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**street ar t**

Development of an Augmented Reality  
Application in the Context of Street Art

Dissertation in the context of the Master in Design and  
Multimedia, advised by Professor Pedro Martins and  
Professor Tom de Smedt presented to  
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# Abstract

Technology is growing at a remarkable rate, allowing people to access information in the most diverse ways.

The mobile application expansion enhances the everyday experience of users looking for information quickly and efficiently, not only in quality but also in quantity, causing a shift from analog to digital.

This dissertation proposes the investigation of two topics: augmented reality and street art. The project developed focuses on this artistic field on which information is scarce, solving with the use of augmented reality to promote and teach more about it. Thus, this document describes the entire process from application planning to a functional prototype.

## Keywords

Augmented Reality, Street Art, Artwork, Information, Animation



# Resumo

A tecnologia está a crescer a um ritmo notável, permitindo que as pessoas tenham acesso a informações através das mais surpreendentes formas.

A expansão de aplicações em dispositivos móveis aprimora a experiência quotidiana de utilizadores que procuram informações de forma rápida e eficiente, não apenas em qualidade, mas também em quantidade, causando uma mudança do analógico para o digital.

Esta dissertação propõe a investigação da combinação de dois temas: realidade aumentada e street art (arte de rua). O projecto desenvolvido debruça-se sobre esta vertente artística sobre a qual a informação é escassa, solucionando com o uso de realidade aumentada para a promover e ensinar mais sobre o assunto. Assim, este documento descreve todo o processo documentando todo o processo desde o planeamento da aplicação até a um protótipo funcional.

## Palavras-chave

Realidade Aumentada, Arte de Rua, Obra de Arte, Informação, Animação





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# Glossary

## **Augmented Reality**

A computer-generated experience that connects and integrates elements of the real world with virtual objects.

## **Baroque**

Heavily decorated artistic style artistic expression prevalent in Europe in the 17th century and the early part of the 18th century:

## **Fiducial Marker**

An object placed in an image to be used as a point of reference or measure.

## **Mixed Reality**

Real and virtual environments merged, producing a new environment where physical and virtual objects co-exist and interact in real-time.

## **Overlay**

Something placed over something else, giving additional information or detail.

## **Personae**

Fictional characters to represent the real target audience of the application.

## **Reality-Virtuality Continuum**

Continuous scale that ranges between the virtuality and reality, consisting of all variations and compositions of real and virtual objects.



**Sensor**

A device that receives a signal and responds to it in a distinctive manner.

**Superimpose**

Place or lay one thing over another so that both are still evident.

**Tracker**

A feature allowing to record and identify movements and patterns.

**Virtual Reality**

A computer-generated environment where the user is completely immersed in a virtual world.

**Wireframe**

Prototype used in interface design to display the structure of an application and relationships between its pages.



# List of Acronyms

3D - Three Dimensional

AR - Augmented Reality

API - Application Program Interface

CHESS - Cultural Heritage Experiences through  
Socio-personal and Storytelling

CT - Computed Tomography

GPS - Global Positioning System

HMD - Head-Mounted Display

HMS - Helmet-Mounted Sights

HUD - Head-Up Displays

MIT - Massachusetts Institute of Technology

MRI - Magnetic Resonance Imaging

PC - Personal Computer

SDK - Software-Development Kit

XML - Extensible Markup Language

# 1. Introduction

Looking upon the present world, it is possible to see the major changes happening over time, especially the increasing technological advances, which seem to be only as limited as the human imagination. Nowadays, technology can extend our senses, allowing us to see more than what others can see, hear what others cannot hear or even touch what others cannot touch (Van Krevelen & Poelman, 2010). This evolution is reflected by people and their constant search for knowledge, where actions are meant to be delivered quickly and through several ways, thus resorting to technological tools.

Augmented reality is a technology that over the past twenty years has had a substantial evolution, both in techniques and in products, such as Google Glass<sup>1</sup> and Pokémon GO<sup>2</sup>, affecting several areas and progressively becoming a part of our lives. One of the areas that has had several interventions with augmented reality is art, on which this technology is being integrated into museums and art galleries as a supplementary source of information.

The focus of this project is street art, an artistic field in which artists create their artworks in public locations, usually outdoors. However, the particularity of this field is that many of the created artworks remain unknown. Unlike museums or galleries, which present the information about the exhibits in signs and leaflets, street artworks only have the artist's signature associated, which sometimes is not clear.

This dissertation proposes the creation of an augmented reality application for mobile devices, where users not only can augment artwork to see information about it but also to see it in motion, thus providing a different and enjoyable experience.

The process of creating and developing an augmented reality system in a real context is explored, as well as the creative methods for animating the murals. This dissertation results in an application that allows users to access quickly and easily information about street artworks, as well as guiding them to more pieces located nearby. Consequently, the user learns more about street art and discovers new artworks that could likely pass unseen.

# 1.1. Motivation

One of the main reasons that led to the choice and development of this project was my growing interest in augmented reality and the potential it has to contribute to a countless number of areas, namely to art.

The street art field is rising, as more and more artists are invited to paint artworks in several cities, promoting forgotten spots or to enhance degraded areas. Unfortunately, some of these creations remain unknown or less understood since, unlike artworks in galleries and museums, street art works usually do not include additional information (e.g., artist's name or title) and tend to be poorly disseminated.

The combination of limited knowledge about street art with an innovative way of transmitting information through augmented reality results in an engaging and educational application. The aim is to provide an experience similar to a museum or gallery to contextualize and summarize the works and their creators. During the development of this project, some questions were sent to street art artists to understand their point of view upon their creations. Also, it was important to comprehend and compare the realities of this artistic field between Portugal and Belgium, since the project was developed with artworks of both these countries.

The interviewed artists gave different answers; however, one of them was unanimous: they consider their art to be ephemeral due to weather conditions and possible vandalism. This aspect motivated me to not only present and give information about artworks that currently exist in good conditions but also about the ones that were damaged. This way, users could see how these artworks once were and to keep a record of the new ones while there is still time.

Another aspect that motivated this choice was the fact that I wanted to explore something beyond what is usually covered in the Design and Multimedia course and, simultaneously, allow me to take advantage of my own knowledge.

Also, one of my major interests in the area of Design and Multimedia is animation, whether it is creating videos or giving motion to images, thus seeming appropriate to choose a dissertation where I could develop and improve my skills in this area.

So, by combining all of these aspects, this project aims to create an innovative application that will improve the street art tour experience by providing users with additional information and interesting trivia related to artworks, while observing it with animation.

## 1.2. Background

Augmented reality is the main field of study of this dissertation and, besides having numerous possibilities of applications, in this project it will be used for educational purposes to give another look upon street art and explore animation techniques. The challenge will be gathering the most relevant pieces of art spread in the streets of Antwerp and Coimbra, animating them, and providing the user with supplementary information in an entertaining way.

Antwerp, the second-largest city in Belgium, was the chosen location to begin this project since it has a huge influence on street art. It organizes several art and graffiti events each year and offers a variety of exhibitions, events and performances, which helped me have a better understanding of some artworks and their creative processes.

The main feature of the proposed application is augmented reality, which will be used to scan and detect artworks. By pointing the device's camera at an artwork, and if it matches one included in the database, it presents information and trivia about its author, creative process and meaning. Also, in some cases, the artwork will be displayed with animation, creating an enjoyable and engaging user experience.



## 1.3. Outlook

This dissertation aims to explore the augmented reality area, more precisely the development of an interface capable of scanning works of art, bringing up supporting media and information.

To better understand the goals and problems that this project intends to solve, it is necessary to carry out an analysis of augmented reality methods to design an interface that effectively serves the real needs of all its users.

Street art is a movement where artists create their artworks in public locations, outside the context of traditional art venues, and for this reason, it does not have information available on a label or leaflet. As a consequence, people who want to know more about what is being seen have to search for it on their phones, and sometimes that information is difficult to find.

By creating an application with augmented reality integrated, it results in a support app that enriches the street art experience, allowing each user to scan the artworks with their mobile devices and getting un-Google-able supplemental information, such as the artist who created it and meaning of the piece.

This can be beneficial for touristic tours since it helps and eases the process of a guide's explanation when presenting a certain location. Sometimes the amount of information is so vast that, if not explained in a direct and captivating way, it can make the audience lose their attention. By supplying this kind of entertainment not only makes the tour more enjoyable, but it can also help people understand and learn more than they usually would. This application can be also adopted by independent users who would rather create their own path. By providing the locations available to augment, they can skip the traditional

tour route since a large part of the information is provided by their devices.

Additionally, this project is not only aimed to regular people but also artists. By exposing and promoting their artworks, it gives more visibility to their creators that sometimes can pass unseen (the signature could be damaged or even unreadable) therefore having the deserved recognition.

In conclusion, developing this application will not only offer an alternative way to discover a city but also enrich an art field that has so much to explore.

## 1.4. Document Structure

After the **Introduction**, the second chapter, **Methodology and Work Plan**, includes the formal aspects of this dissertation, which clarifies the specific goals, the process and approach adopted, and a description of the work plan.

The third chapter, **State of the Art**, presents an overview of the area of augmented reality, which includes the main characteristics of an augmented reality system, its evolution until today, the impact of its application in several fields and the main technological devices used. Five projects, which combine augmented reality with art, are presented to serve as an analysis of approaches that were carried out in this field.

The fourth chapter, **Street Art**, offers a glimpse of this ascending art form, introducing the topic with a presentation of its brief history and discusses its current relevance. Additionally, it is explained how this art form is invading Antwerp and the reason for beginning to develop the project in this location.

The fifth chapter is the **Prototype Design**, which introduces the design planning and process of the application's interface, explaining decisions made from the wireframe to the interface identity.

The sixth chapter, **Implementation**, documents the practical development of the application, from the design until the final product. It describes the development of both animations and application, describing every decision, functionality and technology used.

The seventh chapter is the **Application's Evaluation**, which documents the usability tests to understand the interaction between the user and the application's interface. It is presented a script which users

followed, statistics regarding the tasks they accomplished and a questionnaire to comprehend the usability of the application.

Finally, the **Conclusion and Future Perspectives** summarizes the development of this project, considering the proposed goals and offers a future perspective of this project.





## **2. Methodology and Work Plan**

This chapter describes the methodology followed during the development of this work and how it was applied. In addition, the Goals and Work Plan are outlined and explained.

## 2.1. Methodology

In order to achieve the purpose of this dissertation, it is necessary to understand the problem this project intends to solve. For this reason, this dissertation began with the State of the Art chapter which consisted on a research about augmented reality, exploring image recognition techniques as well as study cases already being put in practice and its benefits.

Next, in the Street Art chapter, it was analyzed aspects such as historical influence and its evolution. This phase involved the exploration of approaches for this application, such as visualization of animated artwork.

The third step was about understanding the context of people with street art and to know what could be improved in a street art experience. For this, a group of people in a street art tour in Antwerp were presented to the idea of an application directed to street art, to which the answer was very positive.

The fourth phase consisted of gathering data about art pieces, which consisted of sending interviews to artists, taking graffiti tours and doing research about artworks displayed in Antwerp and Coimbra.

The fifth step was dedicated to the planning and development of the application. In order to have the best results, it started by choosing the most appropriate platform to develop the app in, followed by a prototype phase with wireframes to make it user-friendly and to satisfy the user's needs. After this being defined, the subsequent step was to start implementing the application.

In the sixth phase, tests were conducted to users in order to understand how the application would work with



real people, detecting errors and improving some features.

Some of these steps were conducted simultaneously whenever it was required to modify certain aspects but in an organized way.

## 2.2. Objectives

The goal of this dissertation is to develop an application able to scan artworks through augmented reality, bringing up supporting media and information to the user, thus promoting this art movement with an alternative visit experience. It is expected that this application will eliminate the problems mentioned in the Motivation section (1.1.), by displaying information regarding artworks alongside animation, presenting more street art locations and as a “memory bank” to collect art pieces that are disappearing. The success of this project will be defined by the fulfillment of the following goals:

### **Collection and gathering of suitable data do display**

The artworks collected are from Coimbra and Antwerp, as the project is initially being developed to cover these two cities. Both of them are different examples of locations where this project can be applied, since the street art movement in Coimbra is still in the beginning, unlike Antwerp, which has a big variety of artworks scattered around. Consequently, this contrast gives strength to the fact that the application can be applied worldwide, as long as there is street art involved.

### **Create artifacts by animating artworks**

The primary focus of the application is to inform the user about the world of street art. In order to have an additional captivating aspect besides the augmented reality feature, the animation of artworks is expected to create an even more enjoyable and engaging environment.

### **Apply techniques of augmented reality understandable by the user**

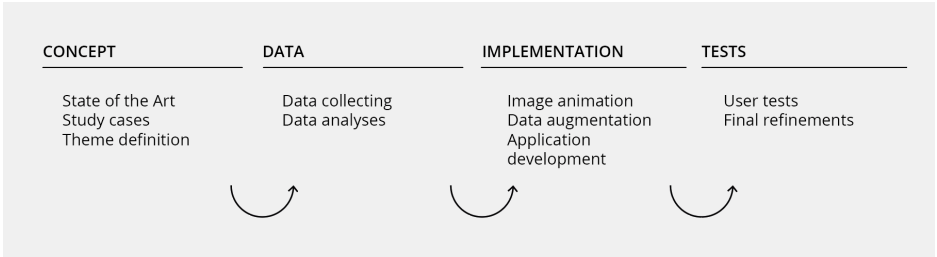
Augmented reality is still a new technology for the majority of users. In order for the application to succeed, it is necessary to implement an interface with a familiar environment so that there is no hesitation from the user when dealing with this technology. Therefore, avoiding a complex and ambiguous interface saves the user time understanding how the application works.

### **Develop an application that satisfies the users' needs.**

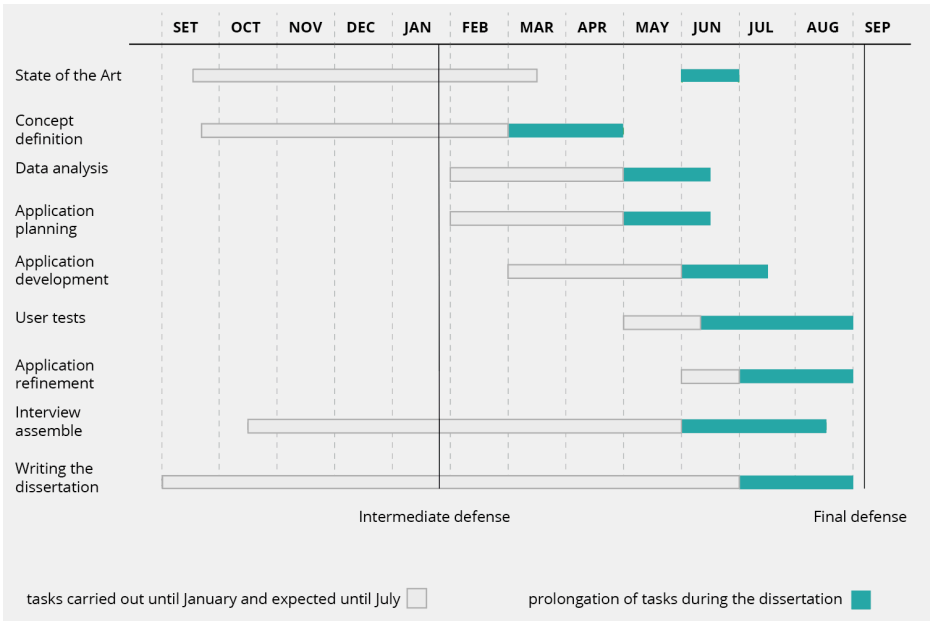
To ensure the success of the application, it is necessary to meet the needs of the users, providing the kind of information they want, and the one they do not even know they need. As a consequence, this generates a surprising feeling and captivates them into using the application more than once.

## 2.3. Process and Work Plan

Defining a process (Fig. 1) and work plan (Fig. 2) enables tasks to be stated, divided, and organized in order to be completed within their agreed time frame.



**Figure 1.** Representative scheme of the work process



**Figure 2.** Representative schedule of task planning

The project began in the first semester, by starting to do research on augmented reality. This first phase was fundamental for the definition of the topic to be explored and allowed for a better understanding of the subject. During this investigation process, the concept and final objectives of the proposal were defined.

The writing of the dissertation focused on documenting the study, conclusions and similar projects, presenting a small contextualization regarding AR, its characteristics and perceptions, and its role and development throughout the last twenty years. This study allowed for a better understanding of how augmented reality has been explored in several fields and the benefits it has brought to areas such as medicine, construction, education, among others.

Alongside with the writing, the features for the application started to be outlined, which served as a basis to create wireframes.

In October, several Portuguese artists were contacted to answer a questionnaire about street art in Portugal and its evolution, whose answers can be read in the Appendix.

The work in the second semester focused on implementing the application, where there was previous research about the most suitable technology to adopt, as well as filtering and analyzing the data concerning the selected artworks.

There was an additional study about integration and contribution of AR to arts and cultural heritage environments, analyzing the existing techniques used in their design.

In February, artists from Belgium were contacted to answer the same questionnaire sent to the Portuguese

artists. These answers were very important to understand their point of view and to compare both realities.

Additionally, the artists' answers resulted in another key feature to be included in the application: the memory bank, which means storing in the database not only artworks that are currently in perfect conditions but also those that were damaged due to their ephemerality. This process was extensive according to the answering time of each artist, which is still being updated with more answers.

As a final phase, there was an evaluation of the application by users external to the project to understand the effectiveness of the information displayed and to do the final refinements.

The writing of the dissertation occurred simultaneously with the implementation to report the evolution of the work and to draw conclusions.







# 3. State of the Art

This chapter overviews the augmented reality area by introducing the topic and briefly presenting its history to understand the origin and evolution of this technology.

Additionally, the features of an augmented reality system are explained, as well as technologies, challenges and open issues of AR, where different techniques are outlined. Moreover, it is explored how this technology has been integrating different areas such as Medicine, Military and Education.

Finally, a series of five projects regarding the combination of art with AR is presented to understand the influence and impact this technology has had in this area.

The current techniques are analyzed, allowing for validation of the proposed project, ensuring that it addresses the need of future users.

# 3.1. Introduction

Nowadays, significant technological advances made it possible to extend our senses, allowing us to see more than what others can see, hear what others cannot hear or even touch what others cannot touch (Van Krevelen & Poelman, 2010).

Augmented reality is a technology that once could only be seen in movies and television series. An early example is Terminator (1984), in which the main character’s field of vision is complemented with additional data about the people and objects he sees (Fig. 3). Another example is Black Mirror (2016), in which the characters can rate people they interact with and see their social status or play games with augmented figures (Figs. 4 and 5). However, augmented reality is gradually becoming a part of our lives.

Augmented reality is a computer-generated experience that connects and integrates elements of the real world with virtual objects and data. As a result, the real environment is enhanced for users to perceive additional information in real-time (Van Krevelen & Poelman, 2010).



Figure 3: Terminator (1984), character analyzing if the clothing size would fit him<sup>3</sup>



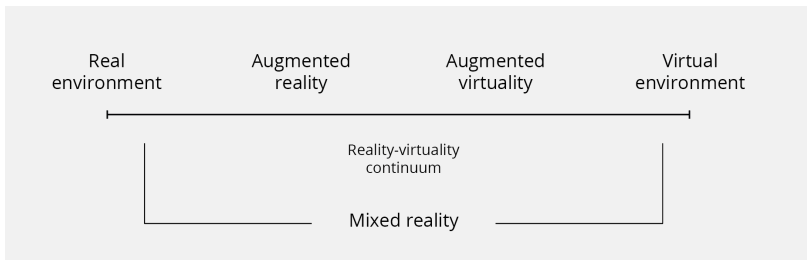
**Figure 4:** Black Mirror (2016), season 3, episode 1 – “Nosedive”. This episode is about a world where people rate others everytime they interact, having an impact on their socioeconomic status.<sup>4</sup>



**Figure 5:** Black Mirror (2016), season 3, episode 2 – “Playtest”. This episode tells the story of a man who accepts a job offer from a video game company called SaitoGemu.<sup>5</sup>

Augmented reality is a term quite often mistaken for virtual reality. In the latter case, the computer generates a whole simulated environment and the user is completely immersed in a virtual world, while the former combines both real and digital content, making them appear to coexist in the same space (Samini, 2018). An important aspect to highlight is the fact that it is not only about displaying information but integrating it to a user’s perception and, therefore, creating an immersive experience. For this reason, it can also be defined by the terms of *mixed reality* or *computer-mediated reality* (Azuma,1997).

The reality-virtuality continuum is a concept proposed by Milgram and Kishino (1994) that relates the objects we see in the real world and the ones we see in digital simulations (Fig. 6).



**Figure 6:** Reality-virtuality continuum (Milgram & Kishino,1994)

According to Fig. 6, mixed reality is the part of the spectrum where there is a combination of the virtual and the real environment, where each one lies in opposite sides of the continuum.

Augmented reality is one section of the area of mixed reality on the reality-virtuality continuum. On the left side of the spectrum, containing virtual environments (also known as virtual reality) and augmented virtuality, real objects are added to virtual ones, substituting the real environment for a virtual one.

## 3.2. Brief History

The work of Ivan Sutherland (1968) defined the beginnings of augmented reality (AR) by creating the first AR prototypes using a Head Mounted Display that showed 3D graphics. During the 1970s and 1980s, this research was continued by a small group of researchers at U.S. Air Force’s Armstrong Laboratory, the NASA Ames Research Center, the Massachusetts Institute of Technology, and the University of North Carolina at Chapel Hill (Van Krevelen & Poelman, 2010).

However, augmented reality has only been recognized as a research field over the past decade. Azuma (1997) published a survey defining the field, describing problems found and summarizing the evolution it had up to that point. As a consequence, AR growth and advances have been outstanding since then. Several conferences related to AR began in the late 1990s, in particular, the International Workshop and Symposium on Augmented Reality, the Designing Augmented Reality Environments Workshop and the International Symposium on Mixed Reality.

### **3.3. An Augmented Reality System**

According to Azuma (1997), three main characteristics define an augmented reality system:

- combination of real and virtual content in a real environment;
- real-time interaction;
- 3D registration of the virtual content in the real environment.

AR systems can track and render virtual objects onto the real world, according to the position of the camera, enhancing it with additional information. In order to make this possible, markers have to be placed in certain objects/areas of the real environment to activate the combination of real and virtual, through pattern recognition and computer vision techniques (Kato, Hirokazu & Billinghurst, Mark, 1999) (Fig. 7).

