Evaluating the use of mobile Augmented Reality as a digital communication tool

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Abstract

For over a century, mankind has been dreaming about technologies that combined reality with the wonders of the virtual world. Nowadays, Augmented Reality (AR) is doing just that, and with an emergence of AR in many new fields, there is reason to believe that it will be a widely used communication tool in the future. However, it is important to know what the benefits and disadvantages of AR is, not just from a user perspective, but also from a developer perspective. Therefore, a literature study on human communication and AR was performed in this thesis, along with the development of a mobile AR application, and also two surveys inquiring about the attitudes regarding AR present in people in the communications industry. The literature study showed that AR can help people process information by increasing the visualization aspect, and that it is a durable technology to the changes that languages go through. There is, however, a risk that AR can be an excluding technology, especially for older people, and the application development process also showed that there are compatibility issues to consider before developing.

Utvärdering av användandet av mobil Augmented Reality som ett digitalt kommunikationsverktyg

Sammanfattning

Acknowledgements

Many people contributed to this thesis in some way, and I would like to express my sincere gratitude and appreciation to them.

**Magnus Bäcklund** - My external supervisor at Humbly. Thank you for helping me with the direction of the thesis and making sure that I had the proper conditions necessary to succeed.

**Giuliano Garonzi, Isak Larsson, and the employees at Humbly** - Thank you for the effort you put into my work and the positive and hospitable atmosphere you provided.

**Shafiq Ur Réhman** - My supervisor at Umeå University. Thank you for your guiding hand through the whole process and answering any questions that I had.

**Daniel Sjöström and Katarina Hägglund** - My peer review group. Thank you for your helpful feedback and constructive criticism.

**Jasmin Simpfendorfer, my family, and Kajsa Palm** - Thank you all for your constant emotional support, without which this would not have been possible.
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1 Introduction

The idea of combining the reality with the virtual world is one that might have seemed improbable for a long time. However, in the minds of great visionaries and inventors, it has only been a matter of time before this idea became reality. As early as 1901, author L. Frank Baum, more commonly known for writing “The Wonderful Wizard of Oz” and the following sequels, wrote “The Master Key”, in which he fantasized about a world with what we today would call Augmented Reality (AR) [1]. What Baum imagined was a pair of spectacles that picked up electric signals to show information about the character of the people that you looked at, and this can be considered the first ever written record of the thought of AR.

In 1997, Ronald T. Azuma [2] defined Augmented Reality applications as a system that combines the real world with the virtual world, is interactive in real-time, and is registered in three dimensions. The benefit of this definition is that it avoids defining AR as something belonging to a specific piece of hardware or technology. With this in mind, if we consider Milgram’s proposal of the virtuality continuum [3], a scale ranging between real environment and a virtual environment, AR would be placed somewhere within the boundaries of Mixed Reality (MR), somewhat leaning toward the reality side of the scale (see Figure 1).

As previously stated, the idea of AR has been around for over a hundred years, but with the advances in mobile technology and the rise of the smartphone, this technology has now seen a huge leap forward compared to just a few years ago [4]. AR technology has the potential to change and improve the way we engage with information in many areas. For example, car advertisers could display their new models in more detail and context, tourists could gain new information about popular landmarks, and medical students could be able to perform procedures on a virtual patient for training purposes.

With the emergence of AR in many new fields, there is reason to believe that this technology will be a widely used communication tool in the future. However, this raises several questions regarding the suitability of this medium for digital communication purposes, both in regard to the users and the developers of such software. For AR to become a truly effective technology in this regard, the benefits need to be sufficient enough for both users and developers when compared to current communication strategies used in such mediums as posters and web services.

For example, how difficult is it to develop an AR application of a virtual art exhibit that can communicate with users in the same way as physical artwork can today? Would this sort of solution be beneficial to the end user when compared to the more traditional ways to consume information?
1.1 Objective

To assess the suitability of Augmented Reality for communication, several things need to be evaluated. First of all, it is important to establish what the benefits and disadvantages are for the users of AR solutions, and also what the possibilities and obstacles are from a developer perspective. The latter was tested by surveying people who work in the communications industry, more precisely at the company Humbly\(^1\), as they would have better insight into the current state of digital communications than many others. When compared against each other, these findings can hopefully provide insight into the overall suitability of AR as a digital communication tool. This thesis attempts to accomplish the following goals:

- Investigate Augmented Reality for digital communication purposes in regard to users.
- Investigate Augmented Reality attitudes among employees at Humbly with varying degrees of experience of developing for AR.
- Develop a simple mobile Augmented Reality application for a virtual art exhibit to assess the difficulties that can arise when developing AR applications based on image recognition (computer vision).
- Evaluate the findings and determine the suitability of Augmented Reality for digital communication purposes.

1.2 Humbly

This thesis is written in cooperation with Humbly, a communication and marketing strategy company based in Umeå, Sweden. Humbly was founded in 1994 under the name "Plakat", but has since re-branded and currently has 22 employees\(^2\). The company looks to key factors such as experience, curiosity, self-confidence, and humility to help them continually surprise and deliver more than expected, while always keeping the customers in mind. A wide range of skills and professions exists among the employees in several different fields, including project management, web development, digital creation, and digital strategy\(^3\).

\(^1\)Humbly (in Swedish): [http://www.humbly.se](http://www.humbly.se)


\(^3\)Humbly - Employees (in Swedish): [http://www.humbly.se/kontakt/](http://www.humbly.se/kontakt/)
2 Background

In order to fully understand the impact that Augmented Reality could have on our communication, we first need to look closer at ourselves, and see how humans both receive and relay information. For this to be possible though, we first need an idea of what the word ”communication” entails, regardless of how obvious this may seem.

2.1 The definition of communication

Defining communication is not an easy thing to do. Over the years, there have been many attempts at coming up with a definition, but time and time again it has proven to be a nearly impossible task [5]. The truth is that communication is not just one discipline, but rather many different types of human interaction patterns that should not be lumped into one single definition. The different types of communication can include anything from two people talking to each other, one person speaking to several others, or a human trying to convey a message to a monkey. From this, it becomes clear that defining communication as a single thing is not just difficult, but also perhaps, in some cases, unnecessary. Instead, it is believed to be preferable to let communication be defined by several other definitions all together, as these definitions help theorists be more flexible in their scientific endeavours [5].

For these reasons, this thesis intentionally uses a very wide definition of communication from the Oxford Living Dictionaries [6]. This definition refers to communication as:

The imparting or exchanging of information by speaking, writing, or using some other medium.

