de realidade virtual cobre mais áreas do mercado, entre as quais a Hospitalidade e Turismo. Atualmente, alguns hotéis implementaram essa tecnologia nos seus serviços. Com base no sistema existente "Guestly" [1], uma plataforma móvel e web que permite aos hóspedes do hotel ver as características do hotel, propõe-se o desenvolvimento de um protótipo para uma interação mais imersiva do utilizador em ambientes de realidade virtual, oferecendo assim uma solução inovadora. O protótipo desenvolvido é estruturado pelas suas características e opções, facilitando a manutenção e o uso do sistema que será desenvolvido. Uma avaliação preliminar foi realizada com utilizadores mostrando que os objetivos inicialmente estabelecidos foram atingidos. Esta nova aplicação tem um alcance inovador em tecnologia, oferecendo uma solução para melhorar o escopo do sistema "Guestly" [1] existente. Para a realização de trabalhos futuros, pode-se analisar que outros recursos ou funcionalidades adicionais podem ser explorados para o seu desenvolvimento e, desse modo, expandir o foco do projeto atual.

Palavras chave

Realidade virtual

Head tracking

Interface de utilizador

Experiência do utilizador

Turismo

Tecnología

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LIST OF ABBREVIATIONS AND ACRONYMS

API	Application programming interface
BTL	Bolsa de Turismo de Lisboa
IDE	Integrated development environment
JSON	JavaScript Object Notation
LMS	Learning management system
SUS	System of Usability Scale
VR	Virtual Reality

CHAPTER I

INTRODUCTION

The use of VR technology provides significant support for all the companies looking to innovate in the future. In the last few years, technological advances have been incorporated in the environment that encompassed companies. This technological evolution promotes a business strategy, since it is a basic factor of new competitive advantages to obtain new business opportunities.

In hotels or tourism is currently a trend the use of virtual reality, although not implemented in all hotels worldwide, every day are more those who implement or want to do it, mainly covering showing the user videos of experiences of other users or simply images of their facilities. This innovative implementation allows hotels to improve the marketing of the services offered.

Guestly [1] provides a system devised by the Tekinsight company and developed by the Proinov [2] team. This system is designed for hotels to allow their guests to see, choose and book all the facilities of the hotel very easily. The key features of this system are: easy backend update by the hotel, in depth analytics, cross selling experience, customer satisfaction, elegant design and multiple languages support.

This project will be a development for the Proinov company, which has the following main objectives:

- Creation of e-learning content;
- Development of multimedia didactic games;
- Implementation of websites;
- Web design;
- Development of web systems, namely, a Training Management system (GESTFORM);
- Implementation and customization of the LMS (Learning Management System) Moodle platform;
- 3D models;
- Mobile application programming (IOS, Android).

Proinov also manages content in the form 360° images that can be viewed with virtual reality devices. The development of a VR application is proposed to facilitate this visualization, allow further interaction with VR environments and provide access to other options such as virtual tour and weather.

The main objective of this development is to create the interface for a virtual reality environment, offering the user a different way to see the functions that are currently in the Guestly application [1].

To develop the system, it is necessary to analyze the scope of services that could be offered to the client, since the existing application has many characteristics, not all would be viable for the VR environment.

The prototype developed can be used to determine what new

services to offer to customers. It ensures a better experience as well as greater technological innovation for business growth.

As stated, this project aims to create an interface in virtual reality based on the options offered by the pre-existing Guestly [1] system, plus new innovative features. A prototype will be developed as a tool to compare new ideas during the development process. With this, it's possible to determine how users are interacting with the new features and tailor the development to supply and experience that suits their needs.

The dissertation is structured as follows:

- Chapter II - State of the Art: A history study of the technology used to develop the project and related works are presented.
- Chapter III - Process: It presents the data were collected for the development, the evaluation of the different tools and what the results obtained from all these analyses were.
- Chapter IV – Development: This chapter is going to present the system architecture, as well as some details of the implementation. It also presents the detail of all aspects of the interfaces developed.
- Chapter V – Evaluation: It presents the tests performed to the users of the created prototype and the obtained results.
- Chapter VI – Conclusions: Indicates the conclusions from the process, development and evaluation. It also provides directions for future development.

CHAPTER II

STATE OF THE ART

In this chapter, the evolution of virtual reality devices from the beginning will be detailed. The following is a presentation of different works and research related to this project.

Before making a journey from the beginnings of virtual reality, it is important to know its meaning and how to differentiate it from other similar technology.

The virtual reality appeared for the first time in 1958, as Jose L. Ortega explains in his article [3], when Charles Wheatstone created the stereoscope. This creation consisted of having two almost identical images observed independently by each eye, which led to how the brain saw them as one with a three-dimensional effect. Nowadays this is the most used technique. But the term "virtual reality" was born in 1965 with the publication of the article "Ultimate Display" [4] by one of the pioneers of information technology Ivan Sutherland where he explains a concept that had no definition on the part of scientists.

As for virtual reality [5] is to see through the devices, another reality different from the one that surrounds us, that is, another world is created, to simulate the user's presence in it and to allow interaction with things totally different.

When it refers to augmented reality [6] it is said that it is the projection

of images about what already exists what are observing around. When you place one of the devices of augmented reality, you continue observing the reality of your surroundings with other things or people that are projected through the device.

As Pablo G. Bejerano explains in his article [7], augmented reality has its beginnings in 1957 when Morton Heilig created a machine that he called Sensorama; this name was given because this creation had the characteristics of projecting images in 3D, sound, seat vibration and wind. At present the devices most known and used in this technology are the Google Glass [8] and Microsoft HoloLens [9].

Next, will be provided a detailed summary of the virtual reality devices.

2.1 History

In relation to the project to be developed, for the following summary on the history of the technology to be used, augmented reality will not be considered, since it is not within the scope of this work and only virtual reality will be mentioned. Will now give a summary of what was the evolution of the main virtual reality devices that opened the way to other devices and are mostly still in use today.

1939: Sawyer's View-Master

The View-Master system [10], consists of thin cardboard disks containing seven stereoscopic 3D pairs of small color photographs on film. The first devices were created with reasons related to travel and tourism,

currently the main content of these reels is designed for children.



Figure 1 View Master View [11]

1960: The Telesphere Mask

The Telesphere Mask [12] was created by Morston Heilig, and it was patented in 1960. It is a “stereoscopic television device for individual use”. This is where virtual reality lenses really started. Even in an era, in which there were countries without access to color television. It was the portable version of the well-known Sensorama (Augmented Reality). It was a rather heavy device, but its function was innovative.

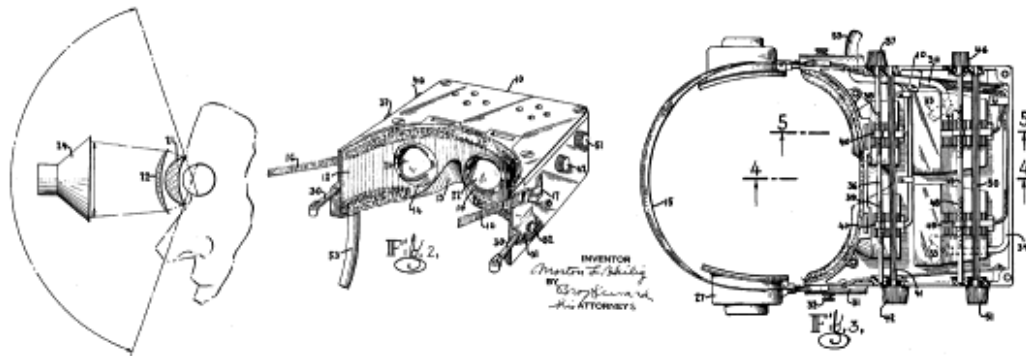


Figure 2. The Telesphere Mask [13]

1995: Nintendo Virtual Boy

The Nintendo Virtual Boy [14] (originally known as VR-32) was a 3D gaming console that was hyped to be the first ever portable console that could display true 3D graphics. It was first released in Japan and then in North America. It was a failure because of a lack of color in the graphics (games were in red and black), there was a lack of software support and it was difficult to use the console in a comfortable position.



Figure 3. Nintendo Virtual Boy (left) how's look the image of the game (right) [15]

2011: Iphone Virtual Reality Viewer

This device [16] works with an iPhone allowing one to experience 3D visualization. It combines the built-in accelerometer in the iPhone alongside free downloadable applications, allowing the 3D environments within to move whenever the iPhone is moved.



Figure 4. Iphone Virtual Reality Viewer [16]

2012: Oculus Rift

Oculus Rift is a lens that connects to the PC to get the images of what you want to watch. As indicated in article [17] this project began in 2009 by creator Palmer Luckey, who wanted to improve existing virtual reality devices. In the year 2012 John Carmack showed interest in Palmer's project and joins him to integrate better and in this way launch to the market what we know as Oculus Rift, one of the most updated projects with constant technological advances.