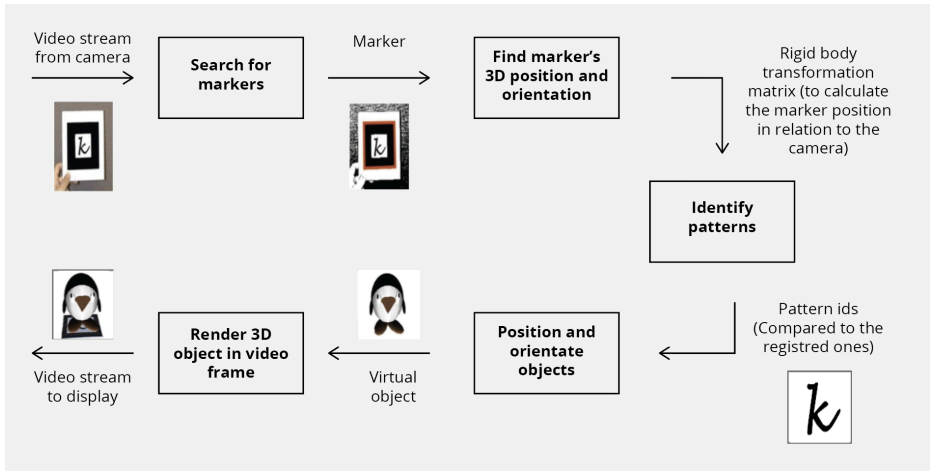


Figure 7: Augmented reality system<sup>6</sup>

Augmented reality is usually associated with adding objects to the real environment; however, it can also remove, replacing them with virtual objects. This is called diminished reality, which is considered a subset of AR (Azuma, 1997). For instance, to remove a chair from the real environment, the system would have to draw a representation of the room (floor and walls) and “paint” them over the chair to eliminate it from the user’s sight.

In addition to the sight, augmented reality can be applied to more senses, such as hearing, touch and smell. For hearing, the user would have headphones, adding synthetic, directional 3D sound, and a directional microphone that would detect the environment noises (Azuma, 1997).

Regarding data density, in order not to clutter the real environment with large amounts of information, making it unreadable and confusing, there has to be a focus on the purpose of the user while using the application. An important aspect that should be kept in consideration is that the real world should not be changed, taking into account the relevance of each element and position of the user that will determine what should be shown. Additionally, it has to be assured that the virtual information is not overshadowing other important elements of the environment.

## **3.4. Technologies, Challenges and Open Issues**

Although the majority of the main AR survey papers mention the major problems affecting this technology are tracking and interaction, Azuma (1997) considered that the registration and sensing errors are the primary problems, which are the basis for the recent problems (Rabbi & Ullah, 2013; Zhou, Duh & Billingham, 2008; Krevelen & Poelman, 2010; Kim, Kang, Choi, Choi & Hong, 2017). Registration refers to the proper alignment of the objects in the real and virtual environments to each other, and sensing errors consist of correctly detecting the location of the objects. Two types of registration errors were differentiated by Azuma: static and dynamic.

Static errors occur by tracking-system errors, optical distortion, incorrect viewing parameters, even though the target objects and the user's viewpoint are in a fixed position.

In the second case, dynamic errors occur due to delays caused by the system. These delays are a result of the difference between the instant the tracking system calculates the position and orientation of the viewpoint and the moment the image corresponding to that position and orientation is presented. Delays related to communication, tracking and scene-generation time contribute to an end-to-end systemic delay, causing dynamic registration errors when motion occurs.

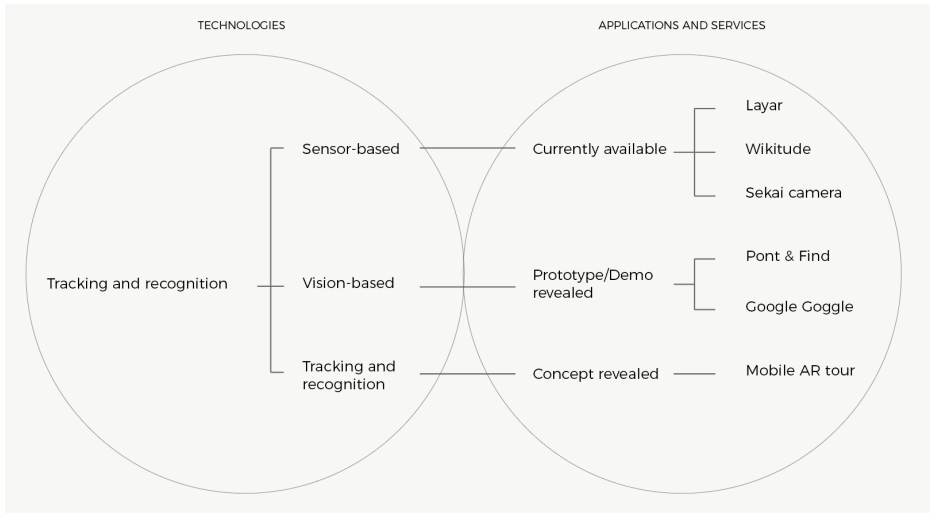
Azuma (1997) observed that registration errors were far from being solved since an accurate registration of virtual objects in the real world requires precise tracking of the viewpoint and correctly locating the target objects.

### **3.4.1. AR categorization based on the tracking type**

One of the most relevant characteristics of an AR experience is tracking. This technology is continually used for locating the position and orientation of objects in the real environment to link and integrate virtual ones into the real world (Kim, Kang, Choi, Choi, & Hong, 2017).

Tracking technologies can be divided into three groups: sensor-based, vision-based and hybrid approaches (Rabbi & Ullah, 2013; Zhou, Duh & Billingham, 2008) (Fig. 8).





**Figure 8:** Mobile-AR process from the technologies to the applications (Kim et al., 2017)

### 3.4.1.1. Sensor-based approaches

Sensor-based approaches can be divided into four groups: acoustic tracking, magnetic tracking, optical tracking and inertial tracking (Kim et al, 2017).

- Optical tracking consists of a 3D-localization technology that monitors, with the use of two or more cameras, a specific measurement space. With this technology, it is possible to track several objects simultaneously.
- Magnetic tracking, when applied to AR, the magnetic-tracker transmitter plays the role of the origin of the virtual coordinate system. By mounting a receiver to the user, its position and orientation are calculated.
- Acoustic tracking, where the tracker measures the amount of time it takes for an acoustic signal to arrive to several receivers.

- Inertial tracking, which measures the linear acceleration, through an accelerometer, and the angular velocity with a gyroscope.

**Table 1:** Sensor-based tracking characteristics (Rabbi et al., 2013)

Sensor-based Tracking	Accuracy	Sensitivity	Cost	Advantages	Disadvantages
Optical Sensors	Accurate	Light	Cheaper	High update rate, better resolution	Effect with optical noise, occlusion
Magnetic Sensors	Less Accurate	Electronic devices, Electromagnetic noise	Cheaper	No occlusion problem, high update rate	Small, working volume, distance affects the accuracy
Acoustic Sensors	Less Accurate	Temperature, Humidity, Pressure	Cheaper	Slow, small, light, no distortion	Occlusion and ultrasonic noise
Inertial Sensors	Accurate	Friction	Cheaper	No reference needed, no prepared environment needed	Due to small friction-conservation error
Hybrid Techniques	Accurate	Depends on what sensor is used	Costly	Compat, accurate, stable	Depends on sensor that is used

### 3.4.1.2. Vision-based approaches

Vision-based approaches determine the camera position through optical-sensor data and can be separated into three groups: infrared sensor, visible-light sensor and 3D structure sensor. Another widespread technique is vision-based tracking where the camera is the only requirement. In this case, image-analysis methods are used to calculate the camera position relative to the objects in the real

environment, and they can be divided into two groups: marker-based tracking and markerless tracking. In the beginning, fiducial markers were used but recent approaches have been using the markerless method.

As for the markerless tracking, the feature edges and/or points are detected to read the camera images. These values are inserted in a multi-dimensional vector to represent the extracted features and for the calculated camera position. The camera position is estimated by model-based methods using models of the tracked-object features or templates. It is defined as a relation between the 2D image and the 3D world frame and, when there is a match, the camera position is estimated by projecting the 3D features into the 2D image plane and by minimizing the distance between the 2D and corresponding 3D feature coordinates (Rabbi et al., 2013; Kim et al., 2017).

### **3.4.1.3. Hybrid-based approaches**

On hybrid-based approaches, data is collected from multiple sensors, enhancing the accuracy and weaknesses of the sensors individually. One of the goals of hybrid systems is the reduction of the disadvantages of the vision-based approaches but, although it provides a stable tracking system, its development remains difficult. However, it provides sound solutions even though increases the tracking complexity, so it suffers from the limitations of each sensor-tracking system (Zhou et al., 2008).

Sensor-based tracking and vision-based tracking are combined to compensate for the limitations of each method, representing the most promising technique for AR applications used indoor and outdoor (Kim et al., 2017).

## 3.4.2. Hardware Platforms

The integration's efficiency of software and hardware platforms with the real world is a key issue of the AR systems. Augmented reality hardware platforms include devices such as computers with webcams, smartphones and tablets, glasses and haptic devices.

### 3.4.2.1. Computer Webcams

With computer webcams, a marker is placed within the camera range of view, showing a live feed. An example is the touch-sensitive screen of Shiseido Makeup Mirror, where the users can pick from selections of the lip and eye colors and blushers to preview how would they look like with the product before buying it<sup>7</sup>(Fig. 9). The kiosk is another example of a PC-based AR that allows users to discover more about a certain item, more specifically, in the “Lego Store kiosk”, where the customer can see the display of a complete Lego set depending on the box they chose (Fig. 10).



Figure 9: Shiseido Makeup Mirror<sup>8</sup>



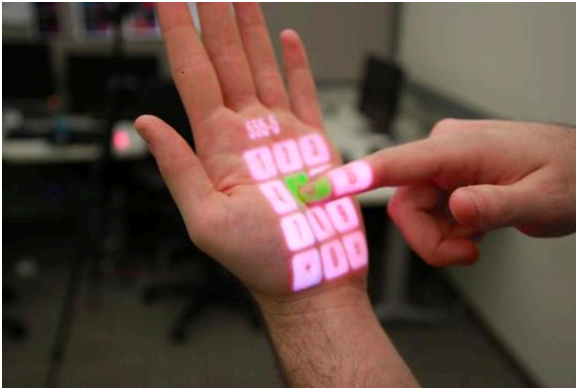
Figure 10: Lego Store Kiosk<sup>9</sup>

### 3.4.2.2. Smartphones and Tablets

Smartphones and tablets are the most popular method to access AR content, and can be divided into two categories: ubiquitous and constantly-held. In the ubiquitous category, an example of an application is Wikitude World Browser where, based on the Web plug-in, the information is continuously displayed with real-world images (Fig. 11). Representing a constantly-held example, the Microsoft omniTouch consists of a wearable computer, a camera with a depth sensor and a projection system for interaction with everyday surfaces (Fig. 12).



Figure 11: Wikitude World Browser<sup>10</sup>



**Figure 12:**  
Microsoft's  
OmniTouch<sup>11</sup>

### **3.4.2.3. Head-Mounted Display**

Head-Mounted Display (HMD) contains a headset with augmented images and information placed onto the user's point of view according to their head movement in any angle or direction. An example of this device is the Skullly Helmet, being the first helmet to feature a 180° Blindspot Camera and a Heads-Up Display promoting a safer usage (Fig. 13).

Another example is the Microsoft HoloLens that allows users to visualize 3D models and interact with digital content and holograms in the real world in real-time. This is possible as it contains multiple sensors, advanced optics and a custom-holographic-processing unit (Fig. 14) (Statt, 2015, Samini; 2018).

Head-Mounted Displays offer a range of applications yet to be explored, such as navigation maps and visualization of past and future environments. Navigation maps will be a way to orientate users outdoors. These users could be either soldiers advancing towards their target, tourists seeking a certain location, or even hikers lost in the woods. Nowadays, these users would get help from a GPS

(and not always this option is available) or searching in their 2D map to guide themselves, associating what they see with the real environment. If the landmarks are not easily spotted, their efforts can become hopeless in this difficult task. With this augmented reality system, and knowing the user's position and orientation, it displays into its point of view the map in 3D with overlaid information related to a mountain, such as name, height, distance, and possible trails around (Kim et al., 2017).



**Figure 13:**  
Skully Helmet<sup>12</sup>



**Figure 14:**  
Microsoft  
HoloLens<sup>13</sup>

### 3.4.2.4. Glasses

Another ascending AR platform is AR-glasses. Although is still an uncommon technology, it is predicted that AR-enabled glasses will become a part of our everyday life such as smartphones, giving the wearer an AR feed continuously according to its individual needs and preferences. Google Glass is the most famous AR-glasses (Fig.15), but there are similar products available for purchase made by Vuzix (Fig. 16). It is estimated that, over time, this technology will be improved and the prices reduced, making them available to a larger community. Ather One smart glasses is another example of an AR-glasses product that promotes a natural interaction as the users can use hand gestures to control it (Fig. 17). This technology consists of two displays for each eye, providing landscape-oriented images directly onto the human eye. Near-to-eye pictures are integrated with distant objects in the same view, and an antenna for wireless communication, seeming that AR content is floating in front of the users eyes (Kim et al., 2017).



**Figure 15:**  
Google Glass<sup>14</sup>





Figure 16: Vuzix<sup>15</sup>



Figure 17:  
Atheer One<sup>16</sup>

### 3.4.2.5. Haptic AR

Haptic AR gives the user the possibility to experience a real environment that is augmented with haptic instructions. To exemplify this case, there is Nintendo Wii U, PS4 and Xbox that give tactile feedback to the user in real-time. If an HMD is combined with the Phantom Stylus (Fig. 18), it is possible for the user to touch and feel the objects that are being visualized.

Another case, when a Virtual Haptic Back system is combined with Phantom Stylus, a surgeon can see the whole body and receive tactile feedback while performing surgery (Kim et al., 2017).



Figure 18: Phantom Stylus<sup>17</sup>

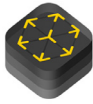
### 3.4.3. Software Frameworks

In the Hardware Platform section, several software frameworks since the most recent ones support multiple platforms, and the framework selection is according to the hardware dependencies. This section is dedicated to exploring AR frameworks, examples of usage and a final comparison of all the platforms.

#### 3.4.3.1. ARKit

Released in 2017, ARKit (Fig. 19) is a Software-Development Kit (SDK) to create augmented reality applications and games directed to iOS products. This SDK supports 2D image detection, triggering AR with images, posters or signs, with the possibility of embedding objects into AR experiences, though it requires iOS 11 or 12<sup>18</sup>.

An example of an application created with ARKit is the IKEA Place app, which users can insert virtual furniture items true to scale in a real space to preview how will it look like.



**ARKit 3**

**Figure 19:**  
ARKit 3  
lototype<sup>19</sup>

Pricing: Free / \$99 annual developer program for distribution<sup>18</sup>

### **3.4.3.2. ARCore**

Google released ARCore (Fig.20), its own AR technology platform, supporting both Android and iOS devices. This SDK has three main capabilities that make it possible to merge the real and virtual worlds:

- Motion tracking - tracking the position of the user's device relative to the surroundings;
- Environmental understanding - detecting the location and size of surfaces.
- Light estimation - estimating the real-life lighting situation.

An example of an application created with ARCore is Just A Line, where allows users to make simple drawings in augmented reality, then share their creations with a short video<sup>18</sup>.



**ARCore**

**Figure 20:**  
ARCore  
logotype<sup>20</sup>

Pricing: Free

### 3.4.3.3. Vuforia

Vuforia (Fig. 21) is one of the most popular platforms for augmented reality development, supported by Android, iOS, UWP (Universal Windows Platform) and Unity<sup>18</sup>

It includes functionalities such as recognition of text, objects, shapes, among others, with the possibility to scan and create object targets with a recognition process alongside a database stored locally or in the cloud (Amin & Govilkar, 2015). These targets are created with the Vuforia Target Manager, using PNG or JPG images until the size of 2 MB. When an image is uploaded to the Vuforia Target Manager, it is processed and evaluated. During this step, its features are extracted and stored in a database, which can after be downloaded and packaged alongside the application. Afterwards, images are ready to be detected and tracked by scanning their features and comparing them to the targets included in the database. Once it is detected, Vuforia Engine will follow the image while it is at least partially in the camera's visual field<sup>21</sup>.



Figure 21:  
Vuforia  
logotype<sup>22</sup>

Pricing: Basic license previously free, and currently costs \$504 annually since May 2019

### 3.4.3.4. Wikitude

Operating since 2008, Wikitude (Fig. 22) is a universal SDK that is encouraging brands to build complex in-depth projects. This SDK is not only directed to mobile app development but it can also be used in Smart Glasses or Unity Games<sup>22</sup>. Wikitude's technology is capable of recognizing and tracking objects and images, 3D markerless tracking, supporting ARKit and ARCore.

This SDK is constantly being updated and improved, adding more functional features such as scene recognition making capable of augmenting large objects for outdoor gaming, construction and so on.<sup>18</sup>



Figure 22:  
Wikitude  
logotype<sup>23</sup>

Pricing: Free trial/1990€.

### 3.4.3.5. ARToolKit

Supported by Android, iOS, Linux, Smart Glasses, among others, ARToolKit(Fig. 23) is an open-source tracking library for AR. This technology uses video tracking abilities that trace square marker patterns by a single-camera position and orientation. When the camera position is known, 3D models are overlaid on the marker. (Amin & Govilkar, 2015)<sup>18</sup>.



Figure 23:  
ARToolKit  
logotype<sup>24</sup>

Pricing: Free.

### 3.4.3.6. OpenCV

Open Computer Vision library, also known as OpenCV(Fig. 24), was created by Intel and is now an open-source project, available for all major operating systems, including Windows, iOS, and Unix. Its functionalities consist in image processing, visual analysis, machine learning, and motion detection, and is kept under consistent development<sup>22</sup>.



Figure 24:  
OpenCV  
logotype<sup>25</sup>

Pricing: Free.

### **3.4.4. Application Domains**

Augmented reality has been widely spread in several fields, combining real and virtual worlds. This section describes the many areas which AR improved and, although it does not cover every potential application of this technology, it refers to six areas that have been explored so far: medicine, manufacturing and repair, annotation and visualization, robotics, entertainment and military aircraft.

#### **3.4.4.1. Medicine and Surgery**

Medicine and surgery are areas that can benefit from augmented reality, providing physicians, surgeons and other healthcare practitioners with virtual information to be used as guidance and to support with valuable information during tasks such as surgeries and diagnoses.

Surgical training with AR can improve the operation procedure by giving instructions about the required steps, allowing the surgeon to have complete focus of the task instead of looking away to consult the manual. These instructions can either be the identification of the organs and specific anatomy locations displayed, thus resulting in better learning methods (Azuma, 1997; Kim et al., 2017).

With the advances of technology, the use of biomedical imaging sensors combined, such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT) scans or ultrasound imaging, give the surgeon the possibility to inspect the inside of a patient in real-time, without having to undergo into a surgical procedure. This results in a more accurate diagnosis and the physical impact of the patient is minimized since the surgeon will

make less invasive surgeries through small incisions. Minimally-invasive techniques are usually difficult surgeries since the surgeons internal view of the patient is conditioned. By integrating AR technology it could provide a better performance without needing larger incisions and consequently reducing the trauma of several operations (Azuma, 1997).

AR can be helpful in several medical visualizations, guiding surgeons and physicians into tasks which involve precision, for instance, drilling a hole into a skull for brain surgery, or position a needle biopsy of a small sized tumor (Fig.19). Using the non-invasive sensors would allow this information to be displayed directly on the patient, showing exactly where to perform (Azuma, 1997).

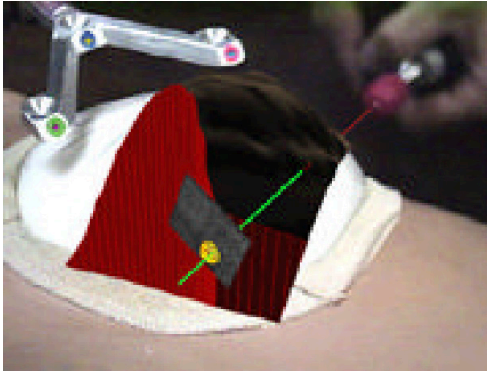
AR can be helpful in several medical visualizations, guiding surgeons and physicians into tasks that involve precision, for instance, drilling a hole into a skull for brain surgery, or position a needle biopsy of a small-sized tumor (Fig. 25). Using the non-invasive sensors would allow this information to be displayed directly on the patient, showing exactly where to perform (Azuma, 1997).

AV400 Vein Viewing System involves a handheld scanner that projects onto the skin the location of the patient's veins (Fig. 26). This kind of procedure is often done to take blood samples or to inject serum, and it's 3.5 times more likely for the nurse to precisely find a vein during the first injection attempt (Kim et al., 2017).

A research group at the University of North Carolina - Chapel Hill, through an ultrasound sensor, was able to scan the womb of a pregnant woman. This resulted in a 3D representation of the fetus inside the womb displayed in a see-through HMD. The purpose of this



application is to build a 3D stethoscope, allowing the obstetrician to see the fetus inside, moving and kicking (Azuma, 1997).



**Figure 25:** Mockup of breast tumor biopsy with 3D graphics guide needle insertion (Azuma, 1997)



**Figure 26:** Vein Viewing System (Kim et al., 2017)

### 3.4.4.2. Construction and Robotics

A big advantage of augmented reality is the ability to give instructions without the person losing the focus of the task that is being performed. To repair complex machinery, AR can superimpose animated 3D drawings of the equipment, displaying a step-by-step guide, rather than explaining it through a manual through text and picture (Azuma, 1997).

BIMEvoke developed the 3D Guided Maintenance application, supporting engineers when repairing pumps. This application assists the person with a certain function by displaying 3D images with information about the tools and illustrates the exact motion that is needed to be done to perform the task (Kim et al., 2017).

The carmaker Hyundai introduced a virtual guide in the format of an interactive manual where AR is used to show how the components of the dashboard and engine area are used, guiding the user to fix minor car-repair issues (Fig. 27) (Kim et al., 2017).

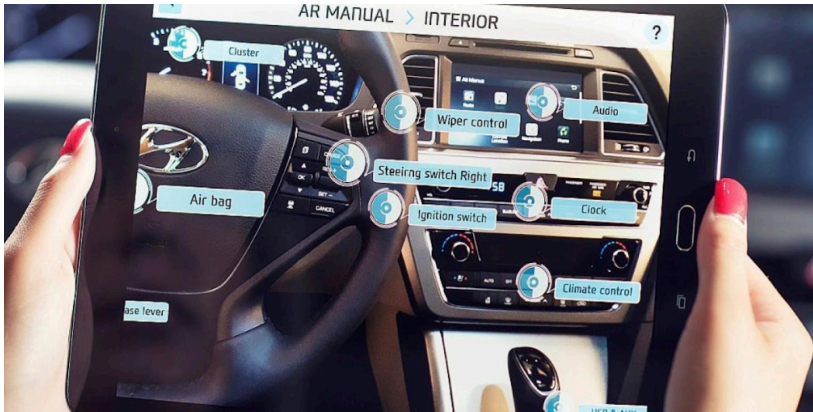
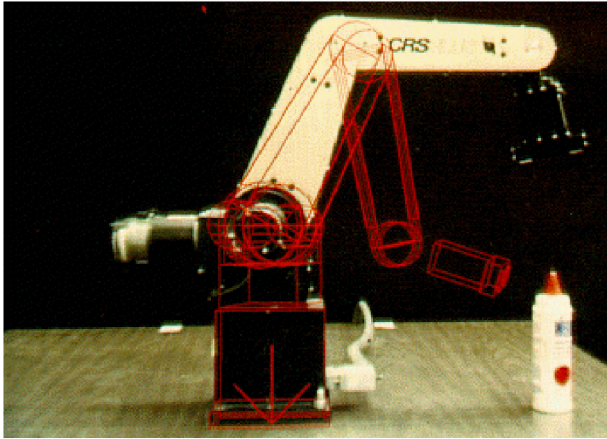


Figure 27: Hyundai Virtual Guide<sup>26</sup>

Augmented Reality can be also used to provide information about objects such as displaying information about the content of books and shelves in a library. This type of visualization techniques can be used where a person could see the name of parts of an engine model by pointing at them with a device (Azuma, 1997).