2.2 Fundamentals of human communication

Now that communication has been defined for the purpose of this thesis, the next step is to look at how humans work, and what makes us unique in the way we deal with information.

Compared to other animals, it is not a stretch to claim that humans are an advanced species in the way we communicate. However, there are certain examples of animals that can communicate at a high level within the species. One of these examples is the communication of prairie dogs. Studies have shown that these animals are some of the more advanced ones when it comes to the way they talk to each other [7]. When
looking at the acoustic structure of their bark-like warning call\(^1\), it has been observed that they have different types of calls depending on what predator is approaching them [7]. It has even been shown that the arrangement of the components that make up their sound represents a syntax that shows an underlying grammar in their language [7].

This example might seem irrelevant in regards to human communication, but it is not. The fact is that the communication of prairie dogs is one of, if not, the most advanced forms of animal communication known to humans [8]. Still, however, the communication of these animals do not even come close to the complexity of the speech and general information distribution that humans are capable of. What this shows is that humans possess a form of communication that requires lots of work to be fully understood.

2.2.1 Verbal communication

Communicating, in the sense in which it relates to humans, is an attempt to share ones thoughts with others. However, can thoughts really be shared? Thoughts never really leave a person’s mind. They come into existence, live, and eventually disappear from there [9]. The best thing a person can do to portray these thoughts is to perform some action, such as speaking. By doing this, a thought becomes represented as something else, and it is eventually this representation that the receiver of the attempted communication is presented with.

After the speaker of the communicated messages has done all this, the work starts for the receiver. In the most simple forms of communication, the speaker says something and means exactly and literally what he or she says [10], but communication is rarely this simple. In fact, there are several cases where sentence meaning (what the sentence literally means) and speaker’s meaning (what message the speaker is trying to convey) differ, such as hints, insinuations, irony, and metaphors [10]. A lot of the communication that humans use have a speaker’s meaning that differs from the sentence meaning. For instance, if Mary was to tell James “Can you pick up the kids from school?”, she is implying that she wishes that James would do so, and not just inquiring about whether or not he possesses the ability to perform the action.

Another important facet of verbal communication is the separation of the sentence’s tone and content. When a sentence is spoken, the receiver has to decode both of these in order to fully understand the intent with which it is uttered. Research has shown that the independent effects of tone are overall stronger than the independent effects of content [11]. From this it can be derived that what a person says most often matters less than how the person says it.

2.2.2 Written communication

Another part of human communication, one that is seemingly unique to our species [12], is the use of written language to communicate. There are several plausible reasons as to why this type of communication has become unique to humans, and one of these is the need for humans to remember things over a longer period of

\(^1\)It is this barking sound that gives the animal, which is not a dog at all, its name.
time. With the advancement of technology, and the increasing amount of tasks that humans encounter on a daily basis, the developing of a written language was eventually necessary to be able to stay organized [12].

One of the major advantages for our species when it comes to having a written communication system is the relative simplicity with which it can be preserved over long periods of time. An example of the longevity of written records is the famous Dispilio tablet, which is an ancient Greek wooden tablet with inscribed markings that has been \( C_{14} \) dated to about 5,260 BC [13].

Language, however, is not a static thing, but rather something that undergoes constant change, albeit an often slow and unnoticeable one [14]. This can be a downside of written communication, as the meaning of texts and inscriptions from different times can sometimes be unrecoverable due to a language’s difference over time\(^2\). Changes in a language can be set off by several different things, such as new inventions that change the needs for the speakers of a certain language, or, as was the case in 18th century England, something as specific as having an upper class with an affection for Latin [15].

2.2.3 Body language communication

Just analyzing the way humans form sentences and use language to communicate will not provide the full picture of the way people share information. As previously stated, humans are complex beings with multifaceted communication systems, and this becomes evident when the combination of nonverbal and verbal communication is analyzed.

It has proven difficult to determine exactly how much of human communication that can be attributed to body language communication. One of the most widely referenced percentages regarding the distribution of the different channels of communication is the 55/38/7 formula, which says that when it comes to human communication, 55 percent of it can be attributed to body language, 38 percent of it to the tone of voice, and 7 percent to the actual words spoken [16]. These numbers should not, however, be seen as an absolute truth that is applicable to every situation in which humans communicate, and this is due to the three C’s of nonverbal communication: context, clusters, and congruence [16].

Starting with context, there are several things that factor into how the previously presented distribution will look in a given communication scenario. For example, if the communication scenario takes place outside, as opposed to inside, people might use different tones of voice because of the level of background noise, which could change the importance ratio of this channel. Context can also mean the relationship between the people involved in the communication scenario. For example, bosses might care much more about the body language of their employees than that of their personal friends, since they have different expectations of their demeanor.

Secondly, we have clusters, which is one of the most important aspects of nonverbal communication. This is a technique that helps humans understand others’ state of mind or emotions as a whole and not just as individual visual inputs. An example

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\(^2\)This has (so far) been the case with the previously mentioned Dispilio tablet.
of this can be a person who is sitting with their arms crossed, shoulders raised, and teeth chattering, which would indicate that they were cold. If we were not able to see these gestures as a whole, but rather individually, we might incorrectly reach the conclusion that the person is resistant or close-minded, simply because they have their arms crossed [16].

Finally, congruence refers to how well the spoken words match the tone and the body language of the speaker [16]. An example of this could be if someone verbally states that they did not find something funny, but at the same time cannot stop laughing or smiling. In this case, it could be reasonable to give less than 7 percent of the distribution to the actual words spoken, since all other communication channels give strong evidence supporting the idea that they did indeed find it funny.

### 2.2.4 Augmented Reality and communication

The use of Augmented Reality for communication purposes is perhaps most apparent in educational contexts. The lack of interest in the course material and low levels of motivation among students are both common complaints among teachers, and it is becoming increasingly difficult to attract the attention of students [17]. Additionally, some students take longer time to learn than others, and this can cause motivational problems. AR has the potential to let students take control of their own learning in a new way, and this could spark an efficiency in the way students consume information [18]. The use of AR technology in schools can, with its entertaining and engaging nature, attract and stimulate students in their academic pursuits [18]. However, the adoption rate of AR in educational institutions is still slow, as the costs of development and maintenance of this technology are still high [18]. Also, the integration of AR with the more traditional learning methods is not something that happens over night, but rather something that requires some time to be properly handled [18].