Figure 5. Oculus Rift [17]

2014: Google Cardboard

Google Cardboard [18] is a complete virtual reality platform. It was developed at the Google Cultural Institute. The hardware side of Google Cardboard uses low-cost viewers, with the reference design made of foldable cardboard, 45mm plastic lenses, and a magnet or capacitive-taped lever to operate the screen. Once everything gets folded into the right configuration, the phone can be slipped into the front of the viewer and an app can be run. [19]



Figure 6. Google Cardboard [20]

2015: Samsung Gear VR

The Samsung Gear VR [21] is a mobile virtual reality headset developed by Samsung Electronics, in collaboration with Oculus, and manufactured by Samsung. The headset was released on November 27 of 2015. The Gear VR headset includes a touchpad and back button on the side, as well as a proximity sensor to detect when the headset is on. [22]



Figure 7. Samsung Gear VR [23]

The present project will be developed mainly for the use of Google Cardboard (and higher devices), mainly the most generic and accessible to the public.

2.2. Related Work

In this section some works that use the technology of virtual reality related to hotels or tourism will be mentioned, separating them in those that are related to the industrial sector and to the research sector.

2.2.1. From the Industry Sector

With the advancement of the virtual reality technology and VR devices becoming increasingly simple, more accessible and economical, as well as more robust devices began to appear to serve in the hotel market. A new service for customers, virtual visits to hotels or exclusive images permits one to have a better idea before making the reservation. The VR experience also became part of the overall experience of the hotel stay. This was demonstrated in the case of GCH Hotel Group and that of the Marriot Hotels.

GCH Hotel Group [24] is a hotel management company in Berlin. It provides a VR portal [25] for its 120 hotels. The site is compatible with the Google Cardboard and any other device with a browser.

Through this site, the user can see the list of the 120 hotels belonging to this group, when entering any of the hotels the user can see some photos, some details and their location.



Figure 8. GCH Hotel Group. Browser view. [25]

Another development in a reality environment for the industrial sector is the one made by Marriot Hotels with the collaboration of Samsung Electronics America created Service VRoom [26], a virtual reality experience in the rooms, which seeks to innovate in tourism. The service consists of requesting a maximum of 24 hours to the Samsung Gear VR headset and access to "VR Postcards", where the user can see stories and experiences of different travelers and destinations.

These "VR Postcards" are stories recorded by tourists in different destinations. The first experiences created were filmed in the Andes of Chile, Rwanda and Beijing.

To request this service, customers can do it from the phone in their room or from the Marriot app. As seen in Figure 9 the service comes in a briefcase containing the Samsung Gear VR lenses and a headset.



Figure 9. Marriot Hotels. Vroom Service [27]

Through his article [28] Alex Gaggioli indicates that there are three main reasons for hotels to include the experience of virtual reality. The first is to take advantage of this innovative technology to sell their services. The second of the reasons is related to the first one but directed to the locality of the hotel to give to the user points of interest or even highlighting landscapes of the place. And finally, it offers the user totally new experiences not to be limited in its locality in its content, to show other places that the user can experience and to feel that it is in another place.

2.2.2. From the Research Sector

Important work has been done in the areas of the use of narrative video in VR technology as well as human interactive issues as VR comes to be utilized by the end user.

Ook et al. [29] describes a study of the evidence of the benefits of narrative video clips in integrated VRs of hotels to alleviate travel safety concerns. It shows that VR experiences provide tranquility and security when traveling. They created a website with VR functions that shows different areas of the hotel. The project was designed to show that people could travel and stay in unfamiliar places with higher levels of perceived security and confidence via the use of virtual reality environments.

The development of interaction techniques based on head orientation or gaze is associated with a well-known problem, called the Midas touch problem [30]. This problem relates to the activation of an element on the interface when the user does not have this intention. Some

solutions for this problem are based on eye blinking and timers. More recent works [31] propose a more natural interaction using a combination of both gaze-directed interaction and a brain-computer interface to know when the user has the intention to activate an element.

Another study by Robert J. [44] seeks to unite the study of the analysis of the interfaces and as control of the means of communication between humans and computers. It gives an approach for disabled users to have a solution that uses multiple inputs, that is, the combination between mouse, keyboard, sensors or other devices. The study and analysis of this technology several years, approximately since 1998 and continues to grow. Applying eye tracking technology to man-computer interaction remains a very promising approach. Its technological and market barriers have been reducing over time.

Another study-based study for a Brain-Computer interface by Dieter Schmalstieg [45] developed a project in which an electroencephalogram based on the brain-computer interface was developed, which is used to capture brain activity with a virtual computer, demonstrating that it is possible to use this technology for useful biometric communion in the deployment of computer services.

In the article [46] written by Zhigeng Pan, is described about a method of conducting a virtual tour based on images, by modeling the navigation in sight in the global model and local model, the user can tour the scenes virtually. A new algorithm of dynamic programming is presented to eliminate the phantom effect in the mosaicked image. They aim for users to visit another point with direct view and not by clicking on the map. Bearing

in mind that they can extend the work such as including other contents and investigating how the development would be for the automatic change between scenes.

In this work, the timer-based approach and the gaze were selected through the movement of the head. Adding to the tourism area an innovative tool for the pleasure of users who wish to experience recent technologies. In the next chapter, a description is described.

2.3 Conclusions

In conclusion, virtual reality continues in technological growth and is increasingly taking over the different market areas, increasing its appearance in the main hotel chains. Furthermore, VR offers them an innovative service to offer their customers a diversity of information before, during and after their stay. Some research work continues to explore the implementation and evolution of this technology, the interaction of head movements and the timer during utilization of the devices.

CHAPTER III

PROCESS

This chapter presents and analyzes the results obtained from the application of data collection instruments, which were used to obtain information regarding the specific objectives that underpin the research.

In the following sections will be presented a previous research which was done to identify the knowledge of a group of people about VR in the last section will be described the process that will be used for the development of this project.

3.1. Preliminary Research

First, a brief survey [Appendix A] was carried out to assess the knowledge people already have regarding virtual reality, their experience with this technology and whether they would be interested in trying it with an application related to tourism. This questionnaire was done via Online, through the "Google Forms" tool, sending the URL to a group of colleagues. The target group consisted of 13 participants, aged 18 to 55. The results are shown in the following charts. Chart 1 on the left shows participants grouped by age, while on the right, they are grouped by gender.

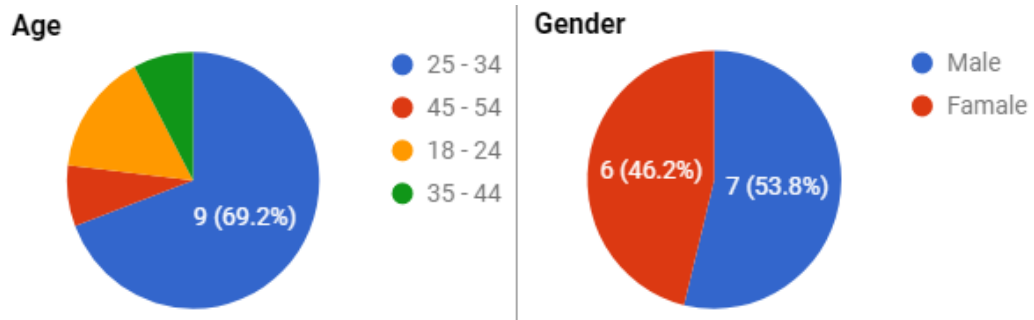


Chart 1. Group of age (left) group of gender (right)

When questioned about whether they had knowledge with virtual reality, a clear majority showed they had experience with it. (see chart 2)

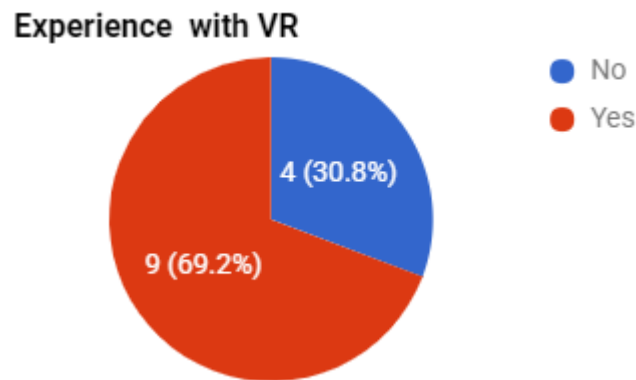


Chart 2. Results about if people had experience with VR

People who answered "Yes" in the previous question, represented in Chart 2, proceeded to ask them which were the devices in which they had experienced the virtual reality, which demonstrated that Samsung Gear VR and Playstation VR were the most used (see Chart 3).