In architecture, if a database contains information about a building's structure, AR can help visualize and plan the representation by displaying the pipes, electric lines and structural support inside walls, making images easier to understand during difficult points of view or poor visibility conditions such as underwater or in foggy weather (Kim et al., 2017).

Operating a robot can be a challenging task, especially when it is done remotely, as there are delays in communication. The role of augmented reality for the solution of this problem would be controlling a virtual version of the same robot instead of manipulating its actions directly on the real one. After previewing the outcome through some tests and planning, the user can instruct the real robot to execute the given task. By having a virtual version, it can also prevent miscalculations caused by delays in communication and for the user to be one step ahead of inconveniences when the robot performs the task (Fig.28) (Azuma, 1997).



**Figure 28:** Motion of a robot arm previewed through red lines (Azuma, 1997)

### **3.4.4.3. Entertainment and Commerce**

From concerts to the cinema, there has been a big integration of AR systems to provide effects where 3D virtual objects are completely immersed in the real-world.

Actors can now be integrated into virtual sets, where they are merged in 3D virtual backgrounds in real-time. With the actor's actions previously scripted, they stand in front of a large blue screen, while a computer-controlled motion camera is recording the scene. Afterward, this data is combined, resulting in a 3D background. Instead of having to build new physical sets from scratch for each movie, the introduction of augmented reality in the entertainment industry is able to reduce production costs by creating those same sets virtually (Azuma, 1997).

To promote the 2014 movie “Into the Storm”, augmented reality brought the storm to the streets of Sydney. A panel was converted into a window where pedestrians could see a virtual storm filled with thunder striking buildings and cars dragged with the strong wind (Fig. 29) (Kim et al., 2017).



Figure 29: “Into the Storm”, 2014<sup>27</sup>

Augmented reality has also been invading the gaming section, expanding it to the real world. “Pokemon GO” is a prime example of AR-based games (Fig. 30). Developed by Niantic in collaboration with Nintendo, this game had a huge impact on AR games implemented on smartphones because of its enormous success around the world. Using a GPS system to track the user’s location, the purpose of the game is to catch Pókemon characters, displayed through AR, in the real world locations, competing with the other players. This game was not only innovative and fun, but it also brought a huge amount of people together to the streets with a common goal (Kim et al., 2017).

AR has become a significant trend to enhance the previews of virtually-created 3D products. With this technology, it is possible for consumers to preview real-life products such as furniture and clothing, linking the gap between real and virtual worlds. The Swedish furniture company IKEA has introduced a smartphone catalog using an AR application where users can select products to preview how would it look in their homes. This was a solution to problems related to furniture returns due to purchases of incorrect sized-pieces for intended locations (Samini, 2018).

EZface Inc also introduced an AR application where users can try their make-up products virtually without having to use real make-up.

Regarding advertisement for the Christmas holiday season, the coffee house chain Starbucks released an AR smartphone application called Starbucks Cup Magic (Fig.31). By pointing the camera of the device to a red Starbucks holiday-season coffee cup, the customer can see interactive animations featuring several characters (Kim et al., 2017).



**Figure 30:** Pokemon GO, 2016<sup>1</sup>



**Figure 31:** Starbucks Cup Magic, 2011<sup>28</sup>

#### **3.4.4.4. Navigation and Tourism**

Augmented reality is becoming an essential technology for travelers. As modern smartphones are extremely useful devices as users can use the GPS to determine routes, many manufacturers have inserted into their vehicles heads-up displays that project into the windshield data such as speed and turn-by-turn directions (Swan & Gabbard, n.d.).

Varia Vision is a device developed mainly for cyclists, where the cyclist's sunglasses have integrated an AR display of turn-by-turn directions. Also, it has the feature of a rearview radar that alerts the user about cars approaching from behind (Fig. 33)(Kim et al., 2017).

AR technology can also assist people with information that will be used during a trip, providing quick and easy access to trip-related information such as real-time weather forecasts, reviews of nearby locations and translations of foreign signs or menus. The Metro AR Pro is an application that identifies the city where the user is in and presents a list of the closest metro and subway stations with the camera view. Another example is the Yelp Monocle that, based on the direction the smartphone camera is pointing at, gives the possibility for the user to see nearby businesses information, such as name and reviews (Fig. 32). Additionally, translation supported by Google Translator is available and converts automatically foreign-language text framed in the camera into the user's native language (Kim et al., 2017).



Figure 32: Yelp Monocle<sup>29</sup>

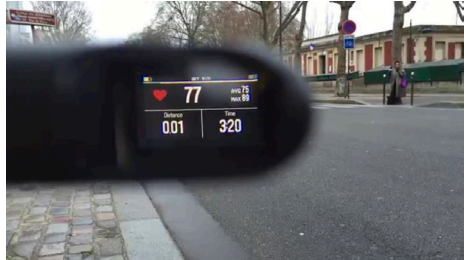


Figure 33: Varia Vision<sup>30</sup>

### 3.4.4.5. Military aircraft

Augmented reality is already been inserted in the military aircraft field with Head-Up Displays (HUDs) and Helmet-Mounted Sights (HMS) that display vector graphics onto the pilot's point of view. Not only this system provides flight and basic navigation information, it also provides help on handling the aircraft's weapons by registering and displaying possible targets in the environment (Azuma, 1997).

### 3.4.4.6. Education

The use of augmented reality integrated in schools encourages the creative expression and elaboration of the acquired knowledge. Different researches have focused on studying the importance and relevance that augmented reality can have in educational contexts, more specifically, when introduced in schools and museums. By establishing a relationship between augmented reality and education, sets out an innovative research field.



Augmented reality is an active technology, giving students a better understanding based on interactions with virtual objects that bring data to life. This interactivity and immersive experience allows better learning and assessment.

Currently, there are two main applications being used in different school contexts: Quiver and Aurasma. Quiver is an application directed mainly to primary schools which, once downloaded, provides coloring pages that are scanned through the mobile camera and animates the objects, animals or other colored images. Aurasma, on the other hand, starts with a framed picture that will work as a trigger image of an overlay. It can be overlaid by other images, videos, websites or 3D objects, and offers several possibilities such as supporting classes with the possibility of adding multimedia content (Panciroli, Macaуда & Russo, 2018).

Devin Smith from the Department of Educational Technology of Arizona University carried out a study concerning augmented reality in art education in order to determine the impact of augmented didactic activities related to art education. This study involved 60 students from third to tenth grade, where the younger used the application Quiver and the older used Aurasma and were submitted to activities concerning art education and art history. Once they were finished, their opinions were collected by a ten-question survey. Results showed that the younger students had already experienced augmented reality before, through Pokemon GO, considering an application with this kind of technology directed to art very amusing. The majority of the answers revealed that the students enjoyed this approach to learning so much that they wanted to continue using it.

The feedback taken from this survey was very positive since “people got to see the process”, concluding that AR inserted in schools gives the possibility to students to share what they are learning in many ways and explore their imagination with a cognitive growth (Panciroli et al, 2018).

## **3.5. Case Studies**

This section presents a number of projects that use augmented reality to display information, in an exhibition-related context. In addition to projects where augmented reality is used to animate artwork and that are more related to the purpose of this dissertation, other projects are also analyzed that do not present a direct relation with the dissertation, but which nevertheless serve as a study of approaches carried out in this field.

Spaces assigned for exhibitions of artwork and places of culture are getting transformed into digitally augmented environments through the use of several technological devices. With AR, visitors have an unusual experience as it can assist visits with original drafts, interesting trivia, data which is not ready to be used yet, as a support for the information panels inside the rooms.

### **3.5.1. MeSch Loupe**

This is a project integrated into the Allard Pierson Museum in Amsterdam, Netherlands, in order to document and analyze the impact of digitally enhancing a visit and encouraging a multisensory engagement with the objects displayed.

This experience is inserted in the exhibitions Feint: Illusion in Ancient Greek Art and Eternal Egypt Experience where, through augmented reality, visitors can observe and interact with several collections of artifacts through a provided tablet<sup>31</sup> (Fig. 34).

Results from this experience concluded that despite the unfamiliarity of many users with augmented reality caused issues regarding the unclear use of the device, they are still willing to learn how to use this new system as long as three main usability questions are clear:

#### **1. What does it do?**

Augmented reality can be a mysterious and rather futuristic concept for people who are not familiar with it. When inside the museum, visitors could grab a tablet available but were not aware of what was the next step or what was supposed to be the result of using the device, making them feel uncomfortable and exposed. These doubts and insecurities can cause a huge barrier to the engagement with this experience<sup>31</sup>.

## 2. How does it work?

The intended task that users have to do with the tablet is to point it at an “active” object, thus producing an overlay, which was a concept that was not understandable by everyone. The fact that the interface was unclear led users to disengage from the experience, as it was intimidating for them. On the other hand, having the opportunity to use a technological device they had never used before caused curiosity and willingness to try this new technology<sup>31</sup>.

## 3. Where does it work?

There was an initial struggle with the identification of the places where the device could be used for interaction, so it was provided a booklet with all the active objects and footprints on the floor for guidance<sup>31</sup>.



**Figure 34:** First prototype being used at the *Eternal Egypt Experience* exhibition<sup>32</sup>

In an attempt to improve these results, it was conducted a second trial on which, instead of using a tablet, the technological device was replaced by a smartphone inside a loupe-shaped object (Loupe) (Fig. 35 and 36), using the application Aurasma. This time, for users not to get lost, the artifacts were presented in the application informing the visitors where to go next instead of letting them decide their path and eventually getting confused. Besides, by displaying them in the Loupe, it made easier for users to recognize on which artifacts could they use the device<sup>33</sup>.



**Figure 35:** Loupes available on the museum with instructions of use<sup>34</sup>



**Figure 36:** Loupe<sup>35</sup>

### **3.5.2. ReBlink**

ReBlink consists of an augmented reality application designed for an art exhibition in Toronto, unusually displaying historical paintings. Alex Mayhew, along with his team at Impossible Things, brought this project to life when he noticed that people have a very reduced attention span when appreciating art. This is an issue that affects museums, presumably as a consequence of technology, causing people being stimulated by quick actions and results. However, this can be also a part of the solution.

ReBlink is the application designed to overcome this problem that museums struggle with, which transforms and shapes ten selected classic paintings to the 21st-century reality (Fig. 37 and 38). In this application, the subjects of the paintings are seen acting as if they were alive in today's days, such as holding selfie sticks, using smartphones or even listening to music through their headphones. To complete the scenario, the landscapes surrounding them are also reinterpreted to modern days.

ReBlink can be downloaded to a smartphone or tablet, therefore creating a higher level of engagement from the visitors since it is an intriguing technology connected with a familiar device, resulting in a different and alternative way to visit an art exhibition.

The outcome of having the augmented reality intervention in this art exhibition was extremely positive, attracting a vast number of people, especially young visitors. As the number of visits was increasing remarkably, the museum had to change the exhibition dates which in the beginning were from the 6th of July to the 3rd of December 2017, extending it to April 2018 (Panciroli et al., 2018).



Figure 37: ReBlink example<sup>36</sup>



Figure 38: ReBlink through tablet and smartphone<sup>37</sup>

### 3.5.3. Project CHES

Project CHES (Cultural Heritage Experiences through Socio-personal and Storytelling) is an initiative to integrate digital narratives to enrich museum visits through personalized storytelling. This is possible using information about cultural artifacts to create customized stories that guide visitors through their smartphones with games and augmented reality, thus activating the user's sense of discovery throughout the experience.

For a better understanding about how this project was developed, we will divide the subjects involved in this experience into two groups: the creators who designed the experience and the visitors who use CHES in their devices (Vayanou, M., Katifori, A., Karvounis, M., Kourtis, V., Kyriakidi, M., Roussou, M., ... & Keil, J., 2014; The CHES project. n.d.).

The CHES developers team consists of scriptwriters, curators and museum staff, creating the storytelling process by following four steps:

1) Scripting - the author carefully chooses the main attractions and story concepts, followed by the plot sketching and writing the narrative.

2) Staging - the author selects a set of spots and paths in the museum environment and associates them with the written script.

3) Production - audiovisual materials, games, quizzes and augmented reality applications are produced for the script.

4) Editing - the multimedia set is selected and the montage for the script written.



This experience begins as soon as the visitor steps into the museum environment. The user logs in into the CHES application through his/her device, filling out a short questionnaire that collects his/her preferences and creates a user's profile with personal data and interests.

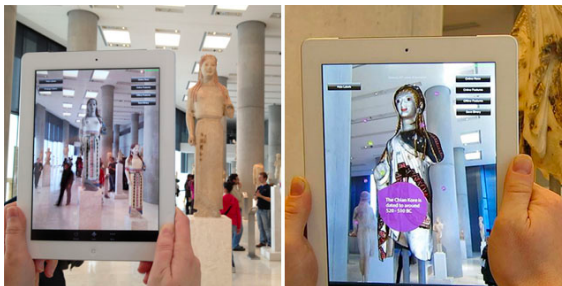
To personalize an experience for each user, CHES uses a persona system that matches visitors to personae by aligning their preferences to the author's understanding of the museum types of visits. This correspondence will consequently create a customized visit, building an individual path according to the person's interests in the fictional story parts. Based on the data inserted on the application, the visit is turned into a discovery game, where the museum artifacts are presented through mixed reality, combining real objects with 3D digital elements (Vayanou, M., Katifori, et al.,2014).

Additionally, CHES profiles can adapt to the user's positive or negative feedback, making adjustments and reshaping the script of the path whenever these actions are detected:

- skipping - which is interpreted as a very negative response to the activity, as the user is not interested in the storytelling;
- completion - meaning low positive feedback. The user completed the storyline but there was no further interest in knowing more details;
- selecting menu options - meaning high positive feedback, where the user is interested in knowing more;
- no menu selections - meaning low negative feedback.

A visit can last from 15 minutes to an hour since there are several and different entities that can be included in the visitor's experience, so the feedback on its own may lead to inaccurate conclusions. For increasing the efficiency of the profiles, it was implemented an explicit feedback dialogue while the user is doing the experience that appears in the menus when certain conditions are met, making it a continuously adaptive system. In the event of one of the users fails in one game or spends quite some time viewing the same artifact, the system can adapt the narrative by turning the experience more dynamic, instead of simply sending the user from point A to point B. Also, if a user is skipping many activities in a row or a specific section he/she showed interest in the initial questionnaire, a menu message is shown asking if he/she disliked that specific section, if he/she is getting tired and wants to shorten the experience or if he/she already knew the upcoming part of the story. (Vayanou, M., Katifori, et al.,2014).

This is an important approach since it requests explicit feedback only when it detects irregularities in the users' actions according to their preferences, minimizing interruptions on the tour.



**Figure 39:** Using a device at to augment artifacts at the Acropole Museum of Athens, Greece<sup>38</sup>

This project reflects a concern to prevent museums to be merely a place where artifacts are exposed, recognizing their background and purpose for being in the museum, that sometimes with the simple observation of the visitor could pass unnoticeable even with a written description next to it. The process of turning these institutions into storytellers through technology by personalizing these experiences provides proximity between the user and the artifact. However, the process of customizing a visit to a museum comes with several profiling challenges such as matching users' interests and preferences according to personae created. (Vayanou, M., Katifori, et al.,2014).

### **3.5.4. ARA COM'ERA, The Ara as it Was**

Built between 13 and 9 BC, honoring the return of Augustus to Rome, Ara Pacis is considered to be one of the most important monuments of ancient Roman art. "ARA COM'ERA", translated "The Ara as it was", is an exhibition that gives the possibility to see the monument as it originally was in the past through special AR visors, merging real and virtual elements directly into the user sight, recovering the original colors of the ancient monument.

This multi-sensorial experience creates an immersive 3D animation that tells the story of the origins of Rome and the Emperor Augustus' family (Fig.40 and 41). It is possible to see the original appearance of Campo Marzio, the area chosen by Augustus to celebrate his power, through virtual elements overlapping the real environment, followed by narration.

Through the course of a decade, the Capitoline Supervisory Body for the Cultural Heritage Department developed this experimental work, aiming to build this hypothetical reconstruction similar to reality through a Samsung GearVR headset fitted with the Samsung S7 smartphones that activate stories when pointed to nine different points of interest. The user embarks into a storytelling experience visiting Campo Marzio, guided by Emperor Augustus, with a 360° filmed view of Ara Pacis as it is today with its original colors, by the combination of live film, 3D reconstructions and computer graphics<sup>39</sup>.



Figure 40: Art piece augmented<sup>40</sup>



Figure 41: Art piece without augmentation<sup>41</sup>

### 3.5.5. Streetmuseum

Brothers and Sisters, an independent advertising agency in the UK, developed Streetmuseum for the Museum of London, an application in which users have the opportunity to explore London with the twist of being able to see how certain places looked like in the past. This application came to life when the museum was searching for a digital idea to attract people into the opening of their new Modern Galleries and since they had an incredible amount of content, they decided to share those collections in the streets.

Streetmuseum guides people to certain locations either by a map or GPS and, once reached the destination, it will recognize and overlay onto the device's camera view buildings and certain spaces with historical photographs or videos, ranging from 1868 to 2003. From Shakespeare to Hitchcock, incredible stories surround the streets of London and this application is a window to the past, revealing how much has changed all over the years. (Figs.41 and 43) (Panciroli et al., 2018) Even though Streetmuseum is only compatible with iPhone, the museum was aiming at a range of 5000 downloads and, not only this number so far reached 500 000, the visitors to the museum tripled.<sup>42</sup>



**Figure 42:** Street-museum showing the Tea Room at Victoria station in 1950. A boy shining shoes and a group of porters with trolleys waiting for travelers to help with their luggage (Zolfagharifard, 2014)



**Figure 43:** Street-museum showing the outside of the Palace Theatre at night before an evening's performance (Zolfagharifard, 2014)

## 3.6. Conclusion

Augmented reality has suffered major changes in the past twenty years, passing from exploratory experiments in controlled lab environments to a large scale technology that supports several interactive applications to public disposal. This expansion is a result of the improvements made in AR's properties such as tracking, registration, display-device and software used, as the technology matured, making the users and applications adopt this technology and allowing them to visualize the world in a different and enriched perspective.

Therefore, AR has become technological support in many areas by helping achieve different tasks. In case of the museum environment, it can support visits and artwork with additional information and consequently provide a better experience.





## 4. Street Art

A revolutionizing art form that is increasing throughout the world is street art, defined as visual art created in public locations, normally outdoors, with an awareness message related to political or social problems.

Street art can be presented in many formats, such as spray paint graffiti, murals, stickers, stencils or wheatpaste poster art and it is starting to become one of the main attractions in several cities, transforming them into open-air art galleries.

Increasingly, this artistic aspect is being detached from the term “vandalism” and there are already several internationally known street art artists receiving numerous invitations to create artworks in several sites.

In this chapter, a brief historical overview of the street art movement will be presented, including a description of the growth, presence and importance of this movement in the city of Antwerp, Belgium, where part of the project was developed.

## 4.1. Early Days

Since the earliest evidence of human creativity until today, art on walls has always been present. From cavemen describing their hunts with drawings to political protests of present days, this art form has been gradually evolving and having a bigger influence in the world as well as a significant role within contemporary art.

The word *graffiti* derives from the Greek word *graphien*, which means *write*, evolving later with Latin to *graphite* that, in Italian, the plural form *graffiti* and means scratching, writing or drawing. When the word is mentioned, there is immediately an association with letters and drawings made on walls with aerosol paint cans (Portelinha, M.,2013).

Around the 1920s, the first evidence of graffiti started appearing with marks which consisted of “tagging”, usually with personalized typography from the artist. During these times, the respect of an artist was based on the level of danger of being caught by the authorities, including restricted areas or higher buildings. As a consequence, there was a stigma related to graffiti since they were seen as a way of vandalism associated with gangs, instead of protests against society’s rules<sup>42</sup>.

However, this artistic expression evolved to criticize social and political issues in society. During World War II, graffiti was used by the Nazi movement to spread their propaganda and their phrases throughout the cities, but it was also very important for groups against this regime as a way of protest. One example is “Weiße Rose”, meaning White Rose, an anti-Nazi movement of the nonviolent German resistance made up of University students, who used graffiti to speak out against the regime of Hitler from 1942 through paintings and slogans on the walls.

This group's members were captured in 1943 and killed. Today, they are still considered heroes and remembered for their high-level interventions and phrases intellectual for that time (Blakemore, 2017).

Around the 1970s the Hip Hop movement was started by Africans and Jamaicans living in the neighborhoods of major cities such as Brooklyn and Bronx in New York, and later in Europe from the outlying neighborhoods of Paris. Alongside with music and dance, graffiti was also an important pillar for affirming, entertaining, and protecting their neighborhoods in large metropolises, used as a marking of territory through symbology and words. This movement resulted in gangs starting to channel the violence in which they lived submerged, and instead competing through art manifestations (Portelinha, M.,2013).

Street art continued to develop, with the constant appearance of new artists with original styles and techniques. Although many people think that this art is fleeting, the truth is that its impact is rising due to the increasing awareness of the practice and respect for this art, and also the support of big brands through their use in campaigns that contribute to putting an end to some prejudices and misconceptions regarding these artists.

## 4.2. Street Art Today

Street art has traveled a long way to become what it is today, shifting from what once was considered an act of vandalism to a celebrated form of creating public art.

Although the movement is still balancing between being legal or illegal, many cities are starting to give commission to artists for them to create murals and display their art pieces of the size of houses and buildings, thus regenerating certain places. Łódź is a Polish city where artists were invited to paint in safe and authorized environments and since 2009 there has been more than 20 large murals placed in the city center as part of a permanent street art exhibition<sup>43</sup> (Fig. 44).



Figure 44: Mural in Łódź, Poland<sup>44</sup>

Street art has the power of not only decorating walls and objects but also of transforming communities. GermanCrew is an artists collective that turned Las Palmitas, Mexico, into a huge and colorful city in order to replace its bad atmosphere and to bring the community together. Before this project came to life, Las Palmitas was an unsafe neighborhood with a bad reputation, where people were discouraged to go at night. After the conclusion of this project, Las Palmitas' became a friendlier place, which contributed to increase the number of visits.<sup>45</sup> (Fig. 45).



**Figure 45:** Before and after of Palmitas

Unfortunately, some artworks are painted in places that can be easily reached, eventually getting painted over by other people and ruining the original piece.

However, as the street art movement grows, some artists become renowned, resulting that each time they create a piece anywhere in the world, their fate is most likely to be protected, whether by the city or by the owner of the wall/building. This is happening due to the touristic and financial value associated with the artist, causing many discussions because, although the artwork is protected from vandalism, it is removed from the streets' walls to be placed

in private collections or to be sold without consent of the artists, changing the purpose of public art<sup>46</sup>.