Another area for AR applications to work in is tourism. Given that information technologies are becoming one of the most important communication tools of our time, tourist organizations will have to construct more attractive multimedia based content to attract tourists [19]. While some museums and art galleries have already started applying digital information to their exhibits to increase the visualization capabilities of its visitors, AR could also enhance tourists’ experience of historical monuments by reconstructing them with a digital layer visible through a phone or a pair of AR compatible glasses [19]. Another benefit to this sort of information, apart from the visualization aspect, is the opportunity for content to be personalized according to a user’s unique characteristics and interests [20].

AR applications can also find a use in an area related to tourism, and that is navigation. At Google I/O in May 2018, Google showed off new features that they had been working on, and one included bringing an AR mode to Google Maps [21]. The AR mode would be a superimposition based approach (see subsection 3.1.1), and would display directions on top of the real world to help the user figure out what way to go. Similar ideas have been floated by Google in the past regarding Google Glass, but unlike those ideas, the new feature for the mobile app would not require any additional headset, but could simply be viewed through the mobile camera. In addition to the navigation provided in the app, the new AR mode would be able
to identify nearby places and display information about them [21]. The benefits and disadvantages of this area of use for AR are difficult to determine at this stage however, due to the early phase that this development is in.
3 Theoretical framework

This section will present the theoretical framework necessary for a better understanding of the thesis and its conclusions.

3.1 Types of Augmented Reality

When it comes to Augmented Reality, there are several different ways that an application can gather information to learn about the user’s context. At certain times, the differences between the five main types of AR [22] may seem difficult to grasp, but understanding what makes them unique is essential for a better understanding of the topic.

3.1.1 Computer vision

Computer vision is an essential tool for many AR applications. What computer vision means is a computer’s ability to perform image recognition, image processing, and object identification, much like the human vision does [23]. This is a type of AR technology that has a different purpose and area of use than the pure sensory approach (see section 3.1.2), but these can also be used together.

Projection based Augmented Reality is a type of AR technology that projects digital objects onto the physical world [22], and does not have to be seen through a phone or another type of device. The low cost and high availability of projection based technology makes this type of AR a more accessible and attractive one to consider for many companies who look to develop AR applications [24].

A difficulty that can arise when using projection based AR is the obstacle of projecting digital information onto a heterogenic surface. There are, however, certain solutions in place for this, such as the use of cameras that can provide the system with 3D information to help understand the topography of the surface onto which the projection will happen [24]. This information can be processed by the system, which will use it to prepare the image that is going to be projected to appear in a visually correct manner [24].

Recognition based Augmented Reality is one of the most widely used types of AR [22], and is based on three fundamental phases: detection, tracking, and recognition [25].

The first part of this process, the detection phase, is of vital importance to the quality of the system. Here, the task-relevant information is separated from the image’s background [25], which allows the system to know what visual information to process and manipulate. Several indicators are used to help with this detection,
such as shape, motion, and also skin colour and anatomical models [25] in the case of identifying human bodies or body parts.

The second phase begins after detecting and identifying the object, and this is called the tracking phase. What this phase is responsible for is making sure that the system can continuously identify the detected object in an image that keeps changing. Tracking, in this form, is a frame-to-frame correspondence of the segmented regions [25]. This phase also maintains a way for the system to estimate variables and features that are not visible at a certain moment in time [25].

The third and final phase of this type of AR is the recognition phase. This part is responsible for understanding what it is that has been previously segmented, and what to do with the information. This phase requires the system to use some form of learning method in order to achieve a high accuracy [25].

An example of recognition based AR is the mobile application Inkhunter\(^1\), which allows a user to see what a virtual tattoo would look like on their body before getting it (see Figure 2). This app works by recognizing a certain symbol that the user has to draw on his or her body, and then replaces the symbol with a virtual tattoo that the user chooses in advance. The user can then see what the tattoo looks like on their body from different angles in real-time.

![Figure 2: An AR tattoo projected onto an arm by Inkhunter.](image)

\(^1\)Inkhunter: http://inkhunter.tattoo

A third type of AR is **Outlining Augmented Reality**, which, as the name sug-
gests, works by outlining objects, mostly with the intention to increase their visibility. An example of this can be to outline the side of a road, which would increase the visibility for drivers. This sort of object recognition technology could also help by outlining pedestrians and other objects that the driver should avoid [26]. A system like this could include cameras on the outside of the car, and would use the windscreen as a Heads Up Display (HUD) [26].

As another type of computer vision AR, Superimposition based Augmented Reality might seem a lot like the recognition based approach. However, what makes this type unique is that it superimposes an augmented image onto the original view [27]. One of the most famous examples of this is IKEA’s mobile AR furniture catalog application\(^2\). With that app, the user can browse through a digital catalog and see how the furniture will look when placed in their home, all by holding up their phone or tablet.

3.1.2 Sensory based AR

Moving away from the computer vision types of AR, there are examples of applications that can implement this technology without using image recognition. These are based solely on sensory information, such as the phone’s GPS to position the camera, the compass to infer direction, and the accelerometer to identify the tilt [28].

The obvious disadvantage to this type of solution, is that the sensory information gathered by your phone can be inaccurate, even with the modern technology we have today. Compass errors that are measurable in tens of degrees can derail the camera’s line of sight, and GPS errors of five metres or more can exacerbate the conditions [28].

In contrast to a computer vision based approach, Location based Augmented Reality applications have benefits in several other areas. For instance, whereas computer vision AR needs to recognize certain objects in order to display information, location based AR can do this at any time, provided that there is some form of information to display. Knowing where a user is at any time can also improve the application through the means of notifications when there is information nearby that could be displayed. Alerting the user of such things can be crucial for making sure that the application shows off as many of its features as possible, as there is a risk that some of them could go unnoticed if the user was not notified of them, which would therefore lower the overall impression of the application.

3.2 Latency and accuracy

Given the different approaches to Augmented Reality solutions presented in section 3.1, it is important to know the pros and cons of these different strategies, and these mostly relate to issues regarding latency and accuracy. Computer vision based AR is much better when it comes to accuracy, but using an application that only uses this strategy will come with a trade-off of latency [28].