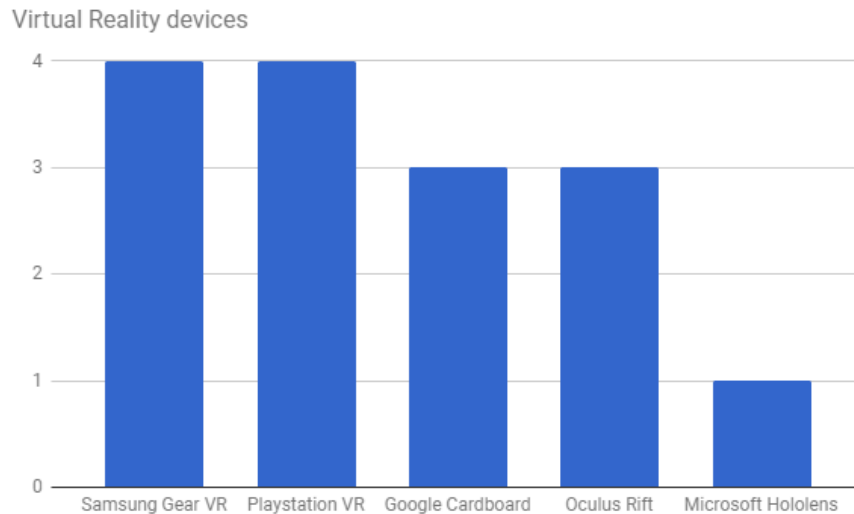


Chart 3. Devices used

As general knowledge, wanted to know what people's perception of the main objective of virtual reality, this way can know the goal of integrating virtual reality with tourism can be well accepted, which resulted in a variety of different answers such as: *"It improves the immersion in the platform (or system) and offers a different way of interacting with the information making it more striking and providing an additional reason"*, *"Escape from reality and live a parallel world "* and the most common answer was *"Video Games"*.

A clear consensus has been reached when asking: "Would you like to experience virtual reality in tourism?" to which 85% participants were positively interested. (see chart 4)

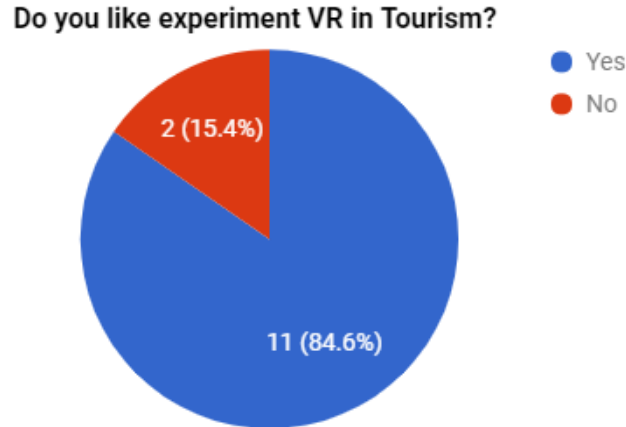


Chart 4. Group of persons who likes experiment VR in tourism

Once the results of the previous questionnaire were analyzed, it was determined that the participants agreed to experiment with virtual reality technology in tourism. This justified our continuing with the process, starting with the analysis of our main objective of implementing an interactive interface with the user in virtual reality environments.

3.1.1. Discussion

Once the project is complete and the analysis process of each section has been carried out, it has been concluded that these questions have an influenced result, and certainly these questions were made to consult people's knowledge about virtual reality rather than to obtain any result that could affect the development of this project.

3.2. Process Description

The subsequent paragraphs deal with the process, design and testing of the VR utilized in this study.

The development process is summarized in the following points:

- Identifying the structure and functions that characterize the current system implemented in the company.
- Specifying the requirements established by the company with respect to the expected performance of the proposed prototype.
- Analyzing the requirements of the structure to guide the design of the proposed prototype.
- Design and developing the proposed prototype for the visualization of the requirements indicated by the company.
- Performing the necessary tests with test users and later with end users.

The subsequent section provides empirically derived results from studies that highlight work to date with respect to these principles.

3.2.1. Structure and Functions of the current system

A useful system for analyzing data has been derived. The system on which going to base and use the information already generated, is as previously mentioned, Guestly [1]. This application is a system for engage hotel guests, this system is composed of a back-office where the hotels enter all the information they want to show from the detail of the

characteristics, images, promotions, etc. It also allows select which menu options to display.

The second component of Guestly is the front-end which shows the information managed from the back-office, figure 10 shows how the main page is seen and in the figure 11 shows an example of how the images are displayed in the demo Guestly website.

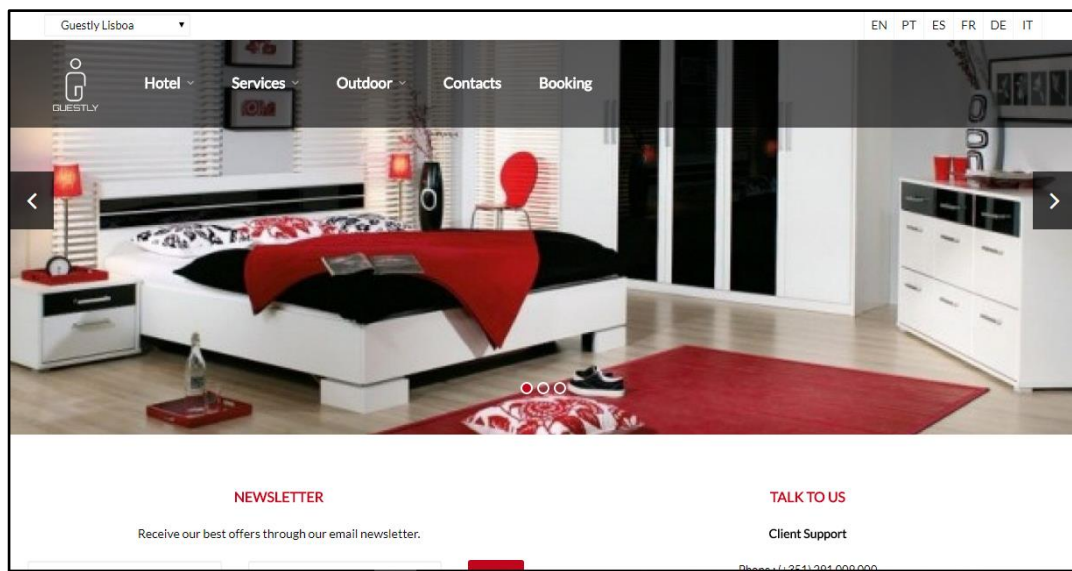


Figure 10. Home of Guestly Demo Web Site

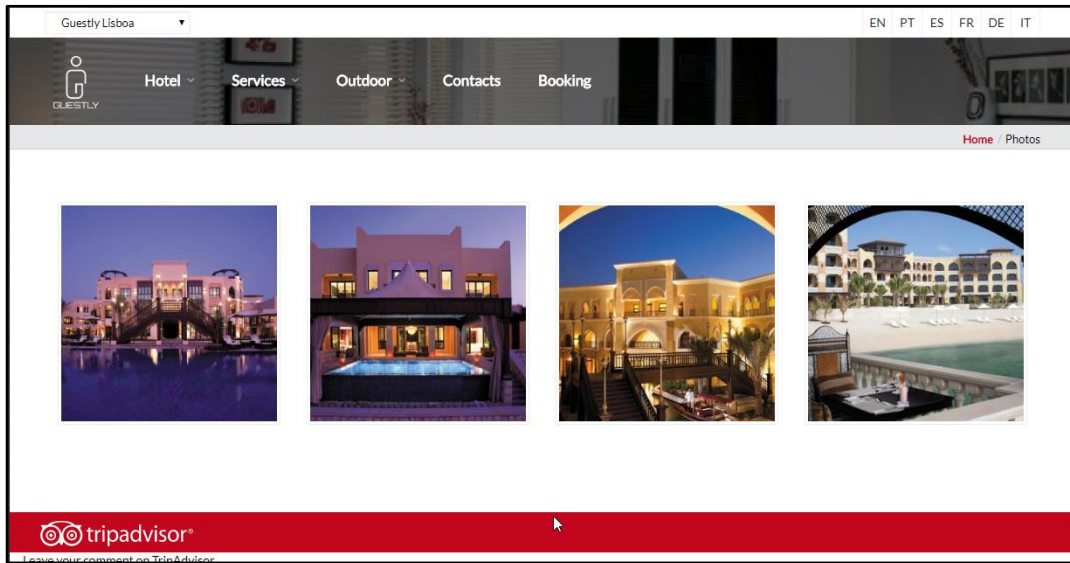


Figure 11. Guestly Demo Web Site option Images

Figure 12 shows the list of hotels belonging to the Guestly demo and in figure 13 the menu is shown with the options selected in the mobile application.