### **4.3. Street Art in Antwerp, Belgium**

Antwerp is the most populated city in Belgium (approximately 520,000 inhabitants), which not only has numerous museums and art galleries, but also a huge street art influence. Throughout the streets, it is possible to see its open-air art gallery and it is currently considered to be one of the most important European cities of street art and graffiti.

During warmer days, it has events promoting art and graffiti, the largest of which is “Meeting of Styles Belgium” located in the ‘Zomerfabriek’ in Berchem, the street art district in Antwerp, hosted for 20 years and counting with the presence of several international artists<sup>47</sup>.

In 2018, Antwerp paid tribute to one of its most famous painters, Peter Paul Rubens, and his Baroque legacy with a festival called “Antwerp Baroque 2018”, offering a range of exhibitions, events and performances. As part of the festival, the Antwerp artist Yvon Tordoir invited three street artists (Astro, Smug and el Mac) to create large murals in the city center related to the Baroque theme. Figure 46 shows some of the artworks that resulted from this festival. The murals have been available to the public since the beginning of June 2018 and the festival will take place throughout the years 2018 and 2019, combining the opening of the Rubens Experience Center and the re-opening of the Royal Museum of Fine Arts Antwerp in 2019-2020<sup>48</sup>.

With this in consideration, Antwerp was a perfect city for the development of this project. It allowed me to explore plenty of street art murals scattered around town, learn about different techniques and styles of the artworks, getting in contact with people in the artistic field and also applying new work techniques due to the partnership with an artistic institution. Also, the fact of being inserted in an environment in the middle of central Europe made me realize how street art is promoted there, the sites that are chosen, the themes related to the city and the connection it has with the locals.



**Figure 46:** Walls in Prekersstraat, adding a new dimension to the Sint-Andries quarter, made by Parisian artist Astro, whose pieces are characterized by powerful colors and depths, creating optical illusions





# 5. Prototype Design

This chapter introduces the design process and planning of the application, explaining decisions made from the wireframe to the interface identity.

First, it is presented the prototyping phase alongside a study of interaction design.

Next, there is a description of the application's visual identity, explaining the decisions made in order to develop an interface that provides the user with a pleasant experience.

This phase is fundamental while developing an application. By planning the process ahead, it is possible to define the flow of the app as well as to detect and prevent initial issues regarding the interface and its interactivity with the user.

## 5.1. Target Audience

To better understand the extent of the problem to be solved, I took the liberty of participating in two graffiti tours in Antwerp attended by people of different age groups. In the end, I had the opportunity to speak with each group about this project, where ideas were changed and suggestions given. The overall feedback was highly positive and very motivating as the vast majority of people were interested in being able to access information about street art in an easier and faster way, as well as curious by the artworks being portrayed with motion.

To define the target audience of the application, four fictional characters called personae were created based on what was said in the conversations with the groups. This is an important tool that allows the design of a truly user-centered product, based on their demands and interests. Therefore, four personae with different backgrounds were created to represent examples of people at which the application is targeted.



**Figure 47:** Fictional picture of Oliver (Photo by Max Flinterman on Pexels)

### **Oliver Smith, 26 years old**

Oliver is from Australia and his passion is traveling. He is taking a gap year to discover the world and what it has to offer, and also to decide what is his next step in life. He enjoys photography, talking to new people and discovering hidden spots that only locals know.

### **Oliver's Goals and Needs**

Oliver would like to share his vision of the world by creating a blog about each place he visits, but instead of writing about the already known spots, he would like to give another glimpse of hidden gems, such as the artistic and alternative side of cities.

### **Oliver's Frustrations**

Information regarding the location of murals is often not available.



**Figure 48:** Fictional picture of Isabel (Photo by Christina Morillo on Pexels)

### **Isabel Garcia, 43 years old**

Isabel was born in Lisbon, Portugal and moved to Covilhã with her husband 26 years ago, but she still visits her hometown from time to time. Despite being an accountant, ever since she was a child she enjoyed drawing and developed an avid taste for art. Quite recently, street art has been invading Covilhã's building's walls, giving another life to the city, and reminding her of the murals that exist and inspired her in Lisbon.

### **Isabel's Goals and Needs**

Isabel would like to get to know more about the message behind each artwork as well as information about its creator.

### **Isabel's Frustrations**

Most of the time, the artist's signature is not perceptible, which prevents her to learn about him/her and discover more artworks. Also, these artistic interventions to Covilhã reminded her of some artworks that once were in Lisbon,

but its conditions got degraded with time. She would like to be able to see how they were once again.



**Figure 49:** Fictional picture of António. (Photo by Billy Chester on Unsplash)

### **António Silva, 22 years old**

António lives in Coimbra and is an art student. He is a very hardworking student, lives a very active lifestyle and loves to wander around the city, whether it's rainy or sunny. His passion is to draw and paint, with his very distinctive technique and occasionally sells his paintings.

### **António's Goals and Needs**

António would like to live in Coimbra forever, as he understands it is a beautiful city and has so much potential to be even more. He would like to boost degraded areas and promote forgotten spaces with his art, converting it to an "open-air museum" thus attracting more people.

### **António's Frustrations**

Life as an artist is not easy and getting recognition for

his artwork even more difficult. António would like to distinguish himself from other artists with his own style and to be able to preview his works in certain spots before proceeding with the actual intervention.



**Figure 50:** Fictional picture of Gitte (Photo by Janko Ferlič on Unsplash)

### **Gitte Engelen, 9 years old**

Gitte lives in Antwerp and she is in fourth grade, in elementary school. She is an only child and her hobbies are playing games on her tablet, reading books, and to write short stories. When she grows up she wants to be a fantasy novel author.

### **Gitte's Goals and Needs**

Whenever Gitte leaves her house she passes by several street art murals, wondering every time what are their meanings, and creates a backstory for the characters.

### **Gitte's Frustrations**

Despite liking the artworks, she is tired of always seeing the same ones. She would like to discover even more located in her area to continue to create her stories.

## **5.2. Interface Design**

The visual representation of interaction design is called interface design, which is crucial to ensure the success of the application. The reason for this is that a user has to handle the application in an easy and straightforward way, without having to lose time learning how it works. Consequently, to create a good and concise interface, Ben Shneiderman created the Golden Rules of Interface Design (Wong, E.,2019):

### **Strive for consistency**

The application must have consistent and coherent sequences of actions for similar situations so that, as the user browses, he understands the connections between what he already saw and what he expects to see.

### **Enable frequent users to use shortcuts**

With visual shortcuts, the user can navigate faster in the application. The number of interactions can be reduced by using abbreviations, function keys or hidden commands.

### **Give informative feedback**

Feedback should be given to the user for his actions. For small and frequent actions, the response should be discreet, while for infrequent and bigger, actions it should be more substantial.

### **Offer simple error handling**

A system should be designed for the user not to make errors. But in case it happens, the system should detect it and offer comprehensible and simple solutions to handle it.

### **Allow easy reversal of actions**

The user must be able to “undo” his actions so that the risk of losing data is much lower.

### **Support internal locus of control**

The application must be designed and implemented for the user to initiate the actions instead of responding to it.

### **Reduce short-term memory load**

Avoid transmitting to the user large amounts of information simultaneously, thus avoiding the overload the user’s short-term memory.

## **5.2.1. Interface Design**

Considering Ben Shneiderman’s Golden Rules of Interface Design, a set of wireframes was created to plan efficiently the application’s visual design.

Figures 51 and 52 display the wireframes of the different screens of the application alongside with its features, and Figures 53 and 54, present a symbol description to show the interface structure and interactions.

Despite the fact that the product has suffered some modifications throughout its implementation phase, this step was essential as the first stage of the interface planning.

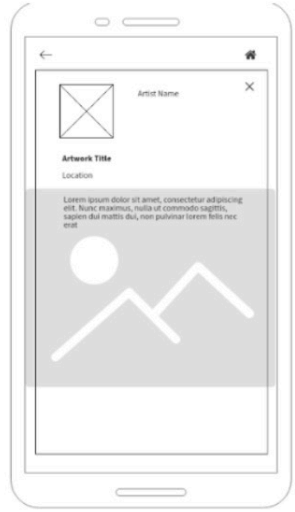




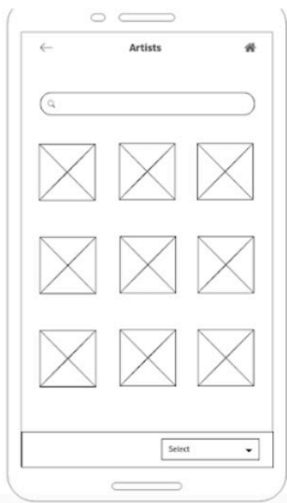
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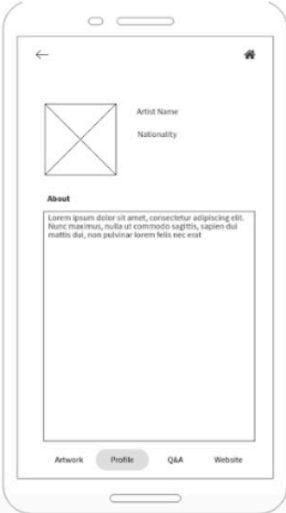
1.



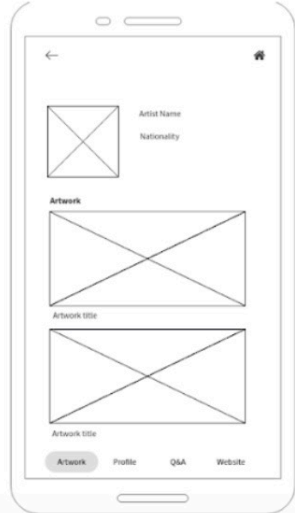
2.



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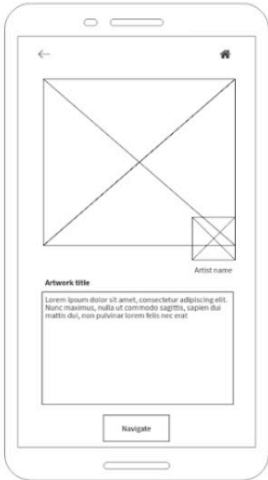


4.



5.

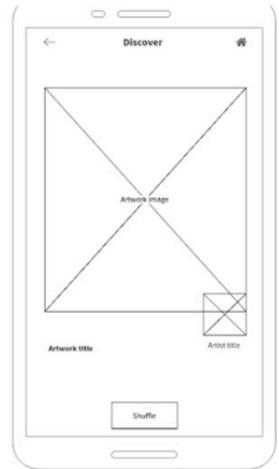
Figure 51: Wireframes of the application, part 1 (wireframepro.mockflow.com)



6.



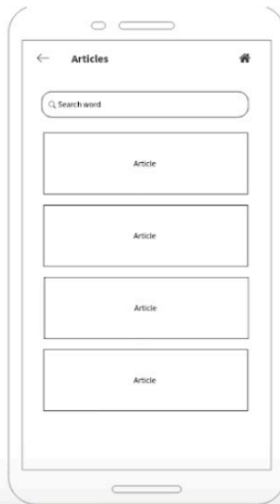
7.



8.



9.



10.

Figure 52: Wireframes of the application, part 2 (wireframepro.mockflow.com)

The first screen in Fig. 51, screen 0, presents the initial page of the application with six buttons which, when clicked on, open a different page.

Screens 1 and 2 display the AR Camera, where the user can augment artworks by pointing the device's camera at the piece, presenting information regarding the piece.

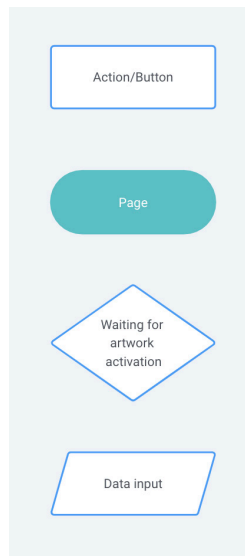
Screens 3, 4, 5 and 6 represent the information regarding the artists, where the user can search and learn about them and their creations.

Screen 7 displays a map with markers indicating where the artworks are located.

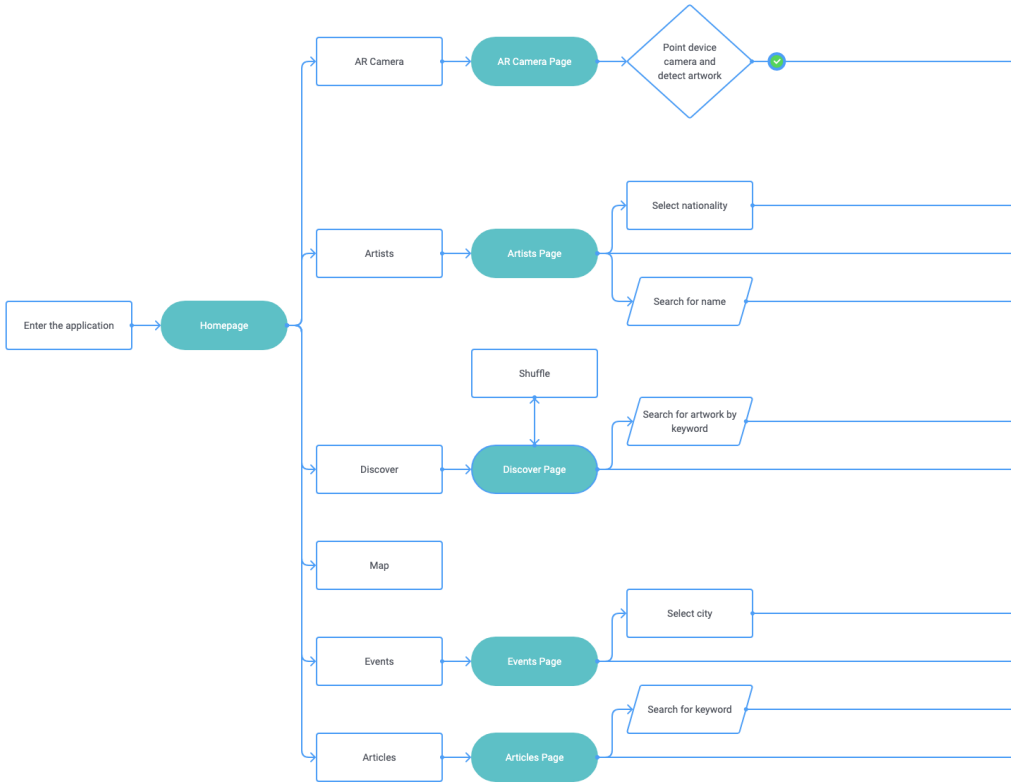
Screen 8 is a discover section, a page where a random artwork is presented and, consequently, encouraging the user to learn about the variety of creations that exist.

Screens 9 and 10 are similar, as one shows a series of street art events for the user to attend and the second one displays several and varied articles on the topic.

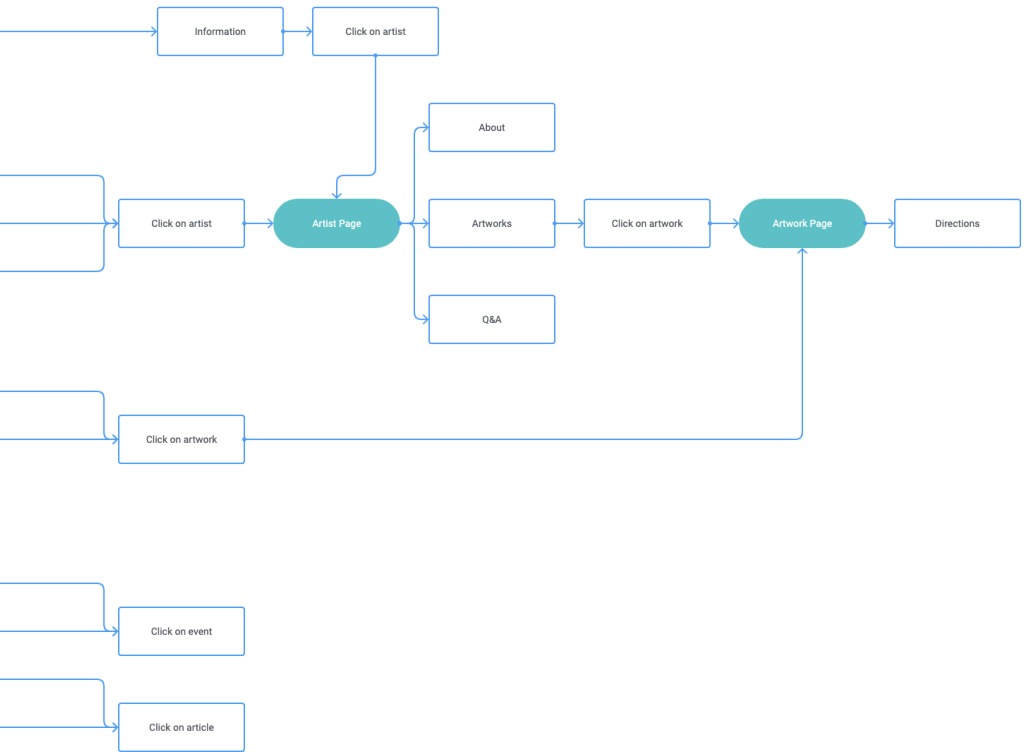
For a better understanding of the structure of the application, alongside the screens, it is necessary to demonstrate the navigation flow according to the different features it will have (Fig. 54). This diagram presents the possible actions a user can execute, displayed by four distinct symbols according to the type of interaction (Fig. 53).



**Figure 53:**  
Symbol  
description



**Figure 54:** Application's navigation flow (flowmapp.com)



## 5.3. Application Identity

The process of creating a visual identity for the application is of extreme importance, as it defines its visible expression. This section describes the definition process of the application's identity to truly represent a clean and intuitive interface, providing the user with a pleasant experience.

The decisions made during this process are described, such as the logotype design and choosing the right typography, each serving a unique purpose, requiring careful thought and intention. It is important to highlight that this section reflects all the information gathered since the prototype phase until the user tests, being subject to various changes throughout this process to reach the most suitable option for future users.

### 5.3.1. Logotype

street ar t is the name given to this application, by joining the two main subjects which define it: street art and augmented reality (AR).

To represent this concept, it was decided not only to distinguish “ar” from “art” with a different color to highlight the augmented reality acronym present in the name but also to separate the “t” from the same word. The reason for this is to provoke curiosity from a more distracted user, and also to assure that the core imagery is powerful enough to deliver the message on its own, without the enhancement of color.

Therefore, the logotype was chosen to be the name of the application, street ar t, with a direct and clean representation using the typeface Hind (Fig. 55).

# street ar t

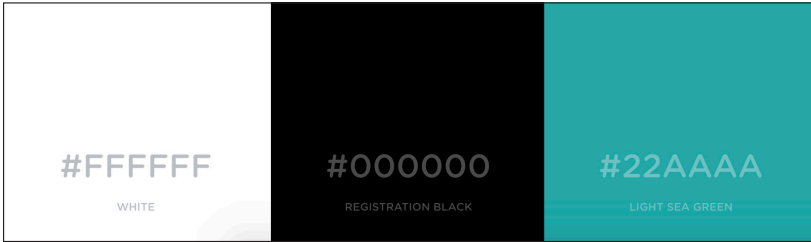
**Figure 55:** Final result of the street ar t logotype

## 5.3.2. Color scheme

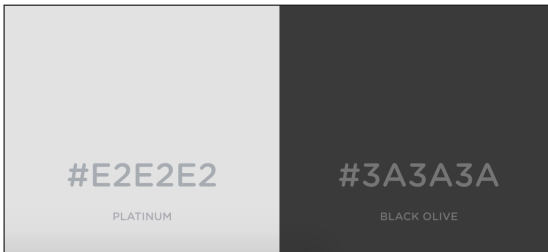
The design process of this application focuses on displaying a simple and straightforward interface.

Since the target audience spans distinct social and age groups, the color scheme study resulted in a palette that pleased the largest amount of people, making the information easy to read and to navigate through.

For this reason, it was adopted a neutral color palette with an additional vibrant color to contrast and to highlight important elements. Therefore, the interface color palette is made up of three main colors: black, white and blue (Fig. 56), with additional complementary colors that are a variation of black and white, for a slight differentiation of information areas in the interface (Fig. 57).



**Figure 56:** Color palette - main colors with hexadecimal codes and color names (coolers.co)



**Figure 57:** Color palette - secondary colors with hexadecimal codes and color names (coolers.co)

Since the application already contains a large variety of strong colors from the artworks displayed, the color palette neutrally complements these elements by not clashing with their tones.

To represent titles, text buttons, and icons, the color black was chosen to contrast with the white background, thus drawing attention from the other elements of the page. Also, the blue shade is used in small details to contrast with the black and white tones, highlighting the selected buttons and small titles on pages where there are no colors present. Consequently, this distinctive color eases the user's navigation through the app and creates a pleasing interface.



The secondary colors are lighter variations of the main ones and are used to avoid the same black and white shade throughout the application. The high contrast of pure black text on a white background can cause discomfort for the eye when users are reading over an extended period, causing their eyes to work harder to adapt to the brightness difference and possibly leading to visual tension. By using dark gray text on a white background, the change in brightness will not be as extreme, preventing overstimulating the retina and allowing users to read for a longer period. In this context, the darker variation tone is used on long text, and the white variation is used in the navigation bar as a soft contrast from the main area of content.

### **5.3.3. Typography**

Typography plays a vital role as it sets the overall tone of the application. It adjusts the text with the design when presenting the content, therefore creating a balanced interface and ensuring a better user experience.

Since the text and content dictate the font choice, it was made a research regarding sans-serif typefaces, because they deliver a modern appearance, and simple enough not to drift the user's attention from the content to the font's style. After analyzing several typefaces, the range possibilities were narrowed because of certain aspects, for instance, poor readability or not reflecting the essence of the information presented.

As a result, this research settled on choosing the combination of Hind for the logotype and Open Sans for the text (Figs. 58 and 59).

Glyph

Hh

Characters

ABCČĆDĎEFGHIJKLMNOPQRSŠTUVWXYZŽab  
cčćdďefghijklmnopqrsštuvwxyzžआईऊऋऌ  
लृऐऔअँअँकखगघङचछजझञटठडढणतथदधनपफबभयर  
वळशषसह12345678900123456789'?'!"(%)[#{  
@}/&\<-+÷×=>®©\$€£¥¢;:,.\*₹

Light  
Regular  
Medium  
Semi-Bold  
Bold

Figure 58: Hind specimen<sup>50</sup>

Hind is the Open Source typeface selected to represent the name of the application, due to the monolinear strokes with flat endings and clear-cut counter forms between the characters<sup>50</sup>. In addition, it is applied to titles and text in buttons to relate with the street art logotype.