What has been found is that solutions that combine the different approaches are usually successful, and can decrease both their latency and accuracy problems to an extent [28]. Mobile AR applications are not best addressed through either sensing or computer vision in isolation, but rather a combination of the two. This combination can use the GPS data and compass readings to estimate what recognizable objects are in the user’s vicinity, and thereby reduce the image recognition and identification processes to a sub-second latency by filtering the back-end database in advance [28]. For example, if it is known that objects A, B, C, and D are in spatial proximity, it might be possible to pre-fetch information about objects B, C, and D when the user is currently looking at object A [28].
4 Methods

In this section, the methods used in the study will be presented. This involves a literature study regarding Augmented Reality from a user perspective, surveys directed at employees at Humbly to assess the general attitudes surrounding AR, and development of a simple AR application to test the perceived difficulties in the development phase.

4.1 Literature study

To be able to obtain a view of the benefits and disadvantages of Augmented Reality as a digital communication tool from a user perspective, a literature study was conducted in a number of different areas of use for AR. The study involved the use of AR within education, tourism, and navigation (see subsection 2.2.4). In addition to this, the literature study also involved the investigation of some of the technologies on which AR is based (see section 3.1). The literature was gathered using both Google\(^1\) and Google Scholar\(^2\), and included books, scientific articles, and also websites, blogs, and news stories that were deemed credible enough for the study.

4.2 First survey

By sending out a survey to employees at Humbly, the attitudes regarding the possibilities and main concerns about the use of Augmented Reality was brought to light. The survey was created using Google Forms, and was divided into four different sections: introduction, general information, knowledge and experience of AR, and attitude regarding AR.

The survey was pilot tested on two men in their twenties, both with knowledge of the thesis and its area of research. The pilot tests were performed by sending out the surveys to these men, and having them answer the questions and report back any thoughts that they had. As a result of this, several changes were made from the original question layout, and some of these are referenced below. The survey was sent out via email on Tuesday, the 20th of March 2018, and remained open for answers until the afternoon of Friday, the 23rd of March 2018.

The first section of the survey only included the title of the survey, ”Experience and Attitude About Augmented Reality”, and an introductory text (see appendix

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\(^1\)Google: https://www.google.se

\(^2\)Google Scholar: https://scholar.google.se
A). This text explained the purpose of the survey, what parameters it wished to measure, and how the results would be handled.

The second section of the survey dealt with questions regarding the general information of the respondent. The first question (see appendix A, question 1) asked of the age of the respondent, and did this by allowing them to choose an age interval. The reason this was chosen, instead of letting the respondent enter their exact age, is because of the small target group of the survey. In order to assure a reasonable protection of a person’s anonymity, it is essential to not phrase questions so that a person can be identified by the answers provided [29]. In such a small target group, it would, for instance, be easy to identify the only person that is both a woman and 27 years old. With the larger age intervals as response alternatives, anonymity can be assured to a much higher degree.

The third section of the survey asked questions that, just like the title of it implies, had to do with the respondent’s knowledge and previous experience of AR. The first question of this section (see appendix A, question 4) asked the respondent to subjectively assess their own knowledge of AR, and was originally asked with the response alternatives being on a scale, with labels for the highest and lowest values. This scale went from 1, with the label ”Very little knowledge”, to 5, with the label ”Very much knowledge”. After analyzing the feedback provided from the pilot tests, this was later changed to the current format. The problem with the first type of answer format was that the response alternatives did not cover all possible scenarios. The respondent could perhaps not know anything at all about AR, in which case they would have to overestimate their current knowledge and answer ”Very little knowledge”. The lower label was therefore originally changed to ”No knowledge at all”, but this led to the problem of balanced response alternatives, as it did not make sense to have the higher label say ”All the knowledge”. After these considerations, the current format was selected.

The fourth section of the survey was a bit more free in terms of the response alternatives, and dealt with the general attitudes the respondent had toward the use of AR. The questions that generated the most beneficial results were most of the ones with free text answers (see appendix A, question 8, 9, 11, and 12), both regarding the benefits and disadvantages of AR from a user perspective, and the positive effects and difficulties that could arise from being part of the development process of an AR application. The phrasing of these questions was constructed as a result of comments from the pilot tests and a careful consideration of word choices.

4.3 Application development

After the literature study and survey was conducted, a simple, computer vision based mobile Augmented Reality application was created to test the development process from an inexperienced developer’s point of view. The application was primarily developed using Unity 3D\(^3\), which is a game engine often used to develop 3D games for computers and mobile phones. Vuforia\(^4\), which is an AR Software Development

\(^3\)Unity 3D: https://unity3d.com

\(^4\)Vuforia: https://www.vuforia.com
Kit (SDK), was also used for the supporting database, and Cinema 4D\textsuperscript{5}, a 3D modeling and animation application, was used for creating animated 3D objects. The created application presents a virtual art exhibit within the office of Humbly.

The development process started with an establishing of the scope of the project, and a decision regarding the time frame of the process. It was decided that the project would encompass the creation of a working mobile AR application that would use the recognition based computer vision approach discussed in subsection 3.1.1, and be able to identify three different targets and project either an image or a 3D object onto them.

After the idea and scope had been decided upon, research was done regarding what different platforms, programs, and tools that would be used for the development process. After careful consideration, it was decided that the AR application would mainly be developed using Unity 3D. This decision was based on the recommendation of others, the work done in previous master’s theses, and by the large availability of online tutorials and forums. The decision to use Vuforia, and its SDK for Unity, was made because of its easy integration with Unity projects, and also because of the quality and usability of the tool itself.

4.3.1 Setup process

Following the decisions made regarding what software to use, the setup process began. This started with an installation of Unity with the Vuforia SDK and Android Build Support in order to make sure that the created application could be built to an Android phone, more precisely a Samsung Galaxy S7 Edge.

With Unity downloaded, the work switched to setting up the database on Vuforia’s website. The database, also known as the Vuforia Target Manager, consisted of several images that were tested as targets for the future AR app, which means that the software created in Unity would detect, track, and recognize these images so that they could be augmented. The Vuforia Target Manager made the process of uploading image targets easy, due to a function that gave each target a star rating\textsuperscript{6} from 0 to 5, which corresponded to how augmentable it assessed that the target would be when implemented. This augmentability rating was tested in Unity by importing the targets from the database, and it was determined that even a target with a rating of 1 star (see Figure 4) was tracked with relatively high precision. A 0 star rated target, however, could not be recognized at all when tested in Unity.

The three images that were used for the development of the virtual art exhibit (see Figure 3, Figure 4, and Figure 5) were selected based on a list of factors provided by the Vuforia forum FAQ section. The factors that determine whether or not a target will be accurately detected, easily trackable, and therefore augmentable are [30]:

- If the target is rich in detail, such as a street-scene or a group of people.
- If the target has good contrast, is well lit, and is not dull in brightness or colour.