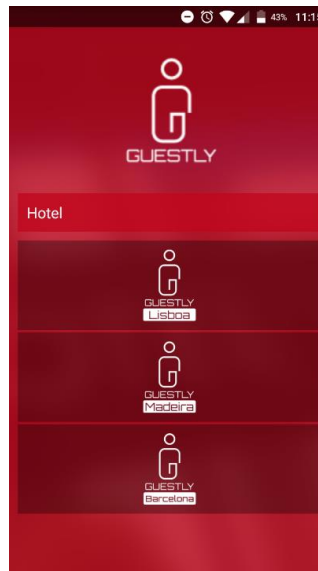


Figure 12. List of hotels belonging to demo Guestly [1]

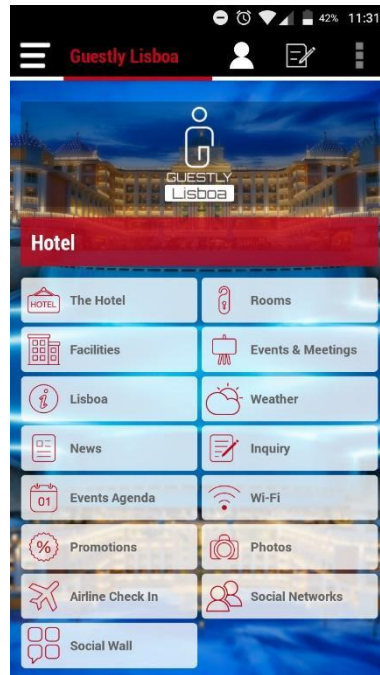


Figure 13. The menu of demo Guestly mobile app

3.2.2. Requirements

A general requirement and the main purpose is to replicate some of the features already existing in the Guestly system in a virtual reality environment.

For this virtual reality application, the interaction method between the displayed options is highlighted without the need of external buttons, which is achieved with head tracking and the definition of a timer to make automatic changes between the scenes.

Through the proposed system, we want to give greater importance to the virtual tour, since it is a new and better solution for the Guestly system, in this sense the user will have the opportunity to see all the areas

of the hotel in 360°, which is achieved that has a better vision of the facilities of the same, and in this way, have greater security at the time of booking.

With this system, it is also necessary to create a menu in which a list of hotels belonging to the customer group can be obtained, then, once the hotel has been selected, it shows another menu with options to view images, location, a virtual tour and weather.

3.2.3. Development tools

After analyzing the functionality that the system should have, was investigated what would be the most appropriate software for the development of this prototype.

Were finally found two software that could facilitate the development of this prototype. The first one to study is Unreal Engine 4 [32], as principal characteristic uses C++ and is multi-platform.

The second, Unity [33] is characterized by the ease of finding documentation for development. Another feature is the selection of the computing language to use, that being C# or Javascript, also providing multiplatform development (Windows, Mac, iOS and / or Android). Additionally, Unity has Asset Store [34] where one can find add-ons for the project, some for a fee, others, free. With all these features, Unity becomes the most suitable software for the development of this project.

For the development of this system the Unity tool was selected, programming in C# language with the obtaining of data through JSON.

The other software that will be used in parallel to Unity, for coding will be Visual Studio 2015 [42], this IDE supports several programming languages like: C++, C#, Visual Basic .NET, Java and PHP. It allows the development of applications that communicate between workstations, web pages, mobile devices, embedded devices and consoles, among others. [43]

The main reason why Unity was chosen to develop this project was because the company already completed several projects using this software and it is quite suitable.

3.3 Conclusions

Once the responses were analyzed, which were mostly positive, in the questionnaire carried out before the development process, a group of users was analyzed, which should be the next steps, despite being a small company, want to have a process as organized as possible for a better solution.

The features of a product or service determine the level of customer satisfaction. This include not only the characteristics of the main goods or services that are offered, but also the features of the services that surround them.

In this way, the development of a system of improvements in the activities carried out in the company becomes feasible, since it generates

the needed customer feedback for the handling of the information while offering greater expectations both to the internal and external client.

Satisfying customer needs and expectations is the most important element of quality management and the foundation of a company's success.

CHAPTER IV

DEVELOPMENT

This chapter explains the basis of the technical formulation of the proposed solution through the approach to the problem. It also presents the main design decisions, the important components defining the system sketch, patterns, structures and mechanisms of interaction.

The implementation was done in two parts, the first was the virtual tour, whose case was taken to BTL [37] and the second implementation was the development of the user interaction menu for the visualization of the different functions of Guestly in a virtual reality environment.

4.1. Overall System

The proposed system will offer users an innovative interface for easy interaction in a virtual reality environment.

This interface will offer users the benefit of being able to interact with certain characteristics, such as a virtual tour of the hotel, a gallery of images, detail of the weather in a graphical way, among other things.

Mainly will be analyze the methods that should be implemented in the menu to show the characteristics, for this will be seen in detail the structures of the JSON from which we will obtain the necessary information.

4.2. Structure of data

For the development of this prototype, will be connect to the API¹ which was developed previously by the company Proinov for the management of the Guestly [1] system information.

Once we have all the available methods as shown in Figure 14, will be proceeding to select the ones that will be used in our system to obtain the necessary information.

```

METHODS
• __construct
• activity_image
• add_activity_comment
• add_activity_reservation
• add_airport_transfer_request
• add_change_towels_request
• add_event_request
• add_general_request
• add_hotel_shop_request
• add_laundry_reservation
• add_maintenance_request
• add_poi_comment
• add_restaurant_menu_item_comment
• add_restaurant_request
• add_room_cleaning_reservation
• add_route_comment
• add_spa_service_comment
• add_spa_service_reservation
• add_stay
• add_table_reservation
• add_taxi_request
• add_wakeup_call_reservation
• apartment_image
• book_apartament
• book_room
• change_pin_hotel_guest
• contactForm
• details_page_image
• freshInstall
• get_activity_comments
• get_activity_ratings
• get_chat_messages
• get_hotel_guest
• get_hotels_list
• get_poi_comments
• get_poi_ratings
• get_restaurant_menu_item_comments
• get_restaurant_menu_item_ratings
• get_route_comments
• get_route_ratings
• get_spa_service_comments
• get_spa_service_ratings
• get_weather_data
• has_activity_like_comment
• has_activity_rating
• has_poi_rating
• has_restaurant_menu_item_like_comment
• has_restaurant_menu_item_rating
• has_route_rating
• has_spa_service_like_comment
• has_spa_service_rating
• hotel_data_v2
• hotel_data_v3
• hotel_data_v4
• hotel_data_v5
• hotel_has_updates
• hotel_list_has_updates
• hotel_shop_image
• hotel_shop_product_image
• hotel_shop_product_sub_category_image

```

Figure 14. Methods on API

¹ http://hoteis.guestly.net/docs/public_apps/classes/Api.html

Following, will be detailed the method used and the information get through in JSON format.

Since the client can have a group of hotels, the first method to use is "get_hotels_list", which returns the list of hotels available for that client. As shown in figure 15.

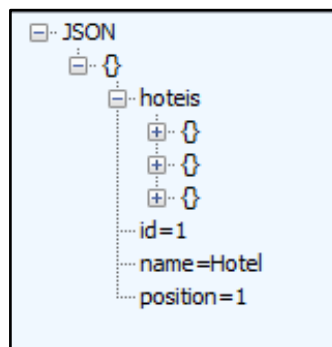


Figure 15. List of Hotels

Will be used the "hotel_data_v5" method to which we will have to send by parameter the hotel identified that we obtained from the last method (get_hotels_list).

Firstly, to obtain the contact details of the hotel, the above-mentioned method will return the structure shown in figure 16.

```
contacto
  address=Av. Linha Torres9000-044 Lisboa
  apps_layout=1
  beacon_welcome_message=Benvindo ao hotel Guestly!
  client_type=hotel
  codPostal=9000-044 Lisboa
  contact_notes=(null)
  currency=€
  email=front.office@guestly.net, informatica@proinov.com
  estimote_beacon_promotion=YES
  estimote_beacon_welcome=YES
  facebook=http://www.facebook.com/pages/GuestlyDemo
  fax=
  flickr=
  four_square=https://pt.foursquare.com/
  googlePlus=https://plus.google.com/114422334159420982995/posts
  hotel_category=1
  id=1
  image_name=logo_lisboa.png
  instagram=
  langCode=pt-PT
  latitude=38.769793
  linkedin=
  longitude=-9.159065
  name=Guestly Lisboa
  newsletter=http://www.guestly.net
  offline_map_name=lisboa-16
  offline_vector_map=lisboa-vector
  package_level=5
  phone=(+351) 291 009 000
  pinterest=
```

Figure 16. Details of hotels

To get the detail and the URLs corresponding to what will be the gallery of images, with the call of the same method (`get_data_v5`), will have been in the section of "Menu Items" the structure of the necessary. (see figure 17)



Figure 17. Get Images

Weather details can be obtained by calling the same method (get_data_v5), will have been in the section "weather_forecast_daily" information necessary to show weather for the next 10 days in the area where the hotel is located, and the JSON's structure is as shown in Figure 18.