Glyph

Characters

O o

ABCČĎĎEFGHIJKLMNOPQRSŠTUVWXYZŽ  
abcčĎĎefghijklmnopqrsštuvwxyzžАБВГГ  
ДЪЕЁЄЖЗСИІЙЈКЛЉМНЊОПРСТЉУЎФХЦ  
ЧѠШЩѡЫЬЭЮЯабвггдђеёєжзсииійјкљ  
љмњопрстћуўфхцѡшщѡыьэюяАВГДЕZH  
ΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩαβγδεζηθικλμνξο  
πρστυφχψωάΆέΈήΉίϊΐΊόΌύϋϚΥΰΩΆΈΌσ

Light

*Light Italic*

Regular

*Regular Italic*

Semi-Bold

*Semi-Bold Italic*

**Bold**

***Bold Italic***

**Extra-Bold**

***Extra-Bold Italic***

Figure 59: Open Sans specimen<sup>51</sup>

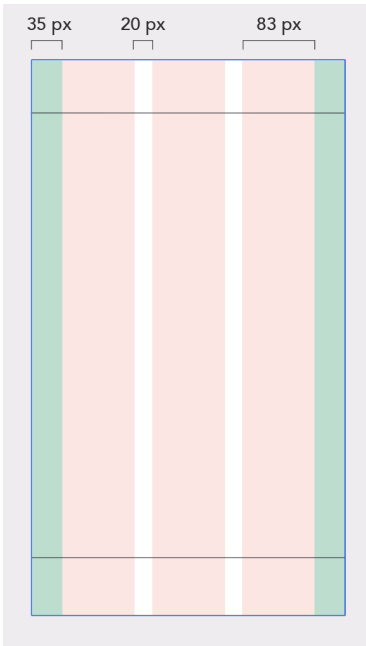
To differentiate and combine with Hind, Open Sans was selected to display long texts because of the readability and clarity of the typeface.

The visual hierarchy formed by the two typefaces creates a balance with the other elements of the interface, keeping the interface graphically clean and allowing for an easy navigation through the app.

### 5.3.4. Layout

It is not enough to carefully define a logotype, color scheme(s) and typography, it is also necessary to provide a truly consistent and cohesive content presentation to make the use of the application a more enjoyable experience. The goal of a design system is to create an intuitive hierarchy and layout that eases the understanding of visual communication.

A base grid was created for the design of the interface, consisting of columns, gutters and margins (Fig. 60).



**Figure 60:** Layout grid with red columns with a width of 83 pixels, green margins with a width of 35 pixels and white gutters with a width of 20 pixels

The layout grid chosen for this application consists of 3 columns, in red, which is where the content is placed. The margins, in green, have a fixed width to all devices and define the space between the right and left edges of the mobile screen. Finally, the gutters establish the white spaces that separate each column with content, thus avoiding visual clutter<sup>52</sup>.

### **5.3.5. Iconography**

Iconography is a visual language displayed by icons that represent functionalities and features in an application, improving the navigation through rapid perception.

Icons can either act alone or in conjunction with text to reinforce their representation and, like the typography and colors, help determine the tone and emotion that the application conveys.

For this application, a set of 14 distinct icons was created (Fig. 61) to represent buttons or markers that trigger a different action when clicked on. The icons' effectiveness depends on their ease of interpretation, so tests were made to design a simple and straightforward version of each that could be comprehensible to everyone.

To enrich the global layout, some aspects were taken into account such as keeping the minimalist style, the consistency between them, the scalability of different sizes and lastly, making them quickly recognizable.

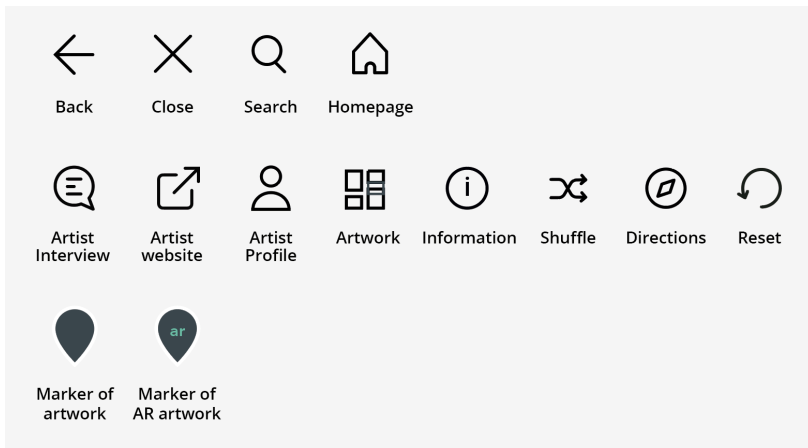


Figure 61: Group of icons

The icons on the top row are used as buttons to perform simple tasks, such as going back to the previous page, closing a panel, search for a specific word and heading to the homepage. These four can be found on more than one page.

The second row contains icons that are also buttons, whose function is for one page only. Each of them is explained in subsection 5.3.5., where mockups are presented.

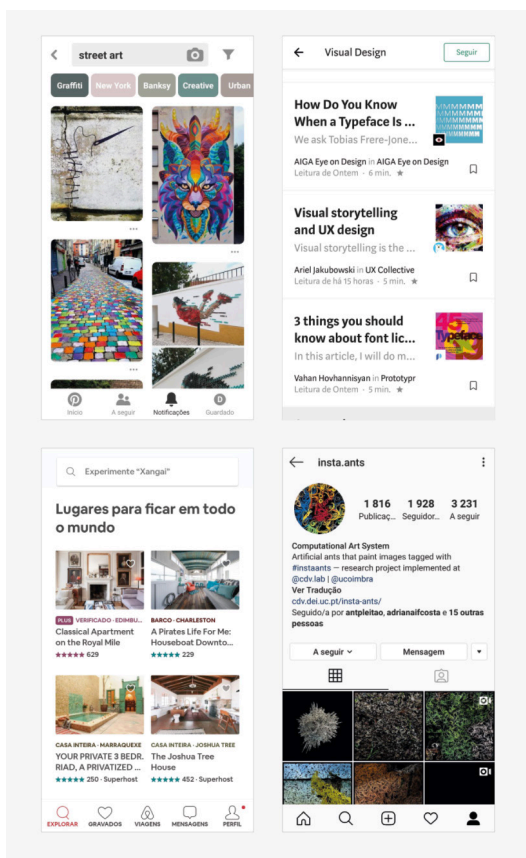
Finally, the last row depicts icons designed with a different style from the rest. The reason for this is because they do not represent buttons; instead, they specify markers placed on the map, identifying the spots where artworks can be augmented by the application. To distinguish these markers from the different elements that exist in Google Maps, they were designed with an inverse theme, filling the icon with a darker shade with a whiter tone contour.

It is possible to apply augmented reality to every artwork marked on the application's map, but there is a difference between both icons. The green "AR" symbol seen in the second marker informs the user that, despite having the information about the artwork available, it is also possible to view the artwork with animation.

### **5.3.6. Mockups**

A key aspect of user engagement is the intuitive design of the application. Nowadays, many applications have been adopting the minimalist design as the users' preferences shift towards a simple interface by reducing it only to essential functions and features<sup>53</sup>. The choice of simplicity allows users to use apps more easily by only displaying clean lines, generous whitespace and minimal graphical elements. As a result, the visual balance created by the clear and concise design allows the content to become the focus for users<sup>54</sup>.

By looking upon some popular apps used nowadays, in order to get inspiration and guidance, it was possible to verify that minimalism was in fact present and effective (Fig. 62).



**Figure 62:**  
Examples of  
minimalistic  
mobile applications  
(from left to right:  
Pinterest, Medium,  
Airbnb, Instagram)

As reflected, applications are leaving behind the unnecessary heavy design and instead adopting a purer feel, more focused on the ultimate goal of creating the best experience for the user.

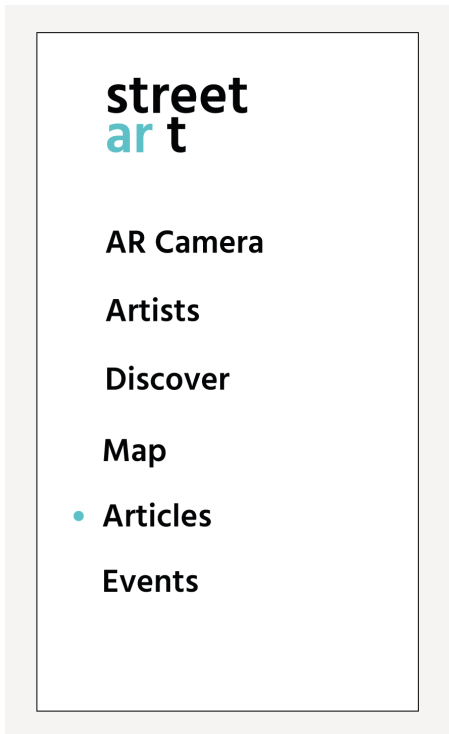
Considering this perspective, mockups for the different pages of the application were created, whose features and functions are described and analysed.



As the application being developed is directed only to mobile devices, the mockups were created with a screen size of 360x640px.

## Homepage

The homepage is the initial screen of the application. When the application is opened, it initially displays the menu with a set of six options for the user to choose from (Fig. 63).



**Figure 63:** Mockup of the Homepage, with the option Articles selected

## AR Camera

The AR Camera (Fig. 64), in which the device camera is enabled and allows the user to apply augmented reality to the available artworks in the app's database, when they are in the camera's field of view. The second screen shows an information panel regarding the artwork being captured, which appears when the information icon is clicked.

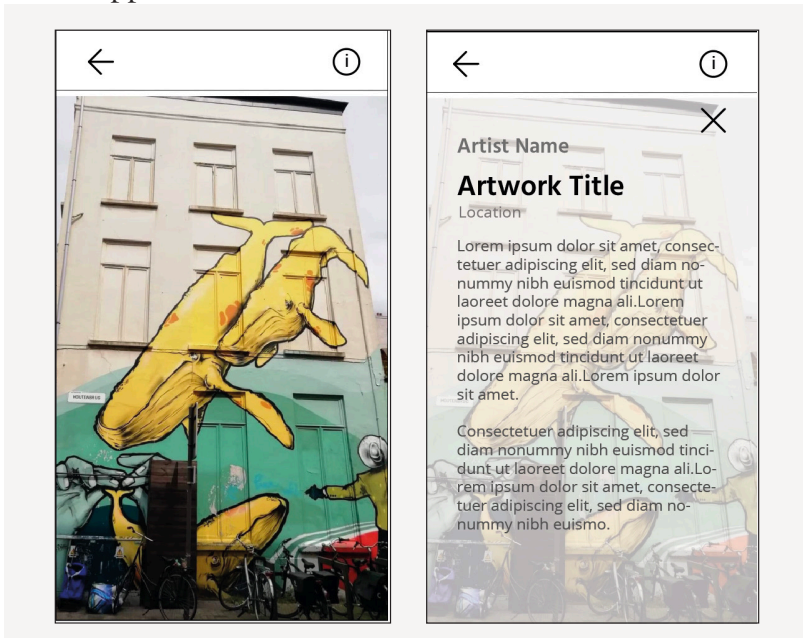
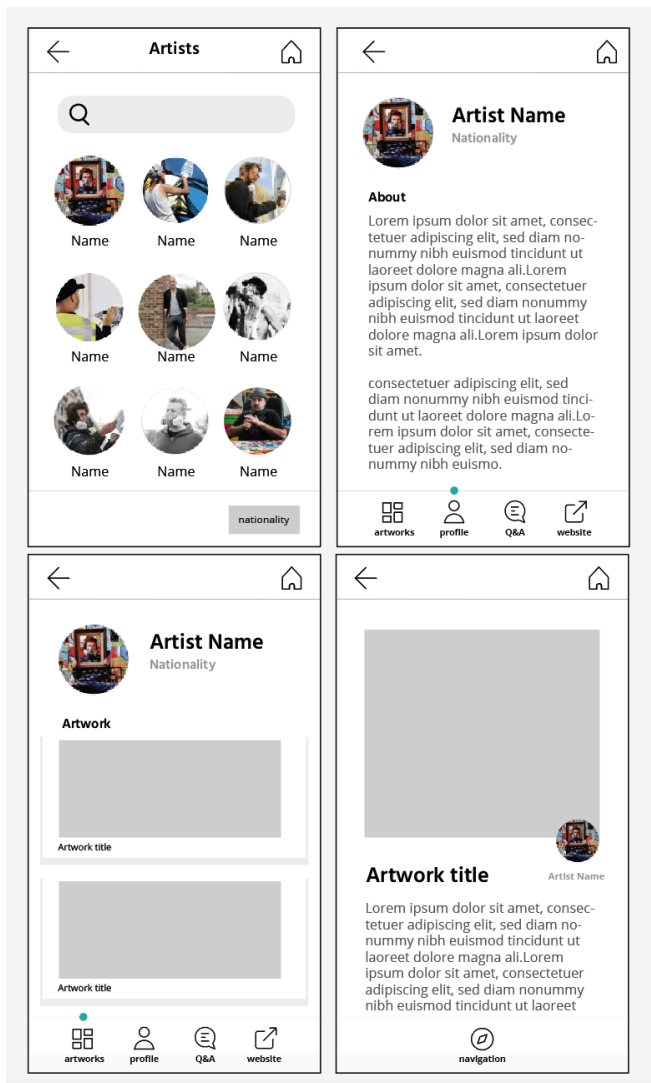


Figure 64: Mockup of AR Camera

## Artists

The Artists' page (Fig. 65), in which a list of several artists are presented, can be filtered in two different ways: typing the name of a specific artist, or selecting their nationality. Because the application is only directed to Portugal and Belgium, only these two nationalities are available, despite the possibility to add more options in a posterior phase, as the application grows.

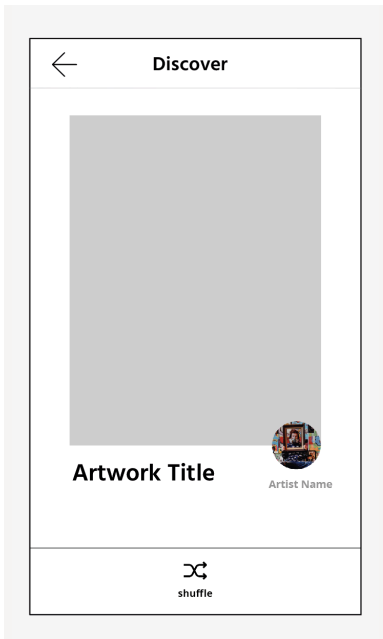
Clicking on a specific artist opens a page dedicated to him/her, presenting his/her biography, artworks created, and also a section with the interview previously conducted. When an artwork is clicked on, it opens another page with information about it.



**Figure 65:** Mockup of (from left to right) Artists, Artist page with the profile option selected, Artist Page with artwork selected, Artwork page, 103

## Discover

The Discover page (Fig. 66) presents one artwork at a time randomly selected from the database. As a consequence, the user learns about more styles and new artworks. Clicking on an artwork opens a page dedicated to it, describing the message behind its creation.



**Figure 66:** Mockup of Discover

## Map

The Map (Fig. 67) displays the world map using Google Maps with an overlaid layer containing all of the street art locations marked, which can be used with the application. When clicking on a marker, it appears a pop-up with an image of the artwork in that location, as well as the title and its creator. This method, despite not being integrated with the application, was the most suitable choice since it is a

dynamic map where the user can search on the whole world for markers and have access to the way how to get there, using his/her current position.

In a future perspective, as the application grows, expanding its database, this feature could be integrated into the app for users who are willing to pay for the amount Google Maps is requiring for the API.

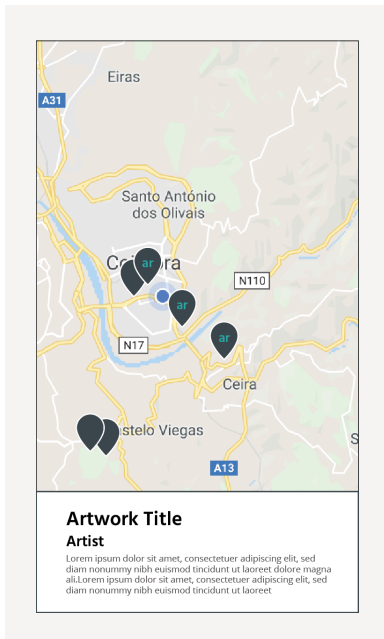
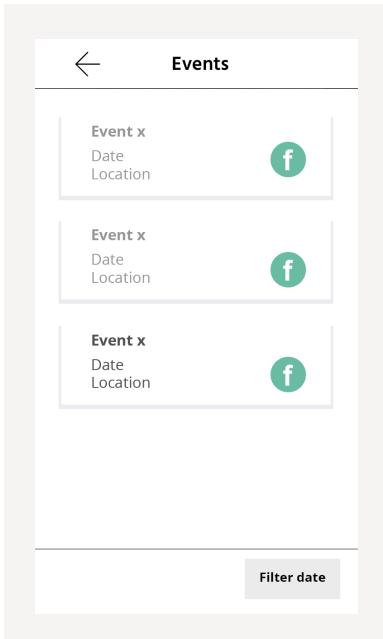


Figure 67: Mockup of Map

## Events

The Event's page (Fig. 68), as the name suggests, presents some events that will happen regarding street art to inform users who might be interested in participating. The events selected for this section are all which are related to street art, whether it is a grand opening of a new piece or even gallery exhibits of an artist's collection of works.



**Figure 68:** Mockup of Events

## Articles

The Articles' page (Fig. 69) provides several articles that might be interesting for a user who wants to read and learn more about street art. These articles are chosen from various sources, from journalism websites or even blogs, and cover stories such as new artworks across the world, problems in the street art world, and so on.

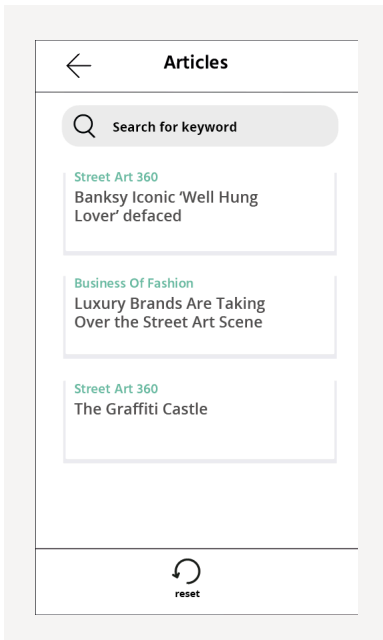


Figure 69: Mockup of Articles

## 5.4. Conclusion

Every decision made in this chapter was essential for the project's development since it excludes and prevents issues that could eventually happen regarding the interface and its interactivity with the user. After having the screens defined, the navigation flow outlined, the visual identity decided and the mockups created, it was possible to proceed to the implementation of the application.







# 6. Implementation

This chapter documents the practical development of the application, divided into two sections: animations and the application itself.

Every decision made during this process is described and explained, considering changes and adaptations done to overcome unexpected problems.

## 6.1. Animations

Street art is an application that is possible to be used all around the world as long as there is street art involved. The first city chosen to develop this project was Antwerp, one of the largest Belgian cities, which has been actively investing in this artistic movement, inviting several artists to decorate different spots in town.

Since it is an augmented reality application that is being developed, recognizing the work and providing information about it would not be engaging enough to be considered a distinctive and innovative app. To further explore this technology, it was decided to add animation to the artworks being seen to attract people's curiosity, as well as to enrich the entire experience.

### 6.1.1. Research

The first step taken for the development of the application was an initial investigation of the artworks scattered throughout Coimbra and Antwerp.

In Coimbra's case, as the street art movement is still in the beginning, it was easy to select the artworks to include in the database.

For Antwerp, I contacted a tourist guide who organizes occasional visits directed to street art, in which he shows and explains some of the artworks displayed around the city, especially the ones in hidden areas unknown to the public.

I participated in two of the visits that happened during my stay, which reinforced the demand for the application because, without these tours, it was possible that I would never see some artworks that were presented.

Additionally, with the animation feature integrated, it will attract not only people who already enjoy street art but also the ones who will start to pay more attention to it, thus promoting the movement.

At the end of the visit, I had the opportunity to present my project to the entire group, who were very curious and enthusiastic about the idea of integrating augmented reality with artworks.

This first step was very important because it served as a starting point for getting a glimpse of street art, its symbology, narrative, content, and later material to deepen the research process.

### **6.1.2. Production**

The elaboration of the animations was based on the analysis of the illustrations, such as the position and display of the elements, combined with the meaning of the artworks. Accordingly, it was possible to determine what type of motion to apply.

Because this is primarily an educative application, in order not to deviate the user from its main focus, the animations had to be designed to be short and straightforward, yet entertaining. Each animation lasts a few seconds, and is presented in loop for users to see as long as they like. Additionally, for the creation of the animations, it was taken into account the boundaries of each wall that displays each artwork, so that the elements did not exceed that perimeter.

The artworks selected represent a distinct style from different and prestigious artists to display a wider variety of pieces.

Despite this project being initially directed to Antwerp, Portuguese artworks, from Coimbra, were added to demonstrate how the application can be directed not only to one city but to several.

Regarding the aesthetics, given the unique nature of the illustrations that served as source material, no change was even considered in stylistic terms.

The creative process for the animation was done with exclusively digital means and in a 2D format, using Adobe Photoshop to isolate each element to animate, and Adobe After Effects to add motion. Most of the photographs of the artworks were taken by me, unless otherwise noted.

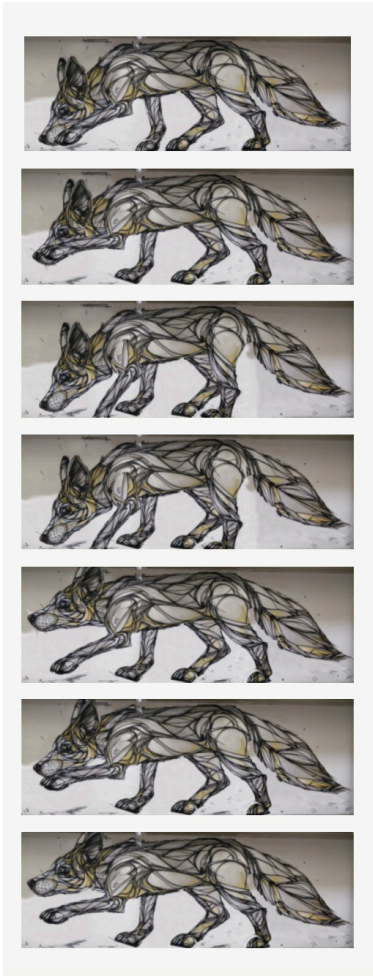
#### 6.1.2.1. “Silver Fox” (Antwerp)

Plantin Metro Station needed to be improved, so De Lijn, a public transportation company, invited three artists to decorate it.



Figure 70:  
“Silver Fox”,  
from Dzia<sup>55</sup>

Dzia was one of the artists who had the opportunity to paint one of its works in this location, painting the “Silver Fox” (Fig. 70). He got his inspiration from the times when Antwerp’s zoo did not exist yet, so the only way to discover exotic animals was by looking at drawings.

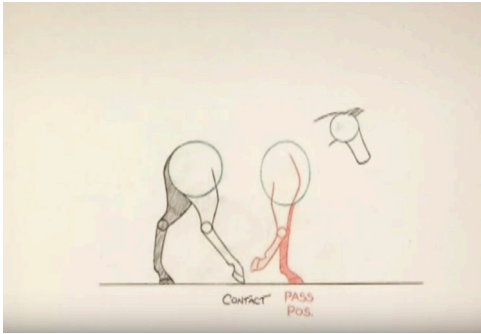


This artwork displays a fox extremely detailed, drawn with bold geometric lines. It was taken into consideration the position of the animal, therefore in this animation, the fox is displayed moving as if it was a real fox. The elements selected to accomplish the motion were the four legs, neck, ears, snout and tail.