\textsuperscript{5}Cinema 4D: https://www.maxon.net/en/products/cinema-4d/overview/
\textsuperscript{6}Vuforia’s own documentation claims that the rating is from 1 to 5, but one potential target uploaded during the development of the project for this thesis got a rating of 0 stars.
• If the target does not have repetitive patterns, such as a grassy field, and other regular grids and patterns.

Based on these factors, Figure 3, Figure 4, and Figure 5 received a star rating of 5, 1, and 4, respectively.

![Figure 3: An image used as a target in the virtual art exhibit.](https://www.publicdomainpictures.net/pictures/250000/velka/dog-street-art.jpg)

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7URL to image source: [https://www.publicdomainpictures.net/pictures/250000/velka/dog-street-art.jpg](https://www.publicdomainpictures.net/pictures/250000/velka/dog-street-art.jpg)
4.3.2 Unity development process

Through Vuforia’s web interface, the database of targets was downloaded as a Unity package file to ensure a simple importing process to the Unity editor. After the targets were imported into Unity, three Vuforia camera image targets were placed in the Unity project scene, and the images from the downloaded database were selected.

* Figure 4: An image used as a target in the virtual art exhibit\(^8\).

* Figure 5: An image used as a target in the virtual art exhibit\(^9\).

\(^8\)URL to image source: https://www.kunstkopie.de/kunst/karl_ederard_ferdinand_blechen/blechen_teufelsbruecke.jpg

\(^9\)URL to image source: https://c.pxhere.com/photos/04/4d/surrealism_arts_digitalpainting_eclipse-163886.jpg!d
for them. The images were printed out to A4 paper sheets, and their ability to be correctly tracked was tested inside the Unity editor through the "Play" preview tool, which allows the application to be run without having to build it to a unit. All targets were tracked with high precision.

The work continued with the help of Humbly employee and designer Isak Larsson, who created two 3D models (see Figure 11 and Figure 12) that were used in the project. These 3D models were placed as children to two of the targets (the ones seen in Figure 3 and Figure 4) and positioned on top of them in the Unity scene. This positioning allows them to be augmented onto the printed images when viewed through a camera.

The 3D model (see Figure 11) created for the image target containing a dog (see Figure 3) included a looping animation of a virtual butterfly flying away from the dog in the image, and then proceeding to come back to land on it again. A virtual button was also placed on the target so that the user could start the animation by pressing the button while using the application. This functionality was added to the 3D model by creating a C# script that registered when the button had been pressed and when it was released. When pressed, the 3D model would switch to a state known as "fjarilflyger", which would activate the animation. When released, however, the 3D model would switch to a state known as "fjarilstilla", which in turn would stop the animation.

### 4.3.3 3D design process

To create the third and final 3D model (see Figure 13) for the project, Cinema 4D was used. The idea for the remaining target (see Figure 5) was for it to have two large spheres burst through its surface from behind and then fall back down and land on the face of the image. This effect was produced by creating a plane object with the same texture as the image target, and adding a Collision object and a Jiggle object to this plane. Two sphere objects were then created and added to the list of objects that could collide with the plane.

Following this, two splines, one for each sphere, were created, and the spheres were subsequently aligned to these splines. The 3D model contained an animation, and to this animation two keyframes were added, one at frame 0 of the animation, and one at frame 60. The spheres were then set to be positioned at the beginning of the spline at the first keyframe, and at the end of the spline at the second keyframe. Given that the animation is played at a frame rate of 60 fps, and that both of the splines began on one side of the plane’s surface and ended on the other, this created a one second animation that showed the two spheres bursting through the plane and making it jiggle as a result.

The final step in creating the 3D model’s animation in Cinema 4D was to make the spheres fall back down and land on the plane. This effect was produced by adding a floor object directly underneath the plane, and by giving the spheres a soft body simulation tag, which allowed them to start falling towards the ground. The animation was extended to a total of 90 frames, and this meant that the final half second of the animation showed the two spheres falling down and landing on the surface of the plane. The 3D model and its accompanying animation were exported
as FBX files and subsequently imported to Unity.

4.4 Follow-up survey

Following the application development phase, a presentation of the work process described above (see section 4.3) was given to the employees at Humbly. In the presentation, the ups and downs of the process were discussed and the listeners could ask questions about anything relating to the application and its development. After this, anyone who wanted to could try out the application for themselves to get a feel for how it worked when used. The reason for giving this presentation was to lay the foundation for a follow-up survey that would assess whether or not the attitudes present at Humbly regarding the use and creation of Augmented Reality applications had changed since the time of the survey that was distributed at the beginning of the work for this thesis (see section 4.2).

The survey was distributed to the respondents of the previous survey via email on Monday, the 7th of May 2018, and remained open for answers until the afternoon of Friday, the 11th of May 2018. This survey was not as lengthy as the former, and only consisted of an introduction and four subsequent questions. The introduction only included the title of the survey, "Experience and Attitude About Augmented Reality", and an introductory text (see appendix B). Just as in the first survey, this text explained the purpose of the survey, what parameters it wished to measure, and how the results would be handled.

The two questions in this survey that were fundamental to the following analysis were the ones that asked about the respondents attitude regarding the use and creation of AR applications (see appendix B, question 2 and 3). The first one of these was based on a question from the first survey (see appendix A, question 7), and, for the sake of comparison, asked the same thing, which is what the respondents general attitude regarding the use of AR for communication purposes was, on a scale of 1 to 5. This question did, however, differ a bit from its counterpart, as the question expressly told the respondent to consider their attitude following the presentation that they had viewed. The second one of these questions asked the respondent to provide their general attitude, on a scale of 1 to 5, regarding the idea of creating more AR applications in the future, and was phrased the exact same way as its counterpart in the previous survey (see appendix A, question 10).

4.5 Survey data analysis

After the data from the follow-up survey was collected, an analysis was performed to check for any significant differences in the mean values of the data from the corresponding questions. The first comparison was made on data from the questions asking the respondent to provide their attitude regarding the use of Augmented Reality applications for communication purposes (see appendix A, question 7, and appendix B, question 2). The second comparison was made on data from the questions asking the respondent to provide their general attitude regarding the idea
of creating more AR applications in the future (see appendix A, question 10, and appendix B, question 3).