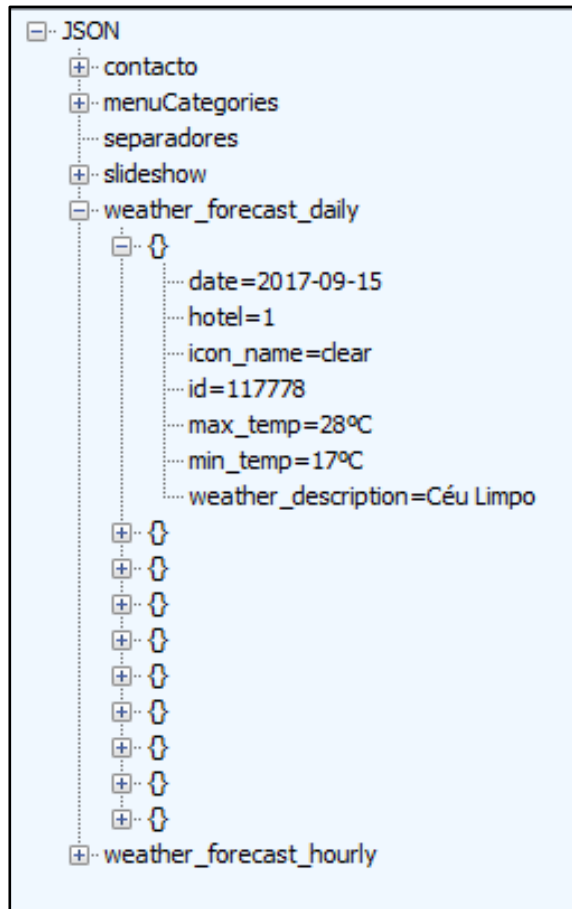


Figure 18. Get weather

4.3 Structure of project

Once you have the information to show, it will be processed to create the project in Unity. This project's structure is as shown in Figure 19 from Visual Studio.

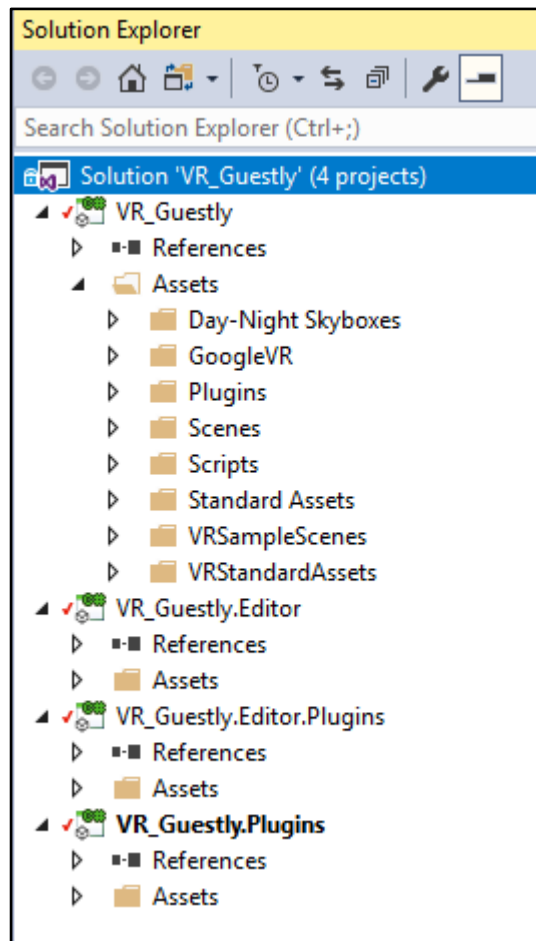


Figure 19. Solution structure

It is necessary to import two assets for the configuration and management of virtual reality environment, the first is Google VR [35], which is an SDK, which can be an extension for Unity, which includes libraries, documentation and some examples with which can work. And the second is Standard Assets [36], a package or collection of tools that we can include in our project such as images, audios or animations which gives us the necessary configuration for the development of this system and characteristics that can be used.

4.4. Structure of scripts

The main feature of our system is the user's handling through the scenes with head movements and the interaction of change of scenery keeping the pointer fixed in the desired option, without interacting with from an external environment.

For this it is necessary to create a script that detects the fixation of the pointer, with the implementation of the resource of Google VR it's possible to obtain the script "GvrReticlePointer" [APPENDIX B]. We have used this script as basis for our purpose, modifying and adding the necessary validations.

The pointer is fixed in the middle of the scenes, in this way with the movements of the Head the pointer will be controlled to place it where needed.

Figure 20 shows the methods that have been altered to be implemented, the "Start" method where the values will be initialized at the moment of initiation of the scene and the methods: "OnPointerEnter", "OnPointerHover" and "OnPointerExit" are the ones that control the view pointer when it is positioned on top of the element, when stays on top of it for a defined time and when leaving the component correspondingly.


```

protected override void Start()
{
    base.Start();
    CreateReticleVertices();
    materialComp = gameObject.GetComponent<Renderer>().material;
    gazeStartTime = -1f;
    gazedAt = null;
}

public override void OnPointerEnter(GameObject targetObject, Vector3
intersectionPosition,
Ray intersectionRay, bool isInteractive)
{
    SetPointerTarget(intersectionPosition, isInteractive);
    gazedAt = targetObject;
    gazeStartTime = Time.time;
}

public override void OnPointerHover(GameObject targetObject, Vector3
intersectionPosition,
Ray intersectionRay, bool isInteractive)
{
    SetPointerTarget(intersectionPosition, isInteractive);
    if (gazedAt != null && gazeStartTime > 0f)
    {
        if (ExecuteEvents.CanHandleEvent<DragDropHandler>(gazedAt))
        {
            gazeStartTime = -1f;
            ExecuteEvents.Execute(gazedAt, null, (DragDropHandler
handler, BaseEventData data) => handler.HandlerGazerTriggerStart());
        }
    }
}

public override void OnPointerExit(GameObject targetObject)
{
    reticleDistanceInMeters = ReticleDistanceMax;
    reticleInnerAngle = ReticleMinInnerAngle;
    reticleOuterAngle = ReticleMinOuterAngle;

    ExecuteEvents.Execute(gazedAt, null, (DragDropHandler handler,
BaseEventData data) => handler.HandlerGazerTriggerEnd());
}

```

Figure 20. Script GvrReticlePointer.

Another script that must be created navigation between scenes is shown in Figure 21, which obtains values of the pointer to change scene when waiting time expires, validation that is done in the “Update” method which is being updated each frame of the scene.

```
public class toScene : MonoBehaviour, DragDropHandler
{
    [SerializeField]
    private Image Timer_img; // image of timer

    private bool Pointer;
    float timeAmt = 2;
    float timer_bar;

    void Start()
    {
        Pointer = false;
        Timer_img.enabled = false;
    }
    void Update()
    {
        if (Pointer == true)
        {
            Timer_img.enabled = true;
            timer_bar += Time.deltaTime;
            Timer_img.fillAmount = timer_bar / timeAmt;

            if (timer_bar >= 2.00)
            {
                SceneManager.LoadScene("NAME_OF_SCENE");
            }
        }
    }

    public void HandlerGazerTriggerStart()
    {
        Timer_img.enabled = true;
        Pointer = true;
    }

    public void HandlerGazerTriggerEnd()
    {
        Timer_img.enabled = false;
        Pointer = false;
        timer_bar = 0f;
    }
}
```

Figure 21. Script ToScene.

To perform the calculation of positions and rotations in question there are two or more elements in the different scenes of the menu, we use the following function, as shown in Figure 22. This formula is based mainly on obtaining each point to position the elements having the assigned center and the calculation of the angle to follow. Calculate the X, Y and Z axis independently, and then be assigned to the position of the element.

```
void PositionOptions(int numPoints, int j, string icon_names)
{
    var i = (j * 0.5f) / numPoints;

    float angle = (float)i * Mathf.PI * 2;
    var centrePos = new Vector3(1, 1, 1);

    var x = Mathf.Sin(angle) * 10;
    var z = Mathf.Cos(angle) * 10;
    var pos = new Vector3(x, 0, z) + centrePos;

    var rot = Quaternion.AngleAxis(-(90 - angle) * j, Vector3.down);
}
```

Figure 22. Function to set position and rotation

It is necessary to keep between the scenes the *id* of the hotel since it must be sent in each request of information of the options of the hotel. This *id* restarts its value once the user enters the menu where the person selects the hotel. For the control of this *id* we use the script shown in Figure 23.

```

public class idHotel : MonoBehaviour {

    public string hotel_id;
    public static idHotel id_hotel;

    void Awake() {
        if (id_hotel == null ) {
            id_hotel = this;
            DontDestroyOnLoad(gameObject);
        }else if (id_hotel != this){
            Destroy(gameObject);
        }
    }
}

```

Figure 23. Script to save idHotel

Following a well-defined process, it is explained that all the actions taken are important to achieve an optimal result, adjusting to the needs of the company interested in the system and the element to develop it.

4.5. Virtual tour

A virtual tour was done with existing 360° images of the Guestly mobile app belonging to the Meliá Madeira hotel [38]. This tour starts at the main entrance of the hotel, next guiding the user to the lobby to take it to the room and can even see the view from the balcony.

Next, some details of the virtual tour:

- To be able to navigate between the hotel facilities using the head tracking.
- The interaction to change scenes through an indicative image. As shown in Figure 24.



Figure 24. First indicative image to change scene [39]

When the user gazes at one of the scene selector points, the timer will be activated, which will increase until the end of the time, the timer will be represented as shown in Figure 25 around the indicator point.