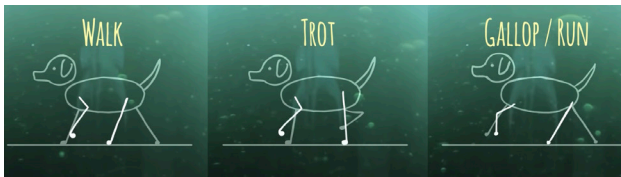
This animation (Fig. 71) took into consideration moves that could be made by a fox, therefore it begins with the animal walking, consequently moving its legs, tail, and ears due to movement. Suddenly, it stops, looks up, lifting his muzzle and neck, as if it found something. After, it bows its head to sniff its paw.

**Figure 71:** Some frames from the “Silver Fox” animation. Duration: 8 seconds.

To portray the motion of a four-legged animal, there was a previous study regarding different types of movement, which is different from a two-legged one (Figs. 72 and 73).



**Figure 72:** Frame of video of “Animation Horse Walk Cycle”<sup>56</sup>



**Figure 73:** Frame of video “Animation Stuff: Animating a Fox Trotting (Quadruped Walk Cycle)”<sup>57</sup>

### 6.1.2.2. “Whale or Giant?” (Antwerp)

Antwerp invited Larsen Bervoets, an artist from Belgium, to paint a mural in the city’s historic center. Given this opportunity, the artist wanted to escape the most common themes the town is known for, such as its large port, or the Red Light District. Instead, he wanted to paint a strong image that also had meaning to Antwerp<sup>58</sup>.



He got inspired by the mythological story of the city, based on whale bones which were found by inhabitants of Antwerp during Medieval times. During this time, they did not know of the existence of whales, so they assumed it was from a giant who once lived in Antwerp, originating the legend of “Druon Antigoon”.

After 10 days of working under very cold weather, this mural was completed and it is one of the main artworks for Antwerp’s street art (Fig. 74).



**Figure 74:**  
“Whale or  
Giant?” by Larson  
Bervoets

The animation created for this artwork consists of four elements: the two whales on top, the man and the hands, each one moving differently, but creating an ecosystem altogether.

This animation begins with one of the whales missing, and the man moving his arms in disbelief while looking to the big whale. The animation refers to the story where people did not know about its existence, despite the man having modern clothes. Suddenly the smaller whale appears from the upper right corner, joining the first one, making him see that there is not only one creature like this, but there are more (Fig. 75).

In the lower-left corner, it is possible to see hands touching the whale. The movement implies the acknowledgment of the creature existence in real life, thus destroying the line that separates mythology from reality.



**Figure 75:**  
Some frames from “Whale or Giant?” animation.  
Duration: 6 seconds.

### 6.1.2.3. “Memoirs of a Geisha” (Antwerp)

Pablo Piatti is the artist who created this artwork after being contacted by Dim Dining, a modern Asian fusion restaurant located in the city center, to embellish its exterior. It portrays his interpretation of *Memoirs of a Geisha*, a novel by Arthur Golden, and it is frequently seen surrounded by people taking pictures and admiring the art piece<sup>59</sup> (Fig. 76).

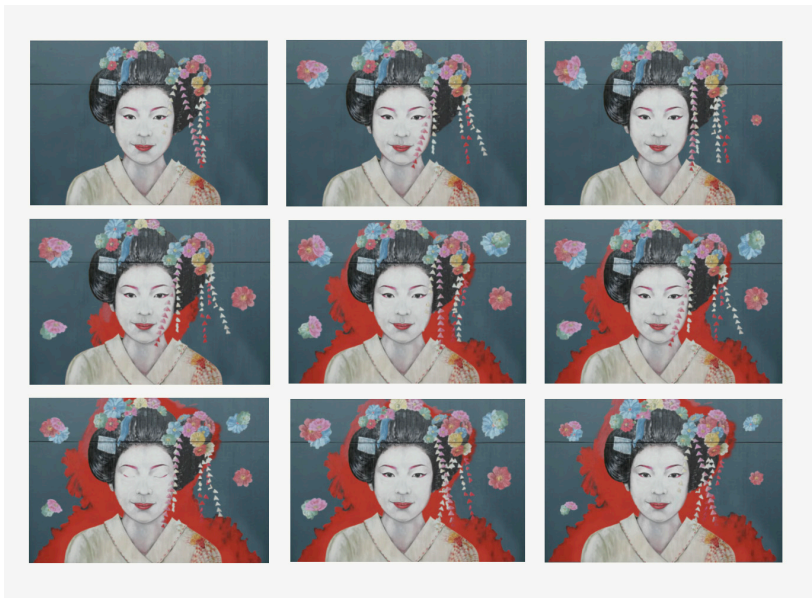


**Figure 76:**  
“Memoirs of  
a Geisha” by  
Pablo Piatti

A *geisha* is a woman highly trained in the arts of music, dance and entertainment, meaning in Japanese “person of art” and portraying the illusion of female perfection.

In this context, the animation created for the artwork is divided into four sections, happening simultaneously.

Taking advantage of the accessories on the character's hair, such as the flowers and strings, part of the animation consists of applying motion to these elements; swinging and changing sizes, moving with a certain rhythm yet transmitting tranquility. In addition, the red halo's size increases, thus creating a bigger focus on the character and the impact of her presence. Also, the head flowers were replicated in the dark blue area, appearing sequentially and spinning, referring to music and dance. As a final touch, her eyes blink to make it seem that there is a real person on the wall staring back at the people seeing it (Fig. 77).



**Figure 77:** Some frames from “Memories of a Geisha” animation. Duration: 4s.

#### 6.1.2.4. “Jayme Planas Cornella” (Coimbra)

The man portrayed in this mural is Jayme Planas Coronellas, the founder of the Wool Factory of Santa Clara, in 1888. It was painted by Samina, a prestigious Portuguese artist.

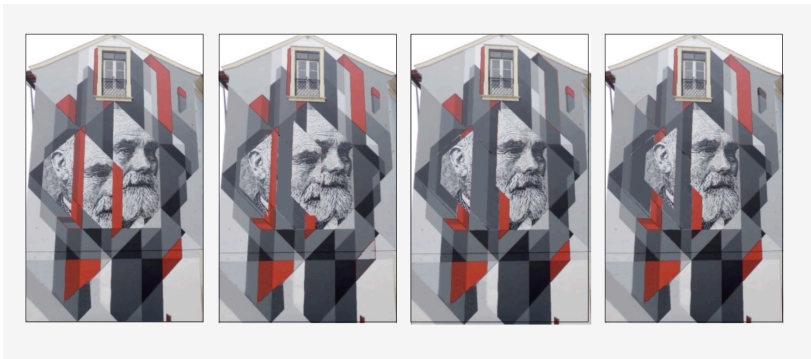
The memories of the workers at the Wool Factory of Santa Clara are the inspiration for this artwork, so painting some of the faces of people connected to the Factory which, when displayed on the streets of the city and surrounding towns, allows us to discover a little more about the history of the Convent of São Francisco, which was the Wool Factory of Santa Clara for about a century<sup>60</sup>.



**Figure 78:** “Jayme Planas Cornella” by Samina.  
Duration: 5s.

In this artwork, it is possible to see the fragmented face of the person who is portrayed, arranged on various geometric shapes.

Therefore, it was taken advantage of three key elements of this work: color, geometric shapes and the face of the person who is represented. Thus, the animation done for this piece is the isolation of each geometric shape of this image, changing randomly from black to red. Simultaneously, the fragmented section of the person's face slowly moves, complementing the other segment.



**Figure 79:** Some frames from “Jayme Planas Cornella” animation. Duration: 5 seconds.

#### 6.1.2.5. “Turquoise Marilyn” (Coimbra)

Quinta das Flores Elementary and Secondary School had the opportunity to paint a wide wall in front of their school area. Visual arts teachers, in 2007/2008, gathered their students from seventh to twelfth grade and spent several weeks painting famous paintings. The difficulty of each painting was adapted to each grade.



**Figure 80:** “Turquoise Marilyn”, by Andy Warhol, 1964 <sup>61</sup>

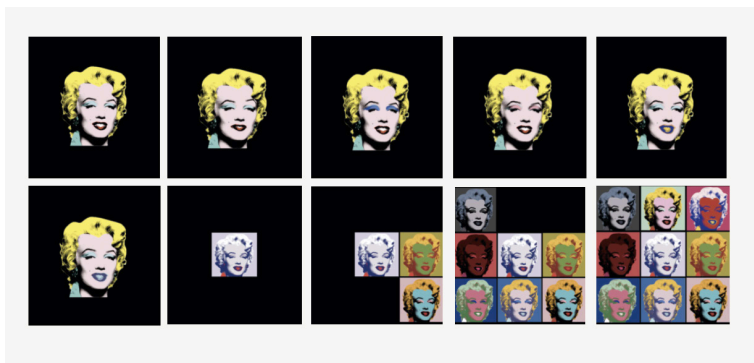


**Figure 81:** Adaptation of “Turquoise Marilyn”, by Quinta das Flores Elementary and Secondary School

Figure 80 depicts “Turquoise Marilyn”, one of Andy Warhol’s most famous screenprints. However, it is possible to notice that its conditions are already very damaged, as the colors already faded, and also an act of vandalism was done to the work (Fig. 81).

Andy Warhol painted several versions of the iconic actress Marilyn Monroe after her death, using different vivid colors, sizes, and formats.

The animation created for this artwork consists of three stages. It starts with Marilyn Monroe’s face, subtly moving her eyebrows and lips. Suddenly, the lipstick and eyeshadow colors begin to change, creating combinations of the other screenprints’ colors (Fig. 82), as these are some of the main contrasting elements. Lastly, a sequence of the other screenprints of this collection is displayed. In this animation, despite of starting with the Turquoise version, ends up covering more versions of this collection, thus showing the user about the different variations that exist.



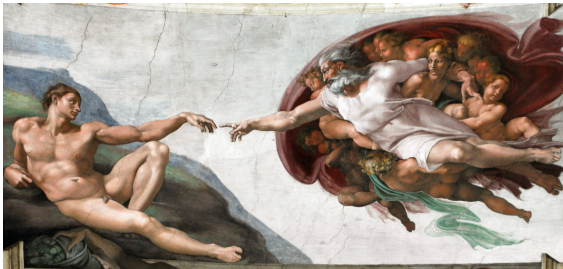
**Figure 82:** Frames from “Turquoise Marilyn” animation. Duration: 14 seconds.



#### 6.1.2.6. “The creation of Adam” (Coimbra)

Another of the various works that the Quinta das Flores Elementary and Secondary School students painted in front of its facilities is a section of Michelangelo’s famous paintings “The Creation of Man” (Fig. 83), 1508-1512.

The original painting forms part of the Sistine Chapel’s ceiling and illustrates God creating the first man, Adam. However, in this artwork, it is only seen the almost touching hands of God and Adam. This work was chosen because of the faded colors, almost unseen (Fig. 84).



**Figure 83:** Original painting “The Creation of Adam”, by Michelangelo, 1508-1512 <sup>62</sup>



**Figure 84:**  
Adaptation by Quinta das Flores

Due to the fact that this work does not have many elements to work with, it was decided to select both arms, separating them in several elements. Therefore, the selected elements were the forearms, the hands, and the two index fingers. Accordingly, this simple animation begins with both arms out of the canvas. Next, God's arm extends pointing His finger to Adam, along with him, who has both fingers clenched. Suddenly, Adam also raises his index finger, resulting in his creation (Fig. 85).



**Figure 85:** Frames from “The Creation of Adam” adapted by Quinta das Flores animation. Duration: 4 seconds.

## **6.2. Application**

This section details the technical development of the application, mentioning the functionalities included, presenting the system architecture, and finally, describing the technologies adopted. During this process, each choice made is documented and explained.

### **6.2.1. Functionalities**

The main functionalities implemented emerged almost empirically by participating in street art tours and observing artworks on the street, recalling scenarios that would add value to the experience. Such scenarios are the possibility of learning about what the message is behind each creation, or to discover more artworks from the same artist. Consequently, in Table 2 it is possible to see the functionalities that integrate the application street art.

**Table 2:** List of functionalities.

<b>Functionality</b>	<b>Brief Description</b>
AR Camera	The main feature of the application which, through the device's camera, applies augmented reality to artwork, retrieving supplemental information and artwork animation.
Artists	Presents a list of several prestigious artists with different artistic styles.
Map	Displays the world map using Google Maps, with markers locating artworks that can be augmented with the application.
Discover	Section where a user can learn about a different artwork by randomly displaying one from the database.
Events	Section to inform the user about street art events.
Articles	Section with selected articles and news related to street art.

Table 2 identifies useful features for street art, which make the application more versatile, even though it is subject to limitations imposed by Unity, which will be discussed further.

Given the amount of information available, despite being all gathered in one application, it is possible for each of the features identified to work as a single application to focus and deepen its content.

Starting with the focus of the application, the **AR Camera**, which, as the name implies, is where the augmented reality camera is located. When the user comes across an artwork, he points his device to include it wholly within the limits of the camera, thus triggering the augmented reality.

If it is one of the artworks with animation available in the application, it will suddenly appear to move, and also a signal alerting is information related to what is being seen. In the case of not having an animation associated, it only triggers the information panel.

The application also has a section dedicated to **Artists**, which displays a list of artists that can be filtered by country or even by searching for their names. Clicking on one artist takes the user to its profile, where he/she can learn more about the biography, the artworks, and the answers to the interview previously conducted.

The **Map** was the most questionable feature since most of the application program interfaces (APIs) that could accomplish the proposed were not free. The options explored included Google Maps, Here Maps, and Mapbox, which all proved not to meet the expected requirements. For this project, it was necessary to have available the world map with markers indicating the locations of the artworks, and by clicking on them, display an informative panel regarding its artist, the artwork and creative process associated with the piece.

Also, if the user wanted to know the way to get there, the application would show the route. In the case of Google Maps, the API recently became paid, making it unusable for this project. Regarding Here Maps, which could be integrated into Unity, is a static map, thus lacking the flexibility to add more features. In the case of Mapbox, one of the main APIs used in Unity, it was possible to customize the map by adding the necessary markers to identify the desired locations and it was a dynamic map. However, this approach had its weaknesses.

The markers generated by Mapbox were part of the map image and were not clickable, so it was not possible to

generate the informative panel. Also, it was impossible to detect the user's position so that it could be created the path to get to the artwork.

Considering all of these factors and research, the final option was to create a customized map in Google Maps, which, when the option Map is selected, takes the user directly to Google Maps, leaving the application. Despite not being the ideal solution, it fulfills all the requirements needed. With this dynamic approach, it is possible to search for a specific city, to see the world map with icons identifying the street art locations and, when clicking on one, the informative panel appears. Also, it has access to the user's location and it calculates in real-time the route to get there. This was the solution for this unexpected problem that is functional and gathers all the characteristics the user needs.

The **Discover** section displays a randomly selected artwork from the database, so the user learns about additional styles and creations. In this page, the user can either click on the artwork to read its description, or to click the shuffle button, which generates a new artwork on the screen. As a result, the user eventually gets to know more artworks and respective locations, creating the curiosity that they might eventually get the chance to see it in real life.

The **Events'** and **Articles'** options are similar yet distinct. Both aim to inform users about street art subjects, but the first is for promoting events, while the second is a collection of articles.

The Events' section presents past and future ones so that the user can have a better understanding of what surrounds him/her, whether there is a lot of activity in

his/her city or not. Regarding the section of articles, it is a collection of relevant articles alluding to the theme, providing a moment of reading and learning.

## 6.2.2. System Architecture

The following diagram presents the application's interface architecture (Fig. 86).

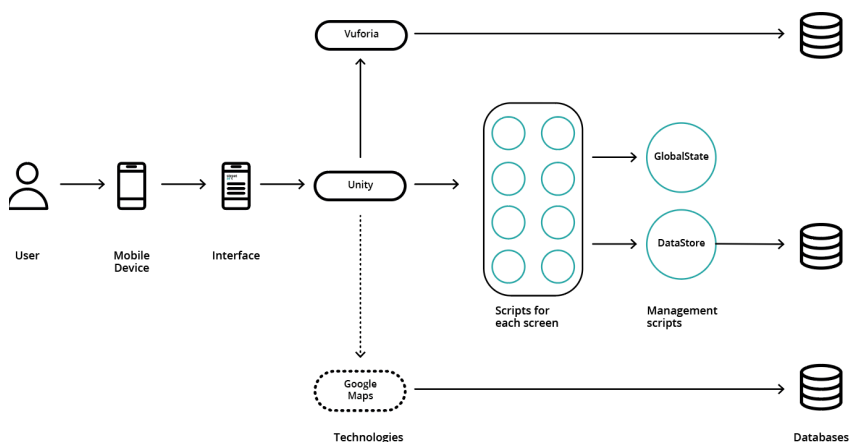


Figure 86: Architecture of street art

Figure 86 demonstrates the application architecture, where information storage and management are presented.

For street art, all information is stored in three types of databases: the Vuforia target manager, the XML files, and the Google Maps layer.

The Vuforia target manager is responsible for keeping a record of every artwork image and for its recognition, which is described in the next section.

The XML files, on the other hand, are handled by the DataStore script, which accesses the information, making available when it is invoked by another script managing a page from the app. The GlobalState script is responsible for managing the application globally, keeping a record of the options enabled and disabled.

Finally, in Google Maps, signaled with a different type of arrow indicating that is outside the application, the information is stored in a layer that is applied to the world map, indicating the markers. Additionally, this layer stores data about artworks, creator and description, shown when clicking on a marker.

### **6.2.3. Technologies**

For the development of the application, the research done in the State of the Art chapter, specifically in sub-section Software Frameworks (3.4.3.), was considered and tested in order to determine the most suitable augmented reality SDK to use.

Because they are free, OpenCV, Vuforia and ARCore were the technologies experimented, of which Vuforia distinguished itself from the rest for the fact of being especially focused on recognizing and tracking, in real-time, planar images previously defined as targets. Therefore, it was possible to superimpose each designated target with an informative layer regarding what is being seen, as well as a video of the animated artwork.

The reason for discarding the OpenCV option was because this technology worked with marker-recognition, meaning that it scans binary square fiducial markers instead of illustrations.



ARCore, on the other hand, was dismissed due to the fact of being more directed to place 3D objects into a space by detecting visually distinct points in the captured camera image.

The next step of the developing process was to determine a platform to develop the application.

Android Studio was the first choice since it is the official integrated development environment for Android application development. Eventually, the choice of this platform was abandoned because of its intricate integration with Vuforia, being replaced by Unity.

Vuforia is natively integrated with Unity and delivered with the Unity editor, providing an easy development workflow and synchronization of new features and bugs fixed with Unity versions. Despite Unity suffering updates frequently, it was a risk I was willing to take since it is the most suitable option for an augmented reality application.

The application's front-end was programmed in C#, supported by Unity, which is a fully object-oriented, event-driven visual programming language.

With C# scripts, it is possible to create isolated methods that can execute each task, defining the triggered actions by the user. Additionally, these scripts are responsible for the management of the XML (Extensible Markup Language) files, the interface's database, accessing information when it is required. By using XML files, it is possible to insert the content of various types, organized hierarchically through unlimited tags, and focused on its information structure for its simplicity and flexibility. This format is independent of hardware and software platforms, so that the data entered can be accessed through a platform other than Unity, in case the application grows and expands.

Moreover, Adobe Illustrator was used for defining the style content, previewing and outlining each screen with the elements included, and also to design every icon to integrate the buttons.

## **6.2.4. Implementation Process**

Since the information had already been collected during the works search phase, the first step was the creation of the database, which, as mentioned in the application architecture (6.2.2.) section, and consists of three types of databases.

Regarding the Vuforia database, it only saves the targets to activate augmented reality, and the Google Maps database has the artworks along with the titles, authors, descriptions and an image of the pieces. The XML files are intended for application content, hierarchically divided into several tags according to the type of item (Fig.87).

The Scripts are responsible for managing the entire application, performing necessary tasks, such as fetching specific data, opening new pages, filtering content, and more. The Resources folder contains all layout elements, such as the fonts, images and icons.

Regarding the application pages, eight separate Scenes were developed for each one in order to have a more organized and iterative navigation flow. To make navigation more user friendly, when a new page is loaded, there is a short animation of elements, smoothing the display of information. This was possible through Unity, which allows to apply animation to its components.