The analysis was performed by running two separate two-sample t-tests in Minitab\(^{10}\), one for each comparison to be made. The t-test, however, assumes that the variables that are going to be tested follow a normal distribution, and this was not the case for any of the data in this analysis, as was shown by performing normality tests. The t-test is robust to non-normality though, and can still be used as long as the sample sizes are large enough \([31]\). This is not a perfect scenario for the relatively small sample sizes used in this analysis, but the two-sample t-test was still deemed the most appropriate test available for comparing the means of the variables. This does, however, mean that the results will not be completely reliable, which needs to be considered. Tests for equal variances were also performed, and the variables that were compared to each other were shown to have variances similar enough to warrant the assumption of equal variances in both of the two-sample t-tests.

\(^{10}\text{Minitab: http://www.minitab.com/en-us/}\)
5 Results

In this section, the results of the work will be presented. This will include a presentation of the survey responses, the application development process, the application itself, and the analysis of the data from the surveys.

5.1 First survey responses

During the three days that the first survey was open for incoming responses, 14 employees at Humbly filled it out and sent in their thoughts. The following subsection will present the responses collected from the survey.

5.1.1 General information

Out of the 14 respondents, eleven were male, and three were female. The age of the respondents ranged from 20-29 years old to 50-59 years old (see Figure 6).

![Figure 6: Distribution of age among the respondents.](image)

The respondents of the survey all worked within four different areas of employment at Humbly, with the largest one being creation/design (see Figure 7).
5.1.2 Knowledge and experience

As mentioned in section 4.2, the third set of questions all inquired about a person’s subjective knowledge and previous experience within the field of Augmented Reality. As can be seen from the results (see Figure 8), there is a wide spectrum of answers when it comes to a person’s perceived knowledge of AR. Two individuals reported their knowledge being a 2 out of 10, while three others said that their knowledge would classify as an 8 on the scale.

Looking at the answers (see Figure 8), the mean value can be calculated, with a precision of two decimals, to be 5.37.

Figure 7: Distribution of area of employment among the respondents of the first survey.

Figure 8: Distribution of subjective knowledge of AR among the respondents.
When it comes to the other part of the third section of questions, that is experience of AR, the results show that a majority of the respondents do not have any experience. As many as ten out of the 14 respondents reported not having used a mobile application that used AR in the last week, and the remaining four reported having used these types of applications only 1-5 times. The same pattern holds true for taking part in the development process of AR applications, as a total of eleven respondents reported that they had never participated in one of these processes. The remaining three respondents reported that they had participated in 1-3 AR application development processes, and just like the usage of AR applications, the results therefore show that the majority of the respondents do not have any previous experience of working with AR.

5.1.3 Attitude toward Augmented Reality

The final set of questions inquired about the respondent’s attitude toward the use and development of Augmented Reality applications for digital communication purposes. The first question of this section (see appendix A, question 7) asked the respondent to provide their general attitude regarding the use of AR applications for digital communication purposes, and the indication from the respondents is that this sort of technology is looked upon with favour. As can be seen in the results (see Figure 9), half of the respondents rated their attitude as a 4 on a scale of 1 to 5, with 1 meaning that the respondent believed that the use of AR applications for digital communication purposes was not at all useful, and a 5 meaning that the respondent believed that it was very useful. These answers produced a mean value of 3.86, with a precision of two decimals.

![Figure 9: Distribution of the general attitude regarding the use of AR for digital communication purposes from the first survey.](image-url)
In a similar fashion to the question about the respondents attitude regarding the use of AR for communication purposes, the survey also investigated how enthusiastic the respondents were when it comes to the idea of creating more AR applications in the future (see appendix A, question 10). For this question, the responses showed an even more favourable attitude among the respondents, with eleven out of 14 rating their attitude on the more positive side of the spectrum (see Figure 10). The values derived from this question produces a mean value of 4.21, with a precision of two decimals.

![Figure 10: Distribution of the general attitude regarding the creation of more AR applications for digital communication purposes from the first survey.](image)

This section also consisted of open-ended questions designed to get more substantial amounts of information from the respondents. The first one of these inquired about what benefits the respondent could think of from a user perspective regarding the use of AR applications (see appendix A, question 8). The most common response to this question (see table 1 in appendix C, answers in both Swedish and English) was that a benefit of AR was that it makes most experiences more fun. As many as seven of the respondents listed that AR being fun is either the main benefit, or another important beneficial aspect of the technology. Another common response that arose as a result of this question was that AR can help with visualization problems, and is a technology that can help display information that would be difficult to display through other, more traditional mediums. The respondents also believed that AR had the potential to help users with everyday problems, such as decorating a house with furniture.

The question that followed the one regarding the benefits of AR from a user perspective asked the complete opposite. Therefore, it let the respondents provide the disadvantages that they could come up with regarding the use of AR applications (see appendix A, question 9). The most common response to this question (see table
The next open-ended question asked the respondents to provide the positive effect that they thought that developing an AR application would have for them, given their role in the development process (see appendix A, question 11). The responses to this question (see table 3 in appendix C, answers in both Swedish and English) varied with what area of employment the respondent had, but the most common response was that they felt that they would learn a lot of new things, mainly because AR could be considered uncharted territory for them.

The final open-ended question asked the respondents what difficulties they thought would arise for themselves when developing AR applications, given their role in the development process (see appendix A, question 12). The most common difficulty that the respondents provided (see table 4 in appendix C, answers in both Swedish and English) was that they have limited knowledge regarding AR, and that they did not know what possibilities and limitations there were to consider. Another common response, however, was that the respondents were unsure of the new development platforms that working with AR would make them encounter, and that there could be technical difficulties that would arise during the work.

5.2 Application development

This section presents the difficulties that arose whilst developing the application, and also what parts of the development process that were less problematic than expected.

5.2.1 Setup process

In the setup process, there were many things to consider, given that every platform that was to be used in the project had to be decided upon. What platforms to use was a decision based mainly on convenience, as some programs had better available tutorials, or were simply recommended by others. This was where the first problems that the development process encountered began, and it mostly had to do with the downloading of the correct versions of different programs. For example, when trying to launch an example app in Unity, errors appeared. After online research about these errors, it was shown that several others had had the same issues, simply because of not having downloaded the correct version of the Java Standard Edition (Java SE). For these reasons, an older version of Java, namely Java SE 8 Update 161, had to be installed, which solved the compatibility issues for the time being.

In contrast to these difficulties, however, the documentation available for the setup process of Unity with Vuforia was detailed and easy to follow. This, along with the previously mentioned availability of online forums with people discussing similar problems, made the process relatively straightforward, with only a few minor hiccups along the way.
5.2.2 Unity development process

Working in Unity was less problematic than expected, and the only thing causing difficulties was the inconsistencies between different versions of the program. While watching video tutorials on how to perform certain tasks within the program, there would often be menus, components, and other minor settings placed in different parts of the program compared to where they were placed in the Unity version used for the application development in this thesis.