Figure 25. Timer around an indicative image [39]

Once the time of 5 seconds ends, the scene changes, and it is not necessary to click with the buttons (if it exists) of the virtual lenses.

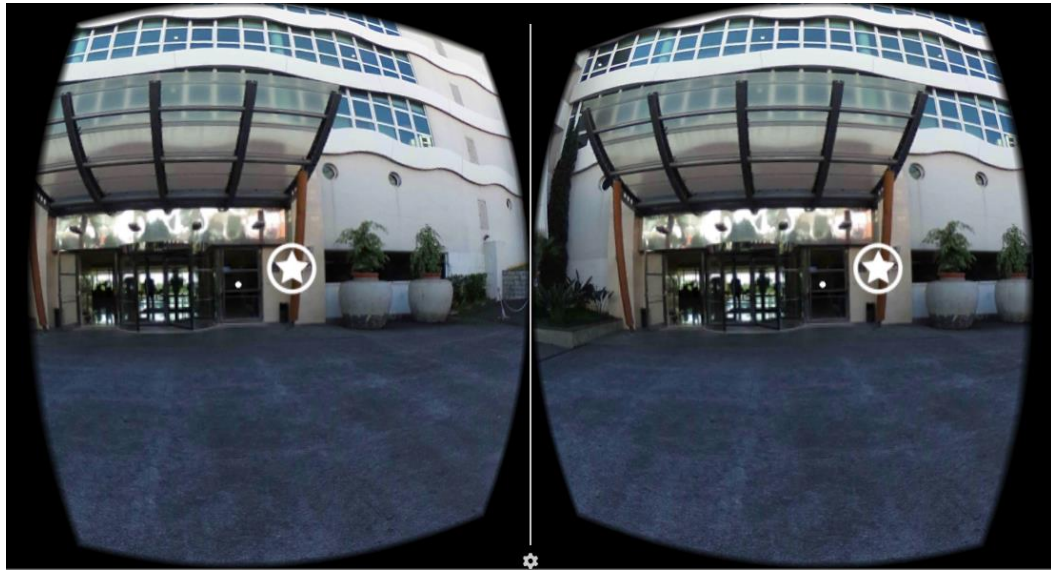


Figure 26. First virtual tour prototype

Figure 26 shows the first prototype of the virtual tour with the characteristics mentioned above.

4.6. Interactive Menu

After the realization of the virtual tour was realized the menu for the integration of the options of the system in the atmosphere of virtual reality. The main idea is to firstly show the available hotels, then another menu showing options to select the options like the virtual tour, images or weather.

The implementation of the menu for user interaction, starts with the hotel list screen. Each of the hotel logos are displayed so that the user selects with the pointer and sets it with the movement of the head for the hotel of his preference. Once the timer is activated, after 2 seconds the scene change. For this feature, the timer icon was changed as shown in

Figure 27.



Figure 27. Timer Menu [39]

The first scene of the interactive menu is as shown in Figure 28, which displays the logos of the hotels belonging to the hotel group. It allows to enter each hotel independently to see the detail of each one of them.

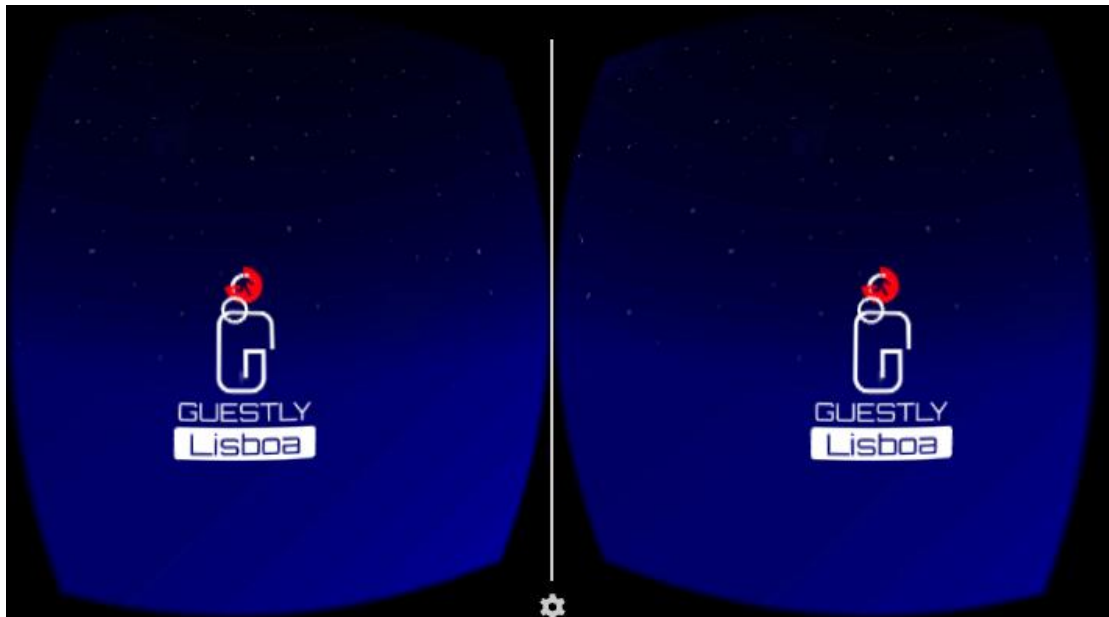


Figure 28. First scene. Hotel select.

In the next scene, the corresponding hotel menu is displayed, as shown in Figure 29, with the main interactive options being the visualization of images, map, virtual tour and weather.

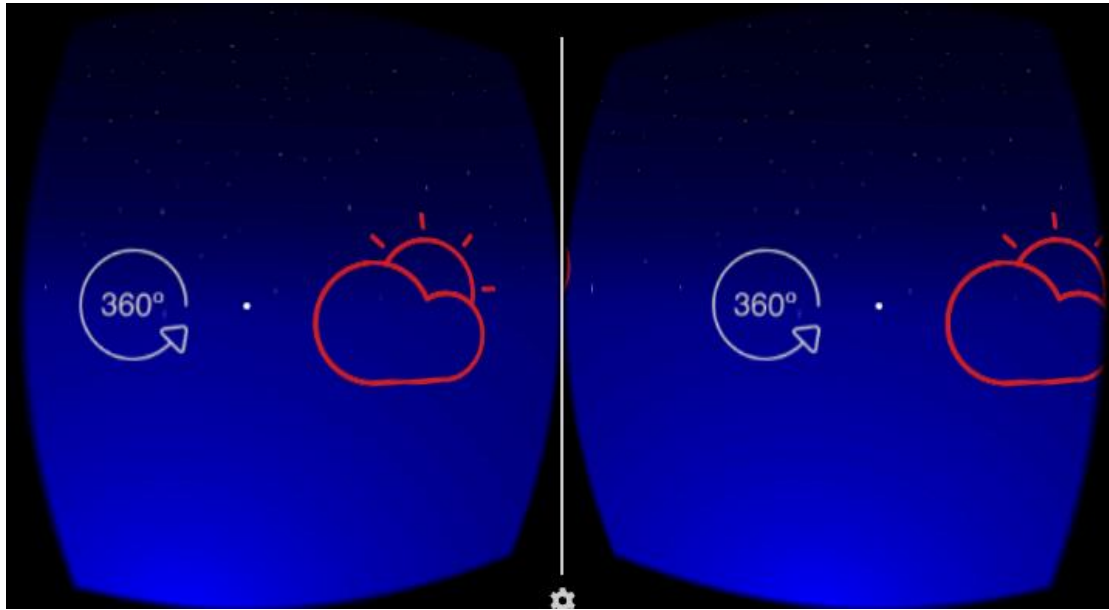


Figure 29. Second scene. Option selection

4.7. Conclusions.

After analyzing the existing Guestly API, it was necessary to obtain the methods to be used for the data acquisition, next create the structure of the application with the necessary plugins.

In conclusion, it was possible to carry out the development of the first prototypes after having collected the information and the installation of the necessary software. The prototype was developed in two parts, the first was the virtual tour with functionalities that were later implemented in the development of the menu for user interaction.

After this development, it will be possible to perform the tests with the users, which will be detailed in the next chapter.

CHAPTER V

EVALUATION

In this chapter, will detail the results obtained from the encounters made with the users who were given latest version of the prototype. The results obtained will be analyzed for control and improvement of the system.

This prototype was tested with a group of 7 people, of Portuguese nationality, whose professional experience of systems developers for tourism. No instrument was used to collect results, the question was asked openly to users who would tell us what their opinion about the prototype, negative or positive. Some of the comments received were: “*The interaction does not make me dizzy*”, “*You can appreciate in detail the hotel facilities*”, “*The interaction without buttons is very useful for cardboard that does not have them*”.