Finally, Unity enables a simple organization of the interface's elements to render on several screen sizes, so street art's is a responsive application, being capable to be used in any Android device.

```

<InventoryItems>
  <InventoryItem ID = "" Type ="artist">
    <Name></Name>
    <Desc></Desc>
    <National></National>
    <Country></Country>
    <Picture></Picture>
    <Website></Website>
  </InventoryItem>
</InventoryItems>

<InventoryItems>
  <InventoryItem ID = "" Type ="artwork">
    <Title></Title>
    <Date></Date>
    <Country></Country>
    <Location></Location>
    <City></City>
    <Link></Link>
    <Exp></Exp>
  </InventoryItem>
</InventoryItems>

<InventoryItems>
  <InventoryItem ID = "" Type ="article">
    <Title></Title>
    <Date></Date>
    <Source></Source>
    <Link></Link>
  </InventoryItem>
</InventoryItems>

<InventoryItems>
  <InventoryItem ID = "" Type ="events">
    <Title></Title>
    <Date></Date>
    <Country></Country>
    <Location></Location>
    <City></City>
    <Link></Link>
    <Expired></Expired>
  </InventoryItem>
</InventoryItems>

<InterviewItems>
  <InterviewItem ID = "" Type ="interview">
    <Title></Title>
    <Questions></Questions>
  </InterviewItem>
</InterviewItems>

```

**Figure 87:**  
XML tags

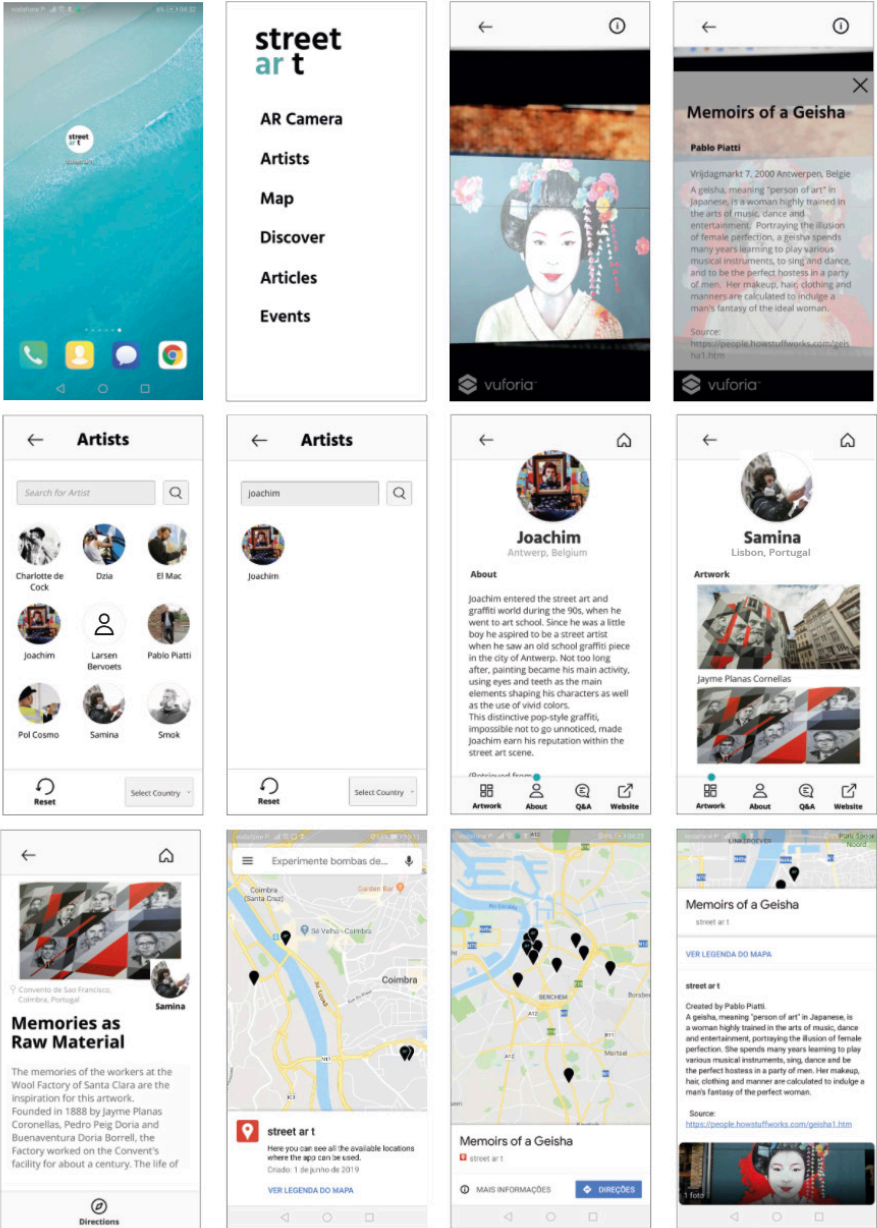


Figure 88: Final screens of street ar t, part 1

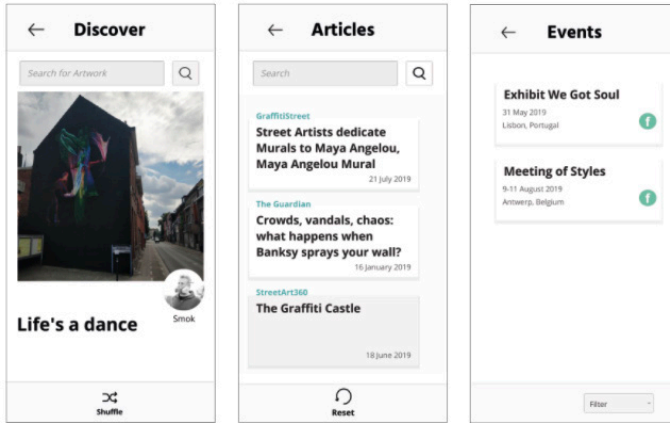


Figure 89: Final screens of street art, part 2

Figures 88 and 89 show the final screens of the application, whose features were previously explained in the Mockup subsection (5.3.5.). The final result was possible after the prototype was tested by users, in order to understand the usability of the application. Therefore, the prototype has undergone changes that are described in the next chapter, the Application Evaluation (7.), to improve the interface thus ensuring a better user experience.

### **6.3. Conclusion**

This chapter described the implementation of street art, putting into practice all the knowledge obtained during this process, along with the outlined planning and proposed objectives.

This phase began with a survey of the artworks selected to integrate into the application, presenting a description, title and author. The description was an essential aspect to be considered when producing the animations, to create consistency in the illustrations with its actions. Each piece presented is followed by some frames demonstrating the animation.

The next step towards implementation lies in the development of the application, with the system's architecture and the definition of the technologies that were used. Thus, it was possible to proceed to the development of the application, in which its usability was later tested by users. Therefore, the implementation phase underwent some changes during this process to correct particular aspects of the application, and adding suggestions given by users.







# 7. Application Evaluation

This chapter describes the evaluation phase of the project, detailing the usability tests process.

This was an essential step for the development of the application since users provided direct feedback on the usability of the interface, detecting errors and giving suggestions. Consequently, with this information gathered, it was possible to correct each flaw found and improve certain aspects, creating a more enjoyable user experience.

The application was tested by a group of people with different backgrounds who followed a previously established script, asked about their expectations regarding the app, performed a set of tasks and, finally, answered a questionnaire. Additionally, this chapter presents an analysis of the usability tests' results, as well as adjustments consequently made to the application.

# 7.1. Usability Tests

This section contains the planning process of the usability tests. It provides a definition of its context, specifies the objectives, explains the strategy pursued, presents the set of users, displays the script read and shows the task list to accomplish.

## 7.1.1. Context

When the application had its functionalities working and features implemented, the next step was to test its usability. The usability tests proceeded with a group of 10 people, in order to correct detected errors and make the necessary improvements.

## 7.1.2. Objectives

The usability tests are a crucial step for the project's development, through which it is possible to conclude if the application meets its previously established goals and creates a feasible solution for the user's needs.

This evaluation is accomplished by submitting each user to test the application's features to analyze the interaction between them and the interface. It allows for a better understanding of the performance of the application, as well as if it provides easy navigation. All in all, the main objective is to validate the purpose of the application, which is to enrich the street art experience with supplemental information and animation.

### **7.1.3. Strategy**

In order to evaluate the effectiveness of the application developed, it was elaborated a script, a task list and a questionnaire, so that every user would use the app in individually and in equal conditions.

It initiated with a script, introducing the application and briefly explaining its context.

Next, each user was asked about their expectations from the application, without previously knowing its. The reason for this step was to understand from the beginning if it includes every aspect mentioned.

After, the usability tests proceeded with a list of tasks they had to follow and perform, while the time was being recorded.

Finally, the users answered a USE questionnaire that addresses the fields of utility, satisfaction, ease of use and learning through the execution of tasks of the application.

Jakob Nielsen presented the 10 heuristics for usability assessment through which we can evaluate an interface (Nielsen, J. ,1994):

#### **1. Visibility of the system status**

The user must have feedback of what is happening with short delays;

#### **2. Match between the system and the real world**

Real-world language (common to users) should be used instead of technical / computer terms;

#### **3. User control and freedom**

The user must be able to decide when to abort an action or to go back in the system;

#### **4. Consistency and standards**

Similar actions should be performed in a similarly;

#### **5. Error prevention**

Errors must be eliminated or predicted;

#### **6. Recognition instead of recall**

The user must be able to perform actions naturally, without having to remember a past experience;

#### **7. Flexibility and efficiency of use**

To the experienced user hidden shortcuts must be revealed (key combinations, for example), but not the inexperienced user, so as not to confuse him;

#### **8. Aesthetics and minimalist design**

Only the essential must be shown;

#### **9. Help users recognize, diagnose, and recover from errors**

There should be error messages and suggestions for their resolution;

#### **10. Help and documentation**

A good interface should not need help. However, it must exist, accessible and online, to the user's case needs.

Nevertheless, competent problem detection can be a difficult task for one person. For this reason, a good heuristic evaluation of an interface results from the gathering of evaluations of different people.

## 7.1.4. Users

Users are an essential element for the development of an application since only when it is tested by real people it is possible to understand the interaction between them and the interface, as well as if it matches its purpose easily and clearly.

According to Jakob Nielsen, to obtain the best results from usability tests, only five users are needed because, by adding more, the same observations will keep appearing (Nielsen, J., 2000) . However, the evaluation of an app that has a distinct set of users needs to be done with more people. As street art is directed to any person who is interested in street art, it is necessary to test the behaviors of different people with distinct backgrounds. Nevertheless, even when the set of users is diverse, there will still be great similarities between the observations, as some behaviors are the same. By testing with distinct users, there is no need to include as many members of each background as it would be in a test of a single group of users (Nielsen, J., 2000).

Therefore, to evaluate street art, 10 users were selected, with an average age of  $31 \pm 13$  years and with different backgrounds such as designers, developers, a project manager, a teenager and adults with no technological experience. With this set of people, it was possible to get feedback regarding the application development, analyzing technical aspects, as well as to understand the interactivity between the interface and the general public. Each test had approximately the duration of 25 minutes.

### 7.1.5. Script and Expectations

This is the first step of the usability tests, where the application is presented to the users and its objectives are briefly explained.

“Thank you for participating in the street art usability test. Every information provided will be used to improve the application and the experience of future users, so any advice, observation and opinion (positive or negative) is welcome.

An increasing amount of cities is starting to invite artists to promote forgotten spots or to enhance degraded areas, but the information about the artworks created is usually unknown.

As a solution, street art application was developed to enrich the experience of seeing these artworks through augmented reality with supplementary information and animation.

The usability test will proceed as follows:

Firstly, I would like to know what kind of information and features you expect from this application to provide.

Next is the testing phase consisting of 4 tasks divided into several instructions for you to accomplish. The time it takes to complete each task will be recorded, and I will not be able to answer questions during this process. It should be emphasized that the purpose is to understand how a user interacts with the application.

When you finish performing the tasks, you will answer a brief questionnaire on Utility, Satisfaction and Ease of Use. After the questionnaire, we will discuss your experience during the tests.

Finally, your feedback is significant throughout this entire process so I can have a better perception of what a user thinks while using the application. ”

After, the user is asked what type of information and features he/she considers to be essential for this application to include. The reason for this is to discover from the beginning if it already contains every aspect mentioned and other features can be added.

### **7.1.6. Task List**

A task list was presented to the user to explore the entire application and know about its many features. Throughout this process, it was possible to understand the interactivity between the user and the interface and to take notes regarding the time of performance and difficulties in accomplishing some tasks.

#### **Task 1**

- 1.1. Enter street art;
- 1.2. Select only artists from Belgium;
- 1.3. How many available artworks from Smok are available in the application?
- 1.4. Where is located the artwork “Corner Fish”?
- 1.5. How can you reach that artwork?

#### **Task 2**

- 2.1. How many artworks are there in Coimbra?
- 2.2. Which one has the possibility to use augmented reality?
- 2.3. Who painted that mural?

### Task 3

- 3.1. When is it the next street art event?
- 3.2. What is it?

### Task 4

- 4.1. Use augmented reality on this mural;
- 4.2. Who is it from?
- 4.3. What's the name of the artwork?



**Figure 90:** User testing the application

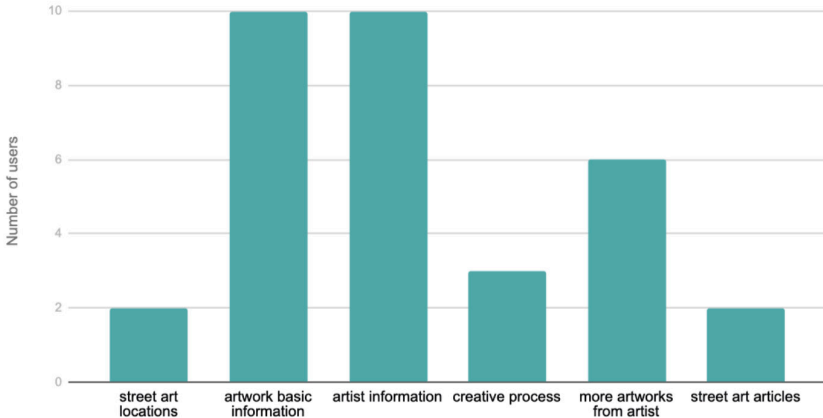
## 7.2. Results

This section contains the results of the usability tests, detailing each step done, analyzing and drawing conclusions about the notes taken throughout this process, as well as the feedback provided.



## 7.2.1. Expectations

After reading the script, each user was asked about their expectations regarding this type of application. The different answers can be seen in Fig. 91.



**Figure 91:** Different expectations from users

This step was very important since it clarified what kind of features users would like this application to have. Unanimously, results show that the possibility of getting to know about the artist and the history behind each artwork presented and the primary goal of using street art.

Besides, there were additional functionalities that users would like to see in the application such as the opportunity to discover more street art locations, to learn about the creative process of each artwork, present more art pieces from each artist available, and to read street art articles. Every aspect mentioned was available on the application, apart from the article section, which was posteriorly included.

In conclusion, this step revealed there is a great interest in discovering more about street art since it can sometimes pass unnoticed when the information is not available at the moment.

## 7.2.2. Time of Task Accomplishment

Table 3 presents different values according to the user performing the tests and concludes with an average of the results alongside the standard deviation. The standard deviation presents the data dispersion, indicating a low value because the times recorded are close to the expected value.

Table 3: Time of accomplishment of the tasks (1 to 4) and its average

	<b>Task 1</b>	<b>Task 2</b>	<b>Task 3</b>	<b>Task 4</b>
User 1	01:12	01:25	00:57	00:49
User 2	00:46	00:31	00:17	00:49
User 3	01:12	01:11	01:01	00:31
User 4	01:22	02:01	01:03	00:55
User 5	02:14	01:23	00:17	01:12
User 6	01:27	01:31	00:19	00:46
User 7	02:14	01:31	00:22	00:37
User 8	02:06	02:02	00:24	01:18
User 9	00:47	02:06	00:15	00:29
User 10	00:39	02:07	00:12	00:27
<b>Average</b>	<b>01:23±38s</b>	<b>01:14±25s</b>	<b>00:23±14s</b>	<b>00:47±17s</b>

## 7.2.3. Difficulties Encountered

Tables 4 and 5 represent the difficulties and failures encountered by users during the execution of each task.

**Table 4:** User’s difficulties while performing each tasks  
(user 1 to user 5)

	User 1	User 2	User 3	User 4	User 5
<b>Task 1</b>					
1.3. Find artist’s artworks	×			×	×
1.4. Finding the location icon	×	×		×	
<b>Task 2</b>					
2.1. Answered one instead of two	×	×	×		×
<b>Task 3</b>					
3.1. Answered a past event					×
<b>Task 4</b>					
4.2. Finding the information button					×

**Table 5:** User’s difficulties while performing each tasks  
(user 6 to user 10)

	User 6	User 7	User 8	User 9	User 10
<b>Task 1</b>					
1.3. Find artist’s artworks		×		×	
1.4. Finding the location icon	×	×		×	
<b>Task 2</b>					
2.1. Answered one instead of two	×	×	×	×	
<b>Task 3</b>					
3.1. Answered a past event		×			
<b>Task 4</b>					
4.2. Finding the information button					

The results show that task 2.1. was the most problematic one for users to accomplish, which consisted of finding how many artworks there were in Coimbra. The reason for this issue was the fact that the marker colors identifying the locations were easily mistaken with the rest of the Google Maps elements, making it hard to trace.

The second most challenging task was 1.4., on which users had to click the location button to find out the path to a certain artwork. This was due to the position where the button was placed on the screen, which was not consistent with the rest of the buttons, causing some trouble when finding it.

The rest of the errors reported were specific situations, where some users, after realizing how to complete the task, stated it was because they were nervous about accomplishing every task.

#### **7.2.4. Questionnaire**

At the end of the tasks, each user was submitted to a USE Questionnaire: Usefulness, Satisfaction, and Ease of Use, developed by Arnold Lund (2001), to measure the subjective usability of the application. Not all of the questions were used since some of them were not applicable to evaluate street art, and the answers can be found in Appendix B.

##### **Usefulness**

It helps me being more effective.

It is useful.

It makes the things I want to accomplish easier to get done.

It does everything I would expect it to do.

### **Satisfaction**

I am satisfied with it.

It is fun to use.

It is pleasant to use.

I would recommend it to a friend.

### **Ease of Use**

It is easy to use.

It is user-friendly.

It requires the fewest steps possible to accomplish what I want to do with it.

I can use it without written instructions.

Both occasional and regular users would like it.

### **Ease of Learning**

I learned to use it quickly.

I easily remember how to use it. 20.

## **7.3. Results Analysis**

### **Task 1**

The first task consisted of discovering the artists and artworks, navigating through their biographies and art creations. This task did not show significant problems since it is very straightforward and intuitive.

However, some users had trouble identifying the navbar and its buttons because of the size and position of the icons, consequently taking slightly longer to complete the task.

## **Task 2**

The second task was about the map section, where many users highlighted the fact that the colors identifying the artworks could be easily confused with the ones already existing in Google Maps. Because of this, many users did not notice some artworks indicated on the map.

## **Task 3**

The third task was regarding the event section, which had very positive feedback since it was an additional section that users did not expect.

## **Task 4**

In the fourth task, the users applied augmented reality to a mural displayed by a projector, with large dimensions to portray an actual artwork. The tasks consisted of retrieving information from the artwork presented, such as the title of the piece and who created it.

This was undoubtedly the task with the most positive reactions due to curiosity and excitement on using this technology. Every user reported that using the AR camera was extremely intuitive with precise image recognition.

Although everyone performed the task without difficulties, three users reported that the information button in the upper right corner of the screen was not very visible, making it difficult to search for information about the artwork.

Every issue mentioned during this process was afterward corrected to assure they would not be repeated again.

All in all, the feedback given by the users was positive, claiming that the application, intuitively and simply, does every task they would expect and more. The fact that it can be used all over the world is a great advantage, as well as the user-friendly interface that everyone with a mobile device can easily use, without previous experience with AR.





# 8. Conclusions and Future Perspectives

This chapter presents the conclusions taken of the entire work process, briefly addressing every step made towards the final result. Additionally, future perspectives are mentioned for the application.

## 8.1. Conclusion

This dissertation proposed to develop an application capable of presenting supporting information and media to artworks through augmented reality, exploring the role of this technology combined with art, specifically street art. The implementation of this project resulted in the scan of 20 artworks in total to retrieve information, 6 of which with additional animation.

The progress of this dissertation focused on the exploration of the augmented reality field, a process that was characterized by studying and applying the knowledge obtained in the development of an AR system. It began with a literature review, with which was possible to understand the state of augmented reality and the strengths of this technology, which is in an increasing state of growth due to the fact of being integrated into several areas. For this project, augmented reality intended to be applied to street art as a method of data representation.

Moreover, the street art movement was introduced, and also interviews conducted with various street artists to have a better insight into the topic. The following stage was dedicated to select several artworks to integrate into the application, from Antwerp, in Belgium, and Coimbra, in Portugal. The reason for choosing these cities lies in the fact that Antwerp currently has a strong street art influence, while in Coimbra the movement is still in the beginning. Additionally, it reinforces the fact that the application can be used in the whole world, as long as there is street art present. Accordingly, it was possible to create a database to store all of the gathered information about the defined artworks.

After the research phase followed the planning of the project. This process focused on the definition of the application's target audience, as well as prototyping through wireframes to determine the features to be implemented, as well as the navigation flow. Furthermore, the visual identity was created, adopting a suitable color palette and typography to represent the application, as well as creating a logotype, layout, and finally, mockups. This pre-structuring process eliminated some errors that could arise during its development, even though some changes were made in a posterior phase.

The next step was the implementation phase, which consisted of two parts: creating the animations and developing the application. The animations were created by selecting elements from the illustrations and considering the background of the artwork. Regarding the application, since its functionalities and layout were already defined, it consisted of analyzing the most appropriate technology to use, based on the study previously made and implementing the features proposed.

After the first prototype of the application being finished, as a way of understanding its usefulness, ten people were submitted to usability tests to verify that the various aspects of the project were well integrated. The people were chosen with different backgrounds to empathize the fact that the application is not directed to a specific age group or social status. This step not only allowed to test the application usability but also for the users to give suggestions on other features that could be added or aspects to be improved. After interpreting the results obtained from the tests, the necessary changes were made to improve the application.

The results of the tests revealed that the system created can communicate the information of the work and give it an innovative aspect, thus offering a new way of exploring street art and allowing the user to learn more about pieces through augmented reality.

After finishing the project, it is possible to conclude that all of the objectives proposed at the beginning of this dissertation were accomplished, having street art beta version now ready to be used.

## **8.2. Final Considerations and Future Perspectives**

This application consists of an engaging augmented reality system that offers the user the chance to augment artworks he/she wants to learn more about. Alongside the possibility to augment artworks, the application also allows the user to learn about different artworks and street artists, the location of other pieces, discover events and read articles about the street art theme.

The main objectives of this project were: to understand the augmented reality process and the different approaches available, to identify problems and challenges this field faces, and to be capable to present data in an augmented reality process. All of them, established at the beginning of this dissertation, were accomplished and, currently, a prototype is ready to be used. However, this application can improve since it still has a variety of options to explore.

street art consists of a junction of features that could constitute various applications where they are explored individually, due to the large amount of information being dealt with. In the future, this app

could benefit from the work of curators, who would update and deepen the content displayed.

Although at the moment the app is only limited to Coimbra and Antwerp, the existence of curators will consequently add more artists from more nationalities, promoting their work and making new styles and artworks known to users.



**Figure 92:** street art t prototype being used in Coimbra

Another aspect that can be added is the possibility for users to have their own profile, where they can contribute with artworks animation videos. Thus, if there are several animations for a single work, there could be a section where all could be accessible, and also the chance to give ratings to each. Curators, in turn, would verify to see if the animations are appropriate to be exposed. Also, because users have a profile, they may have a feature that allows them to register the places where they have already used the app.

Regarding the map, Google Maps could be integrated into the application if users are willing to pay for the required amount for the API, thus avoiding leaving the app and making their navigation easier.





# Notes

- [1] Google Glass, <https://www.google.com/glass/start/>
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# Appendix A

## Testimonials

The most effective approach to understanding the street art movement is to talk to artists themselves. Therefore, Portuguese and Belgium artists were contacted and sent a questionnaire to learn in first-hand about their points of view, beliefs, and creative process. The answers received were quite interesting, allowing to have an insight of street art in both countries. Also, it was important to comprehend and compare the realities of this artistic field between Portugal and Belgium, since the project is going to be developed with artworks of both countries. The answers of the Portuguese artists were translated to english.

# Samina

João Samina was born in 1989 in Portugal and currently lives between Portugal and Brazil. With 14 years old, Samina entered in the street art world by designing and spreading stickers on the streets. For several years, he accompanied the growing street art movement in Portugal and developing himself as a self-taught artist inspired by what he saw on the streets. During that time, he discovered the stencil and his ambition to grow as an artist was rising, feeling capable to build and produce bigger artworks.

Between 2007 and 2013, the artist took a Bachelor and Masters in Architecture, which gave him the knowledge to expand creativity. Samina is an artist in constant search for new challenges and experiences on every work that he builds, through stencil techniques combined with graphic design, painting, architecture and his own roots in street art<sup>63</sup>.



**Figure 93:** “MURAL for Conquista o Sonho - PPF” (“Mural for Conquer the Dream - PPF”, by Samina Portimão, Portugal, 2018)<sup>64</sup>

The answers below give an insight of Street Art in Portugal and the artist's point of view.

**1) How is street art evolving in Portugal?**

“Urban art is evolving well in Portugal. We have more and more initiatives and related events. Some brands also begin to value urban artists in a different way. But mostly there are more and better artists, and that is the most interesting and the main reason for things to go forward. For sure there is still a lot to evolve and grow but I think the way has been constantly rising in the last years.”

**2) What is the main theme in your artwork?**

“The theme always varies from work to work, from urban context to urban context. What I seek is to represent expressions through faces more or less known by the locals. The most important thing for me is for the expression portrayed to communicate with people. Obviously there is a concern and a purpose in the choice of the expressions. Sometimes it has to do with the place, others with a message that might be important to mark.”