A major benefit of Unity that arose during the development process was the high quality of the program and the general lack of unsolvable issues and major bugs while developing. Additionally, if an error would occur in the development process inside Unity, the console log most often provided helpful and easily understandable error messages that helped get the project back on track.

5.2.3 3D design process

The most difficult part of the application development process was the one regarding the creation of 3D models and exporting them for use in Unity. The two 3D models created by Isak Larsson (see Figure 11 and Figure 12) were mostly unproblematic when it came to their use in Unity, but the third and final 3D model created for this thesis (see Figure 13) was more challenging to work with.

The reason for these difficulties is the compatibility issues between Cinema 4D and Unity, which can, as was shown in the project for this thesis, lead to scenarios where not all parts of a 3D model can be displayed when transferred between the platforms. The 3D model created for the surrealist painting (see Figure 13) had, as mentioned in section 4.3.3, a Collision object and a Jiggle object, both of which could not be included in an FBX file, and this, of course, caused issues when trying to display the animation in Unity. The two spheres included in the 3D model simply went straight through the plane, without colliding with it, and as a result of this, the jiggle effect was not present in the animation either. In addition to this, the simulation tags added to the spheres, giving them a soft body that would allow them to fall back down to the surface of the plane and land on it, were not included in the FBX file either. The lack of these objects and tags made the animation look almost nothing like the animation originally created in Cinema 4D.

The solution to this problem was a time consuming one, and included saving each and every frame in the animation, a total of 90 frames, as individual FBX files in Cinema 4D and importing them all to Unity. Following this, an empty GameObject was created in Unity and every frame of the animation was added to a list belonging to the GameObject. A script was then created for the GameObject which looped through all of the frames with a delay of 0.075 seconds between each frame, which circumvented the restrictions previously discussed, and produced a custom-made animation instead. The GameObject was, however, when tested, not able to be scaled at all, which caused it to be so big that the full object could not fit in the mobile camera’s field of view when running the application and pointing it at the target.

However, even with all the problems that arose during this part of the development
process, Cinema 4D proved to possess a variety of tools that could be of use in an Augmented Reality application development process. The program had many features that were compatible with Unity, and the possibilities to create entertaining and immersive content are still present.

5.3 The application

The resulting application is a computer vision based mobile AR application that allows the user to view a virtual art exhibit consisting of three artworks. These were a dog (see Figure 3) with an augmented butterfly that flies away when a virtual button is pressed (see Figure 11), a mountain valley with a bridge (see Figure 4) that is displayed as a box like 3D object when viewed through the app (see Figure 12), and a surrealist painting (see Figure 5) that contains an animation of two large spheres bursting through its surface on a loop and making it jiggle (see Figure 13).
Figure 11: An augmented butterfly flying away from a dog, prompted by the pressing of a virtual button.
Figure 12: A box like shape of the artwork of a mountain valley with a bridge.
Figure 13: Two spheres having just burst through a surrealist artwork.
5.4 Follow-up survey

During the time that the follow-up survey was available, ten of the previous 14 respondents filled it out and sent in their thoughts. Nine of the ten respondents were spread across four different areas of employment at Humbly, whereas one respondent was a designer previously employed by the company who has, since the first survey, stopped working for them (see Figure 14).

![Figure 14: Distribution of area of employment among the respondents of the follow-up survey.](image)

The next question in the survey (see appendix B, question 2) asked the respondent to provide their general attitude regarding the use of Augmented Reality applications for digital communication purposes after learning about the development process of the application created for this thesis and seeing the results of the process. When compared to the corresponding question from the first survey, the mean value of the responses was higher, and landed at a value of 4.2. As can be seen in the results (see Figure 15), not a single respondent provided an answer on the lower end of the spectrum.
The third question of the survey asked the respondents to provide their attitude regarding the idea of creating more AR applications in the future (see appendix B, question 3). All ten respondents rated their attitude as either a 4 or a 5 (see Figure 16), and these values produced a mean value of 4.5, which, just like the mean value for the previous question, is higher than in the first survey.
5.5 Survey data analysis

Beginning with the question that inquired about the attitudes regarding the use of Augmented Reality (see appendix A, question 7, and appendix B, question 2), the hypotheses and significance level used in the test was set to the following:

Null hypothesis, $H_0$ : The sample means are equal.

Alternative hypothesis, $H_1$ : The sample means are not equal.

Significance level : $\alpha = 0.05$.

The two-sample t-test produced a P-value of 0.299. This P-value is higher than the set $\alpha$, which means that $H_0$ can not be rejected, and no significant difference between the means was found.

Moving on to the second question, the one that inquired about the respondents’ attitude regarding the idea of creating more AR applications in the future (see appendix A, question 10, and appendix B, question 3), the hypotheses and significance level were the same as the ones used in the previously mentioned t-test. The P-value produced by this test was 0.337. This is also higher than the set $\alpha$, which means that $H_0$ can not be rejected, and no significant difference between the means was found.
6 Discussion

This chapter evaluates the overall suitability of Augmented Reality as a digital communication tool, and proceeds to discuss different topics that relate to the methods and results of this thesis. These topics include a change in the original method, which statistical hypothesis tests that were considered, the phrasing of two corresponding questions in the surveys, and finally the subjective assessments present in the responses of a question in the first survey.

6.1 Evaluation of suitability

In order to properly assess the suitability of Augmented Reality as a digital communication tool, several different aspects need to be considered. For instance, it is important to discuss how humans communicate, and how this is used in AR. Additionally, it is also important to consider the problem areas that were brought up by the people who work in the communications industry, and seeing how they relate to the difficulties that arose in the development process of the virtual art exhibit created for this thesis.

As previously discussed (see section 2.2), human communication is complex, and consists of several different types of communication. AR as a technology does not make much use of verbal or body language communication, but instead relies heavily on the use of written communication technologies. The downside of written communication is its vulnerability to the passing of time, as languages constantly change and evolve (see subsection 2.2.2). However, it could be that AR and other digital forms of written communication can circumvent this issue, due to the fact that digital media has the possibility to be updated, and is not as static as its printed counterpart. Additionally, AR applications can help people process information, as, for instance, in an educational context (see section 2.2.4). AR is entertaining and engaging, and could help people visualize things differently, which in turn enhances their information processing abilities.