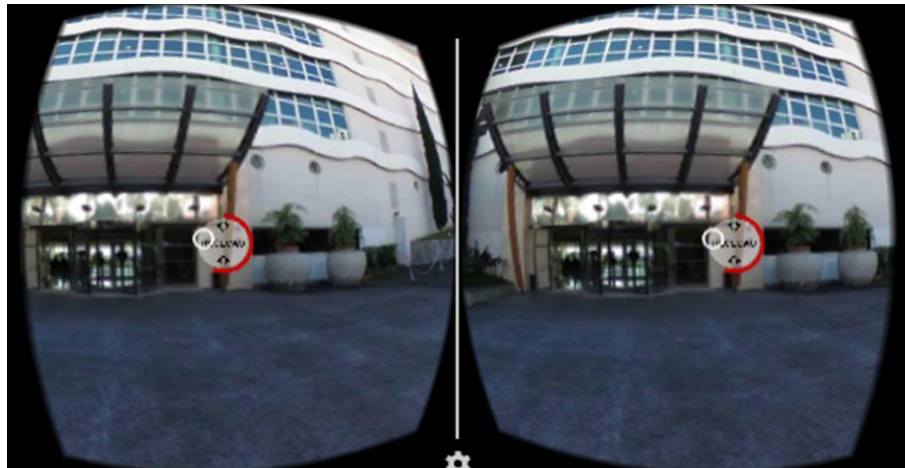


Figure 30. An illustration of the last virtual tour prototype

And another comment received was the fact that the images were not easy to understand since they did not indicate the area to which it was directed, this feedback provided a later improvement, the images were changed for ones in which the name was visualized. From the area to go, this is the reason why images were changed for some with the names of each section, as it shows in Figure 31.

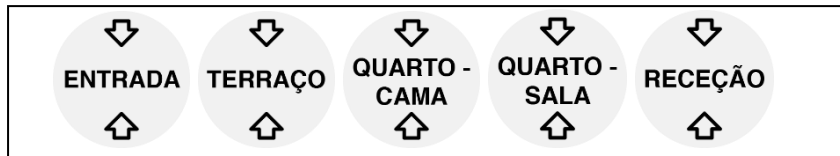


Figure 31. Finals indicative images to change scenes

In Figure 32 illustrates how interaction points are displayed with the latest changes made in the images.



Figure 32. Presents a close-up image from the virtual tour

Further feedback suggested the waiting time to change the scene, which was configured to be 5 seconds, this time has seemed a long time, so later a couple of tests were made to analyze which should be the appropriate time, with which reached the conclusion of a final time of 2 seconds for the change of scene.

Another feedback received show that there was no option to return to the main scene. So later the improvement was made to place the logo of the hotel at the bottom of the scene to return to the main scene, as shown in Figure 33 and through this return to the main menu.

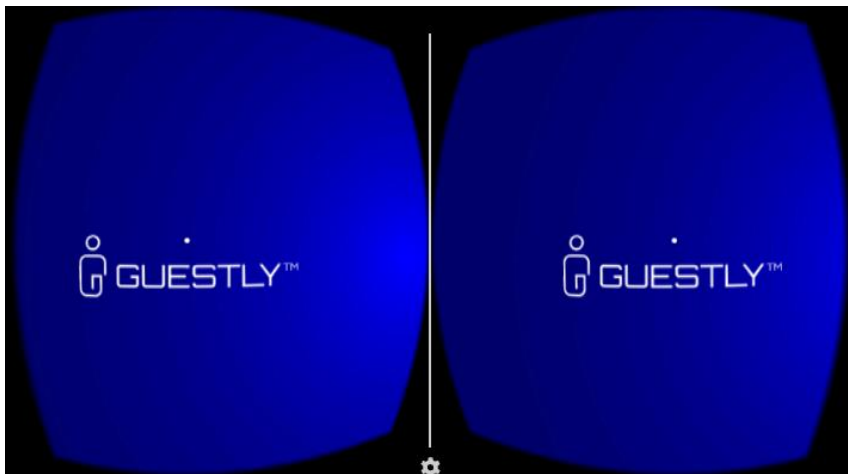


Figure 33. Option to back

To obtain a better understanding of the usability and accessibility of the system, a SUS questionnaire [40] was applied to 7 users after the prototype interaction. SUS is a reliable tool to measure usability by asking participants answer ten questions with number ranging from 1 (strongly disagree) to 5 (strongly agree). [APPENDIX C]

Table 1, shows the results for each question made to the users. Each participant has their score [41] on a scale of 0 to 100. The average was 90,35. And the deviation was from: 4,89.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Person 1	5	1	5	1	4	1	5	1	5	1
Person 2	4	1	4	1	3	1	4	1	4	1
Person 3	3	2	4	1	3	1	3	2	4	1
Person 4	5	1	5	1	3	1	5	1	5	1
Person 5	4	2	4	1	4	1	3	1	4	1
Person 6	5	1	4	1	3	1	5	1	4	1
Person 7	4	1	5	1	4	1	5	1	4	1

Table 1. Results of SUS

	Score	Deviation	Square deviation
Person 1	97.5	7.142857	51.02040816
Person 2	85	-5.35714	28.69897959
Person 3	90	-0.35714	0.12755102
Person 4	95	4.642857	21.55612245
Person 5	82.5	-7.85714	61.73469388
Person 6	90	-0.35714	0.12755102
Person 7	92.5	2.142857	4.591836735

Table 2. Results SUS. Part 2

As indicated by Nathan [41], an average greater than 80 is the highest acceptance and usability, and so, it can be observed that users liked what they saw and interacted with. Then results represented in a graph for better reading. (see chart 5)

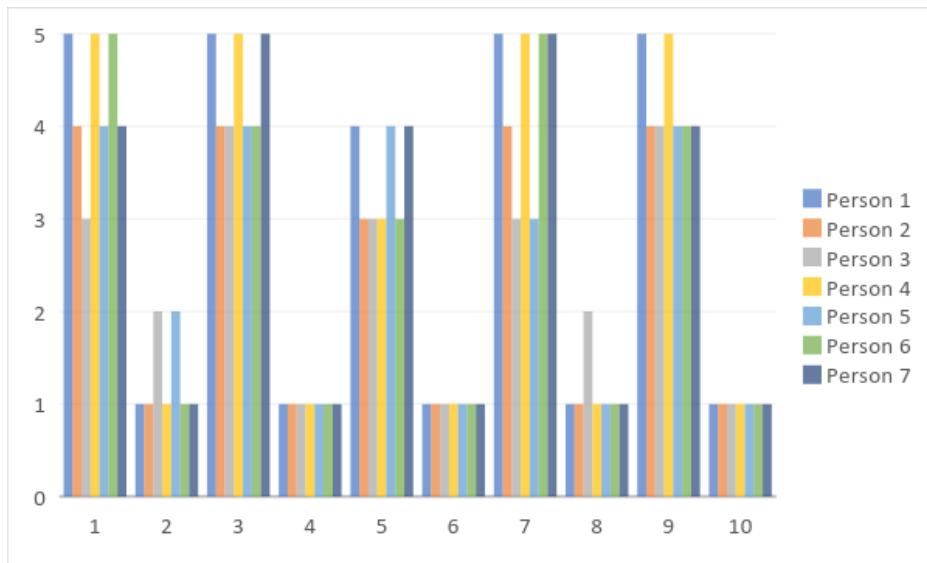


Chart 5. Results of SUS, grouping by person

In conclusion, despite having a small number of people to be tested, we obtained positive results, with comments on things to improve and a rather positive acceptance.

CHAPTER VI

CONCLUSIONS

The present dissertation had as main objective the development of an interface of the already existing system Guestly for the user in a virtual reality environment, in this way offering a new innovative solution.

A prototype was developed to provide an innovative solution to visualize the services offered by the system for hotels, Guestly. Highlighting the virtual tour as an innovative solution for customers with an easy interaction and compatible with different virtual reality devices, for this project it is emphasized that it is easily accessible and without major requirements of virtual reality devices, as it is characterized by the interaction without the need for external buttons that make it compatible with low cost lenses.

To begin the development process, we conducted a small survey of a group of people to assess their knowledge of virtual reality and their experience with it, we got a positive response when asking if they would be interested in interacting with virtual reality in tourism. Based on the results obtained in the users' interest in experimenting with a virtual hotel application, the development process started.

Development of this system was done with Unity, which has a series of features that help integration with the world of virtual reality, software that keeps up to date with technological advances. For this project it was possible to find updated documentation and assets that allow us to obtain

better features for our system.

The development was divided in two parts, the first one was dedicated to the development of the virtual tour, which was shown in the BTL² with this previous demonstration was possible obtain different comments for improvements. The second part was the development of interactive menu to visualize the different options offered in Guestly.

Soon, other features that can be implemented to extend the scope of the current prototype can be evaluated, like podcast-style 360° videos made by hotel guests showing them experience at the hotel or around at location. This prototype is expected to be implemented by different hotels in Madeira and Lisbon.