**3) What is the most challenging factor in this type of artistic creation?**

“I think the most challenging aspects of mural painting is the context itself. It can be very challenging a wall of 4 or 5 floors by its insertion and dimension, as can be challenging a painting of 1m<sup>2</sup> in a certain specific place. The great challenge of mural art is to establish a certain connection with the place, in a direct or indirect way, more friendly or even provocative. To paint an urban context, always implies taking into account the same context, even if it is to subvert it.”

**4) How are the spaces/canvas chosen?**

“On larger murals, it is usually the event organizations that do the work of choosing and assigning walls. Other times I’m looking for some place where I find interesting to intervene. Whether large or small, while being small, it is naturally easier to find and run the project. Often abandoned places are excellent choices.”

**5) The inspiration strikes you spontaneously or is there a brainstorming process?**

“Sometimes there is an idea that comes more spontaneously than others. But there are also days when “things do not come out.” Obviously I know that the more available you are mentally to have ideas or to solve problems and you get solutions, the more that happens. You can not rely only on the inspiration “from heaven”, you also have to work and think a lot about things so that ideas flow. A brainstorming is always a help, for example.”

**6) Knowing that your artworks are exposed to nature’s elements, do you think that your art is ephemeral? How do you try to contradict that factor?**

“I do not think so, I’m sure that my art (on the street) is ephemeral and I do not do anything to contradict it. It’s part. There are other works, such as paintings or serigraphs, which are more timeless.”



**7) What separates street art of vandalism?**

“I think this is very personal. You can even do an incredible painting but if it is in a place where it is not supposed to be illegal, it can be seen as vandalism.”

**8) What is your opinion on augmented reality could be available to street art?**

“I think it might be interesting. This type of artistic expression has evolved and walked in different directions. More and more artists are keen to integrate new concepts and techniques into their work. Augmented Reality is another tool at your disposal. It is up to the artists to know if it is in their interest to integrate this into their work, even if it is timely. Personally I find interesting and there is not lack of ideas to be able to do interesting things in AR.”

Original version:

**1. De que modo a street art está a evoluir em Portugal?**

“A Arte urbana está a evoluir bem em Portugal. Cada vez temos mais iniciativas e eventos relacionados. Algumas marcas também começam a valorizar de outra maneira os artistas urbanos. Mas principalmente cada vez há mais e melhores artistas, e isso é o mais interessante e o principal motivo para as coisas em redor andarem para a frente. Com certeza ainda há muito a evoluir e crescer mas acho que o caminho tem sido a subir constantemente nos últimos anos.”

**2. Qual o tema predominante nas suas obras?**

“A temática varia sempre de trabalho para trabalho, de contexto urbano para contexto urbano. O que eu procuro é representar expressões através de rostos mais ou menos conhecidos pelos locais. O mais importante para mim é que a expressão retratada comunique com as pessoas. Obviamente há uma preocupação e um propósito na escolha das expressões. Uma vez tem a ver com o local, outras com uma mensagem que possa ser importante marcar.”

**3. Qual é o factor mais desafiante neste tipo de criação artística?**

“Acho que o aspectos mais desafiante na pintura mural é o próprio contexto. Pode ser muito desafiante uma parede de 4 ou 5 andares pela sua inserção e dimensão, como pode ser desafiante uma pintura de 1m2 num determinado lugar específico. O grande desafio da arte mural é estabelecer uma certa ligação com o lugar, seja mais directa ou indirecta, seja mais amigável ou até de provocação. Pintar um contexto urbano, implica sempre ter em conta esse mesmo contexto, mesmo que seja para o subverter.”

#### **4. Como é feita a escolha dos espaços/telas utilizados?**

“Nos murais maiores, normalmente são as organizações dos eventos que fazem o trabalho de escolha e atribuição das paredes. Outras vezes sou eu que procuro algum lugar onde ache interessante intervir. Seja grande ou pequeno, sendo que pequeno, naturalmente é mais fácil de encontrar e de executar o projecto. Muitas vezes, lugares abandonados são excelentes opções.”

#### **5. A inspiração atinge-o espontaneamente ou há algum processo de brainstorming?**

“Por vezes há ideia que chegam de forma mais espontânea do que outras. Mas também há dias em que “as coisas não saem”. Obviamente sei que quanto mais disponível estiver mentalmente para ter ideias ou para resolver problemas e arranjar soluções, mais isso acontece. Não dá para confiar somente na inspiração “vinda do céu”, é preciso também trabalhar e pensar bastante sobre as coisas para que as ideias fluam. Um brainstorming é sempre uma ajuda, por exemplo.”

#### **6. Sabendo que as suas obras estão expostas aos elementos da natureza, acha que a sua arte é efémera? Como tenta contrariar esse fator?**

“Não acho, tenho a certeza que a minha arte (na rua) é efémera e não faço nada para contrariar isso. Faz parte. Há outros trabalhos, como quadros ou serigrafias, que são mais intemporais.”

**7. O que separa a street art de vandalismo?**

“Acho que isso já é muito pessoal. Até podes fazer uma pintura incrível mas se for num lugar em que não é suposto e de forma ilegal, pode ser visto como vandalismo.”

**8. Qual é a sua opinião em relação ao facto de a realidade aumentada poder estar ao dispor da street art?**

“Acho que pode ser interessante. Este tipo de expressão artística tem evoluído e caminhado em diferentes direcções. Cada vez mais os artistas estão à vontade para integrar novos conceitos e técnicas ao seu trabalho. A realidade aumentada é mais uma ferramenta à disposição. Cabe aos artistas saber se lhes é interessante integrar isso no seu trabalho, mesmo que pontualmente. Pessoalmente acho algo interessante e não faltam ideias para poder fazer coisas interessantes em AR.”

# Pariz One

Pariz One is was born in 1984, graduated in audiovisuals, recognized international graffiti artist, Creative Director and art Curator.

The artist started doing graffiti in 1999, and collaborated and performed artworks on a professional level for individuals, private companies and brands.

In 2003, Pariz started travelling around Europe which gave the artist an overview upon different cultures and artistic expressions, having now worked in more than 60 cities around the world<sup>65</sup>.



**Figure 94:** “Two Of One Kind”  
by Pariz One and Telmo Miel -  
Lisbon, Portugal<sup>66</sup>

The answers below give an insight of Street Art in Portugal and the artist's point of view.

**1. How is Street Art evolving in Portugal?**

“I think it is progressing in a sustainable way, and at a normal “pace, it is due to the opening of more specialized stores, the continuous appearance of online material, and the reception of the local authorities to this art form.”

**2. What is the predominant theme in your works?**

“Futurism of the past and above all of the present.”

**3. What is the most challenging factor in this type of artistic creation?**

“The street! The walls are like screens in an open-air gallery, where you can find everything that is expected like the weather, the type of mural and the environment that surrounds it, the scale, but the most surprising is the fact that there is no know who is going to approach you, how you are going to approach, the feelings and emotions that your play can convey to these same people.”

**4. How is the choice of spaces / screens made?**

“It depends on whether the project is personal or if I am invited by an entity, at the first choice the location according to its location, the visibility of the piece is very important, and the surrounding environment, these two factors together determine the final result of the piece. In the second are given options by photo, I choose the mural to my liking based on the factors mentioned above.”

**5. Does inspiration reach you spontaneously, or is there a brainstorming process?**

“I am always very spontaneous in what concerns the general idea, the brainstorming comes a little later in order to complete in detail the general idea, above all it is a very purist process, the possible barriers already appear during the painting process, with additions complementary to the final work.”

Original version:

**1. De que modo a Street Art está a evoluir em Portugal?**

“Penso que está a a evoluir de uma forma sustentável, e a um ritmo “normal”, parte deve-se à abertura de mais lojas especializadas, do continuo aparecimento de material online, e à recepção das autarquias a esta forma de arte.”

**2. Qual o tema predominante nas suas obras?**

“O futurismo do passado e sobretudo do presente.”

**3. Qual é o factor mais desafiante neste tipo de criação artística?**

“A rua! As paredes são como telas em uma galeria a céu aberto, onde se pode encontrar de tudo o que é esperado como as condições climatéricas, o tipo de mural e o ambiente que o rodeia, a escala, mas o mais surpreendente é o facto de não saberes quem te vai abordar, a forma como te vai abordar, os sentimentos e emoções que a tua peça pode transmitir a essas mesmas pessoas.”

**4. Como é feita a escolha dos espaços/telas utilizados?**

“Depende se o projecto é pessoal ou se sou convidado por uma entidade, na primeira escolho o local consoante a sua localização, a visibilidade da peça é muito importante, e o ambiente envolvente, estes dois factores juntos determinam o resultado final da peça.

Na segunda são me dadas opções por foto, escolho o mural do meu agrado com base nos factores anteriormente mencionados.”



**5. A inspiração atinge-o espontaneamente ou há algum processo de brainstorming?**

“Sou sempre muito espontâneo no que toca à ideia geral, o brainstorming surge um pouco depois de forma a completar com detalhes a ideia geral, acima de tudo é um processo muito purista, as possíveis barreiras aparecem já durante o processo de pinturas, com adições complementares à obra final.”

# Pol Cosmo

Pol Cosmo is an artist from Ghent, Belgium, whose real identity is not known. His artwork main theme is insects that can be found all around Belgium, whose style is characterized by black and white drawings, bold lines and different patterns.

Although he is the only one who creates these pieces, there are several people who want to help spread his artwork and receive his insects by mail. They can post the insects with the condition that they will not vandalize spaces, but instead bring some color in the city, to make the neighborhood a nicer place to live and to surprise the people in a positive way.



**Figure 95:** Pelikaanstraat, Mural in the red light district of Ghent<sup>67</sup>

## **1. How is street art evolving in Belgium?**

“Over the past several years there is definitely a fresh flow noticeable in the Belgian street art scene. Both on the legal and illegal side of the scene. Every city seems to have his/her own street art festival: Ostend, Ghent, Antwerp, ... A lot of cities see the touristic potential of street art and become more open-minded towards graffiti/street art. Which can lead to a somewhat hypocritic situation where a city invites several artists to make big (legal) murals, but is very repressive towards the same artists when they make an illegal mural. On the illegal side, I have the impression that painting trains is bigger than ever (however, that might also be a false impression, simply because I’m more attentive to it lately).

Also, the graffiti/street art spotters are more organized (Ghentizm, Streetantwerpenaar, Street Art Cities, ...) which makes it easier to follow the scene on your computer, smartphone, ...”

## **2. What is the main theme in your artworks and why?**

“Insects, obviously! :-) But why...? They are small, hardly anyone notices them, yet they are incredibly important. If you want, you can see it as a metaphor for a lot of people in our society who do great work outside of the spotlights. Hardly anyone notices them, but they are so important. Gradually I became more and more interested in the real insects, nature, climate, ... (most people think it is the other way around: that I was an insect freak first and then started drawing them :-)) Finally, there is also a practical reason: insects, with their fragmented body structure, are just perfect for my drawing style which includes a lot of patterns.”

**3. What is the most challenging factor in this type of artistic creation?**

“The most challenging factor... I guess... overcoming my uncertainty and insecurity when I start drawing. Even though I’ve drawn so many insects by now, every time I have that little voice in my head that says “maybe you’ve lost it”.”

**4. How are the spaces/canvas chosen?**

“I choose places that are not so obvious. My insects are small and I put them where they feel most at home: somewhat hidden, close to the ground or crawling on the side of a wall.”

**5. Does inspiration strikes you spontaneously or is there a brainstorming process?**

“Both. There are days everything goes smoothly and other days where you’re struggling, thinking, trying, failing, ... The spontaneous days are the best. :-)”

**6. Knowing that your artworks are exposed to nature’s elements, do you think that your art is ephemeral?**

**How do you try to contradict that factor?**

“The ephemeral aspect is crucial in my work. Nothing lasts forever and certainly not in nature. It reminds me we should be humble in the face of nature. I work on paper and paste my bugs, but nature (rain, wind, sun, ...) takes it back when the time is ready. Some of my fans are troubled by the ephemeral aspect, but I think there is also beauty in the slow decay.”

**7. What separates street art from vandalism?**

“Beauty lies in the eye of the beholder... ;-) For me personally, I respect a certain ‘moral code’ which comes down to: don’t do anything you wouldn’t like yourself. So I don’t put my work on private houses on a freshly painted wall. I wouldn’t appreciate that myself. But it’s easy talking for me: I have a list of hundreds and hundreds of addresses where I can paste my insects (people can send me their address and I put them on a to-do list). Nevertheless, I still can’t resist the urge to leave some bugs on illegal places too... ;-)”

**8. What is your opinion regarding the fact that augmented reality could be available to street art?**

“I think new technologies can make the street art scene even more interesting, so I’m curious!”

# Smok

Bart Boudewijns, more known as SMOK, is a artist from Antwerp, Belgium. He discovered graffiti/street art when he was 14 years old and since then he has not stopped painting. His art works are known for depicting endangered animals, striving not only to make people smile with his pieces, but also to motivate them to think about nature, social awareness, and the human responsibility that lies therein<sup>68</sup>.



**Figure 96:** Artwork from Smok in St-Niklaas, Belgium 2018<sup>69</sup>

**1. How is street art evolving in Belgium?**

“It is becoming more and more ‘accepted’ in the cityscape. Some cities are really proud of their street art. There is even an alderman of street art in the city of Berchem.”

**2. What is the main theme in your artworks and why?**

“I mainly paint endangered animals. Because we (the people) are responsible for their extermination. Animals just live, they do not pollute and do not disrupt mother Earth.”

**3. What is the most challenging factor in this type of artistic creation?**

“Getting permits for good walls.”

**4. How are the spaces/canvas chosen?**

“It depends, sometimes they are commissioned (so not chosen) other walls are chosen because they attract me in some way. Or the walls are well located (lots of passersby...). I also like to paint in other cities/countries.”

**5. Does inspiration strike you spontaneously or is there a brainstorming process?**

“There is a process, but mostly the inspiration comes with the wall/location.”

**6. Knowing that your artworks are exposed to nature’s elements, do you think that your art is ephemeral?**

**How do you try to contradict that factor?**

“I’m not. I like the fact that it is ephemeral. It reminds us that we are ephemeral.”

**7. What separates street art from vandalism?**

“Some Art is Vandalism, but mostly the artist wants to bring a message that’s more than reacting by means of vandalism.”

**8. What is your opinion regarding the fact that augmented reality could be available to street art?**

“I think new technologies always bring new trends in the Art world. Artists are always developing so the inspiration is always welcome and comes from the weirdest corners.”







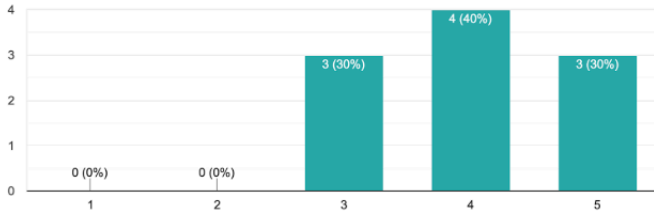
# Appendix B

## Answers to the USE Questionnaire

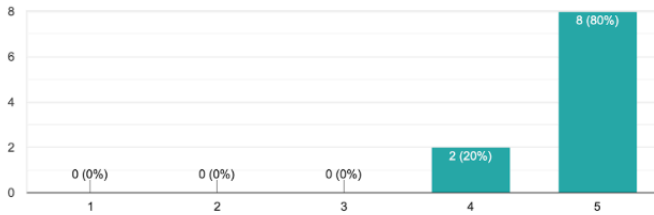
This section contains the answers from the 10 users who tested the application to the USE Questionnaire. The results are displayed in graphs for better insight into usability, satisfaction, and ease of use.

# Usefulness

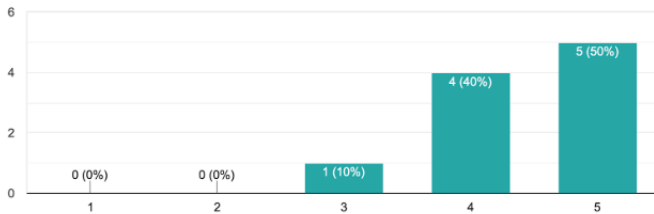
It helps me be more effective.



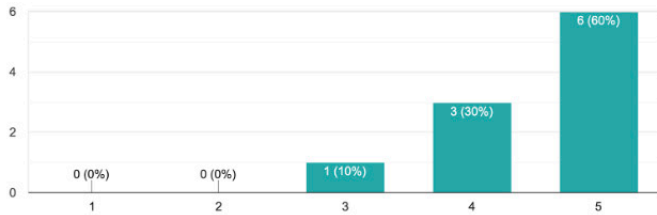
It is useful.



It makes the things I want to accomplish easier to get done.

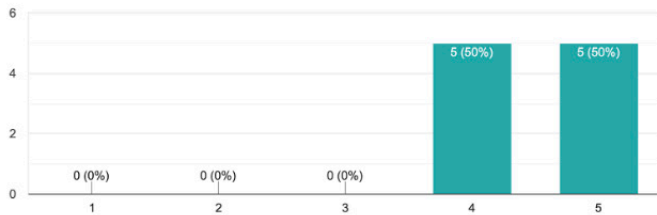


It does everything I would expect it to do.

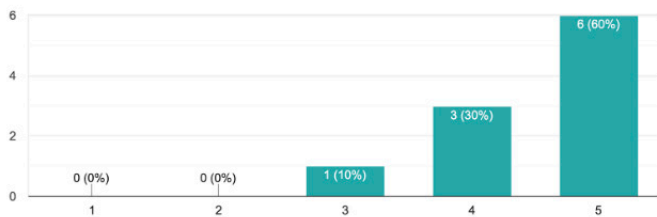


## Satisfaction

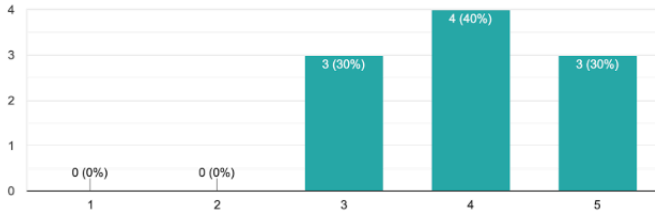
I am satisfied with it.



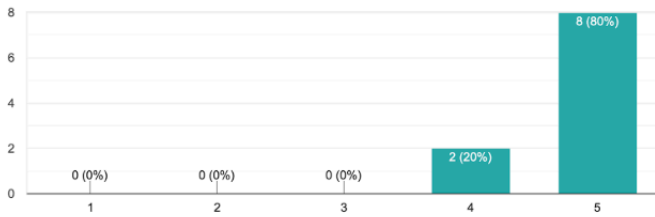
It is fun to use.



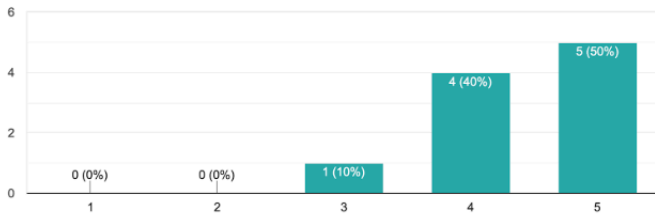
It helps me be more effective.



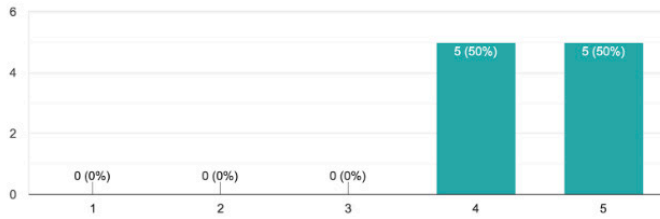
It is useful.



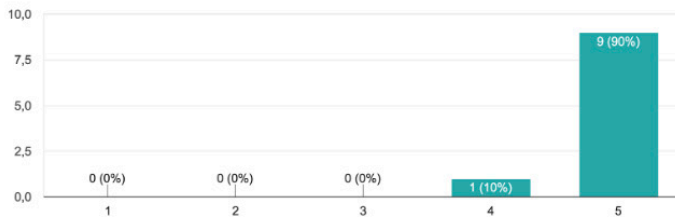
It makes the things I want to accomplish easier to get done.



It is pleasant to use.

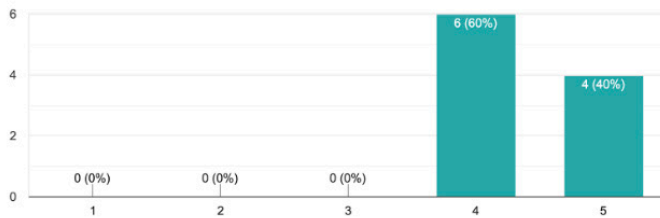


I would recommend it to a friend.

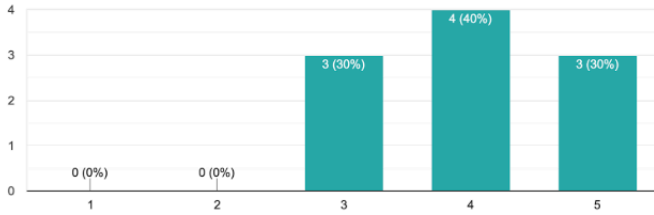


## Ease of Use

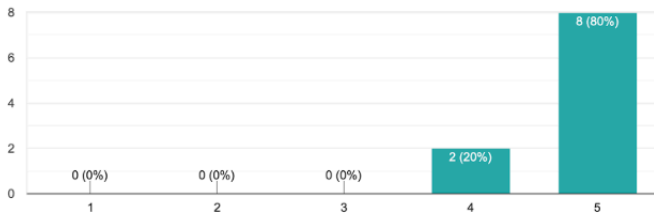
It is easy to use.



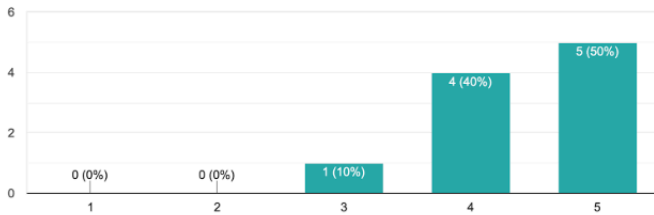
It helps me be more effective.



It is useful.

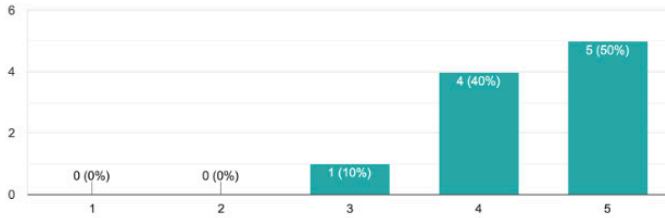


It makes the things I want to accomplish easier to get done.



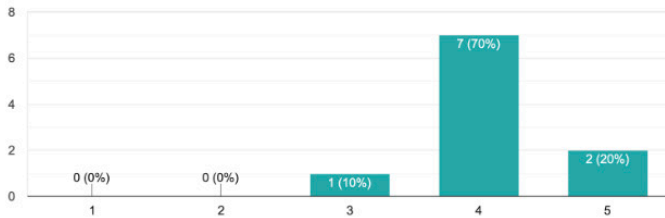


Both occasional and regular users would like it.



## Ease of Learning

I learned to use it quickly



I easily remember how to use it.