² <http://btl.fil.pt/?lang=en>

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APPENDIX A. QUESTIONNAIRE TO KNOW THE KNOWLEDGE OF VIRTUAL REALITY IN PEOPLE

Age *

- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 55

Gender

- Male
- Female

Which of these devices do you own and use regularly? *

- Smartphone
- Tablet
- Laptop
- PC
- Smartwatch
- Smart TV
- None

Do you know Virtual Reality? *

- Yes
- No

If the answer above is affirmative. Which of these virtual reality devices have you experienced? *

- Google Cardboard
- Microsoft Hololens
- Oculus Rift
- Samsung Gear VR
- HTC Vive
- Playstation VR
- None

In your opinion what is the main use of Virtual Reality. *

Your answer _____

APPENDIX B. SCRIPT GVRRETICLEPOINTER FROM GOOGLEVR.

```
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//  
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// WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or  
// implied.  
// See the License for the specific language governing permissions and  
// limitations under the License.
```

```
using UnityEngine;
```

```
/// Draws a circular reticle in front of any object that the user points at.
```

```
/// The circle dilates if the object is clickable.
```

```
[AddComponentMenu("GoogleVR/UI/GvrReticlePointer")]
```

```
[RequireComponent(typeof(Renderer))]
```

```
public class GvrReticlePointer : GvrBasePointer {
```

```
    /// Number of segments making the reticle circle.
```

```
    public int reticleSegments = 20;
```

```
    /// Growth speed multiplier for the reticle/
```

```
    public float reticleGrowthSpeed = 8.0f;
```

```
    // Private members
```

```
    private Material materialComp;
```

```

// Current inner angle of the reticle (in degrees).
private float reticleInnerAngle = 0.0f;
// Current outer angle of the reticle (in degrees).
private float reticleOuterAngle = 0.5f;
// Current distance of the reticle (in meters).
private float reticleDistanceInMeters = 10.0f;

// Minimum inner angle of the reticle (in degrees).
private const float kReticleMinInnerAngle = 0.0f;
// Minimum outer angle of the reticle (in degrees).
private const float kReticleMinOuterAngle = 0.5f;
// Angle at which to expand the reticle when intersecting with an object
// (in degrees).
private const float kReticleGrowthAngle = 1.5f;

// Minimum distance of the reticle (in meters).
private const float kReticleDistanceMin = 0.45f;
// Maximum distance of the reticle (in meters).
private const float kReticleDistanceMax = 10.0f;

// Current inner and outer diameters of the reticle,
// before distance multiplication.
private float reticleInnerDiameter = 0.0f;
private float reticleOuterDiameter = 0.0f;

protected override void Start () {
    base.Start();

    CreateReticleVertices();
}

```



```

    materialComp = gameObject.GetComponent<Renderer>().material;
}

void Update() {
    UpdateDiameters();
}

/// This is called when the 'BasInputModule' system should be enabled.
public override void OnInputModuleEnabled() {}

/// This is called when the 'BasInputModule' system should be disabled.
public override void OnInputModuleDisabled() {}

/// Called when the user is pointing at valid GameObject. This can be a 3D
/// or UI element.
///
/// The targetObject is the object the user is pointing at.
/// The intersectionPosition is where the ray intersected with the targetObject.
/// The intersectionRay is the ray that was cast to determine the intersection.
public override void OnPointerEnter(GameObject targetObject, Vector3
intersectionPosition,
    Ray intersectionRay, bool isInteractive) {
    SetPointerTarget(intersectionPosition, isInteractive);
}

/// Called every frame the user is still pointing at a valid GameObject. This
/// can be a 3D or UI element.
///
/// The targetObject is the object the user is pointing at.
/// The intersectionPosition is where the ray intersected with the targetObject.
/// The intersectionRay is the ray that was cast to determine the intersection.

```

```

public override void OnPointerHover(GameObject targetObject, Vector3
intersectionPosition,
    Ray intersectionRay, bool isInteractive) {
    SetPointerTarget(intersectionPosition, isInteractive);
}

/// Called when the user's look no longer intersects an object previously
/// intersected with a ray projected from the camera.
/// This is also called just before OnInputModuleDisabled and may have have
any of
/// the values set as null.
public override void OnPointerExit(GameObject targetObject) {
    reticleDistanceInMeters = kReticleDistanceMax;
    reticleInnerAngle = kReticleMinInnerAngle;
    reticleOuterAngle = kReticleMinOuterAngle;
}

/// Called when a trigger event is initiated. This is practically when
/// the user begins pressing the trigger.
public override void OnPointerClickDown() {}

/// Called when a trigger event is finished. This is practically when
/// the user releases the trigger.
public override void OnPointerClickUp() {}

public override float GetMaxPointerDistance() {
    return kReticleDistanceMax;
}

public override void GetPointerRadius(out float innerRadius, out float
outerRadius) {

```

```
float min_inner_angle_radians = Mathf.Deg2Rad * kReticleMinInnerAngle;
float max_inner_angle_radians = Mathf.Deg2Rad * (kReticleMinInnerAngle +
kReticleGrowthAngle);
```

```
innerRadius = 2.0f * Mathf.Tan(min_inner_angle_radians);
outerRadius = 2.0f * Mathf.Tan(max_inner_angle_radians);
}
```

```
private void CreateReticleVertices() {
    Mesh mesh = new Mesh();
    gameObject.AddComponent<MeshFilter>();
    GetComponent<MeshFilter>().mesh = mesh;
```

```
int segments_count = reticleSegments;
int vertex_count = (segments_count+1)*2;
```

```
#region Vertices
```

```
Vector3[] vertices = new Vector3[vertex_count];
```

```
const float kTwoPi = Mathf.PI * 2.0f;
```

```
int vi = 0;
```

```
for (int si = 0; si <= segments_count; ++si) {
```

```
    // Add two vertices for every circle segment: one at the beginning of the
    // prism, and one at the end of the prism.
```

```
    float angle = (float)si / (float)(segments_count) * kTwoPi;
```

```
    float x = Mathf.Sin(angle);
```

```
    float y = Mathf.Cos(angle);
```

```
    vertices[vi++] = new Vector3(x, y, 0.0f); // Outer vertex.
```

```

    vertices[vi++] = new Vector3(x, y, 1.0f); // Inner vertex.
}
#endregion

#region Triangles
int indices_count = (segments_count+1)*3*2;
int[] indices = new int[indices_count];

int vert = 0;
int idx = 0;
for (int si = 0; si < segments_count; ++si) {
    indices[idx++] = vert+1;
    indices[idx++] = vert;
    indices[idx++] = vert+2;

    indices[idx++] = vert+1;
    indices[idx++] = vert+2;
    indices[idx++] = vert+3;

    vert += 2;
}
#endregion

mesh.vertices = vertices;
mesh.triangles = indices;
mesh.RecalculateBounds();
;
}

private void UpdateDiameters() {
    reticleDistanceInMeters =

```

```

    Mathf.Clamp(reticleDistanceInMeters,          kReticleDistanceMin,
kReticleDistanceMax);

    if (reticleInnerAngle < kReticleMinInnerAngle) {
        reticleInnerAngle = kReticleMinInnerAngle;
    }

    if (reticleOuterAngle < kReticleMinOuterAngle) {
        reticleOuterAngle = kReticleMinOuterAngle;
    }

    float inner_half_angle_radians = Mathf.Deg2Rad * reticleInnerAngle * 0.5f;
    float outer_half_angle_radians = Mathf.Deg2Rad * reticleOuterAngle * 0.5f;

    float inner_diameter = 2.0f * Mathf.Tan(inner_half_angle_radians);
    float outer_diameter = 2.0f * Mathf.Tan(outer_half_angle_radians);

    reticleInnerDiameter =
        Mathf.Lerp(reticleInnerDiameter,    inner_diameter,    Time.deltaTime *
reticleGrowthSpeed);
    reticleOuterDiameter =
        Mathf.Lerp(reticleOuterDiameter,    outer_diameter,    Time.deltaTime *
reticleGrowthSpeed);

    materialComp.SetFloat("_InnerDiameter",    reticleInnerDiameter *
reticleDistanceInMeters);
    materialComp.SetFloat("_OuterDiameter",    reticleOuterDiameter *
reticleDistanceInMeters);
    materialComp.SetFloat("_DistanceInMeters", reticleDistanceInMeters);
}

```

```
private void SetPointerTarget(Vector3 target, bool interactive) {  
    Vector3 targetLocalPosition = transform.InverseTransformPoint(target);  
  
    reticleDistanceInMeters =  
        Mathf.Clamp(targetLocalPosition.z, kReticleDistanceMin,  
kReticleDistanceMax);  
    if (interactive) {  
        reticleInnerAngle = kReticleMinInnerAngle + kReticleGrowthAngle;  
        reticleOuterAngle = kReticleMinOuterAngle + kReticleGrowthAngle;  
    } else {  
        reticleInnerAngle = kReticleMinInnerAngle;  
        reticleOuterAngle = kReticleMinOuterAngle;  
    }  
}  
}
```

APPENDIX C. SYSTEM USABILITY SCALE QUESTIONNAIRE

System Usability Scale

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	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
2. I found the system unnecessarily complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
3. I thought the system was easy to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
5. I found the various functions in this system were well integrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
6. I thought there was too much inconsistency in this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
8. I found the system very cumbersome to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
9. I felt very confident using the system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5