AR is, however, a potentially excluding technology for certain groups. As previous studies have shown, only 20 percent of Swedes above the age of 76 have either an Android or iPhone smartphone [32], and while these two types do not make up the entirety of the smartphone spectrum, the usage of other types of smartphones is essentially negligible [32]. The fear is that a technological landscape based more on the need of a smartphone could make older people feel ostracized by society, and the expanded use of AR could contribute to this. Therefore, it is important that these people are taken into consideration when a new application is being developed. If a company is creating a new mobile application, they would need to properly evaluate what their target group is.
AR is today used in several different areas, such as education, tourism, and navigation (see section 2.2.4). While older people may not be a relevant target group to consider when developing educational applications, they are important when it comes to tourism and navigation. Older people still travel, and are still in the need of directions when they visit a new place. Given the smartphone usage numbers mentioned above, it would therefore not always make sense to create an AR application within these areas, at least not when there is a chance that the application in question will replace the more traditional methods used in the tourism and navigation sectors. However, this could change with time, since it seems probable that older people will be in possession of smartphones to a higher extent in the future.

A more positive aspect regarding AR as a digital communication tool is the attitude from the people who work in the communications industry, namely the employees at Humbly. The high mean value (see section 5.4) produced in the follow-up survey when the respondents were asked about their attitude regarding the idea of creating more AR applications in the future (see appendix B, question 3) is a sign of a positive attitude when it comes to exploring further possibilities of the technology. The open-ended question regarding the positive effects that the respondents believed that developing an AR application would have for them (see appendix A, question 11) also generated interesting results (see subsection 5.1.3). Most respondents’ belief that developing an AR application would lead them to learn new things within new areas can be backed up by the application development process performed as part of this thesis. The platforms, programs, and tools used in the development process are unlikely to ever be used in the development of, for example, websites, posters, or other more traditional communication mediums. Even though other platforms, programs, and tools can be used for development of AR applications, the ones used in this thesis are at least an indicator that someone without AR development experience would have to encounter and learn new things.

The development process did, however, confirm some of the problem areas speculated in by the survey respondents. When asked about difficulties that they thought would arise in the development process of an AR application (see appendix A, question 12), several respondents said that technical difficulties was a concern (see table 4 in appendix C, answers in both Swedish and English). This was shown to be true in the work done for this thesis, as the compatibility issues between Cinema 4D and Unity impacted the work negatively (see subsection 5.2.3).

6.2 Method change

A part of the analysis for this thesis was to look at the benefits and disadvantages of Augmented Reality from a developer perspective, and this was originally meant to be done by collecting responses from a survey and following it up by performing in-depth interviews. However, as the results of the survey were analyzed, it became clear that the provided answers would be sufficient for further analysis without the need of in-depth interviews. This, along with remaining time of the project, led to the decision of skipping the interviews altogether. As a result of this, the follow-up survey was added instead.
The original thought behind the interviews was to allow some of the respondents to expand on their thoughts regarding the benefits and disadvantages of AR. The answers in the survey, however, were more expansive than first thought, which rendered the interviews partially unnecessary. If the interviews would have been performed anyways, it is possible that the responses given would not contribute much to a better result, which would mean that a lot of time had been spent on something that did not further the work of the thesis.

6.3 Statistical hypothesis testing

Performing an analysis on the data gathered from the surveys meant that decisions had to be made regarding what tests to use for the statistical hypothesis testing. For several reasons (see section 4.5), two-sample t-test was chosen for this purpose. One of the other potential tests that was considered during the decision making phase was the Mann-Whitney test. The Mann-Whitney test is used to compare two unpaired samples that do not have to be normally distributed [33]. However, the downside of this test is the fact that it compares the medians of the two samples, rather than the mean values. This would not be the best method of testing for differences in the samples used in the analysis, since they come from discrete variables with a small amount of response alternatives. Additionally, the Mann-Whitney test could not even be performed in Minitab, due to the fact that the two samples were of different sizes.

6.4 Survey phrasing

One thing that has to be considered when reading the results and the conclusion is the phrasing of the survey questions. Despite careful considerations of word choices, the phrasing shown when giving examples of "communication purposes" (see appendix A, question 7, and appendix B, question 2) could lead the respondent to believe that the term in question only includes the things specifically mentioned. This could of course alter the results, and should be kept in mind when analyzing them. However, the extent to which this affected the respondents can only be speculated in.

6.5 Subjective assessments

One question in the first survey (see appendix A, question 4) asks the respondent to subjectively assess their own knowledge of AR, and this could be inaccurate to some degree. The reason for this is that a respondent might very well overestimate or underestimate their own knowledge, since it is likely that the respondents use different reference frames for determining their own knowledge level. Therefore, the value should really only be thought of as an estimate of the true knowledge present at Humbly regarding AR. However, with a mean value of 5.37, it is not a stretch to claim that the employees at Humbly are neither experts nor novices when it comes
to dealing with AR.
7 Conclusion

This study shows that there are several benefits and disadvantages when it comes to using Augmented Reality as a digital communication tool. One of the most prevalent benefits of this technology is that it is entertaining and engaging, which helps people visualize things differently and process information in a better way. Furthermore, AR applications, along with other forms of digital media that primarily make use of written communication, are more durable to the constant and ongoing change that a language undergoes. Creating AR applications will most likely force the creators to learn about platforms, programs, and tools that they would not encounter when creating websites, posters, or other more traditional communication mediums.

However, AR can potentially be an excluding technology, and this is partially due to the low smartphone usage among older people. Therefore, if the target group of a mobile application is older people, AR is not the best technology to base it on. From a developer perspective, it is important to consider the compatibility issues between the different platforms when developing for AR. These issues could limit the potential of what an application can do, and would need to be taken into consideration during the development process.
References


Appendices
Experience and Attitude About Augmented Reality
This is a form to analyze the current knowledge, experience, and attitude present at Humbly regarding the technology of Augmented Reality (AR). Please read over the questions carefully, and answer them as truthfully as possible. It is perfectly okay to answer the questions in either English or Swedish. The survey is anonymous, and the results will only be used in this study and the associated master’s thesis by Niclas Drugge.

*Required

General Information
The following section contains questions regarding general information about you.

1. How old are you? *
   Mark only one oval.
   - <20
   - 20-29
   - 30-39
   - 40-49
   - 50-59
   - >60

2. Select your gender *
   Mark only one oval.
   - Female
   - Male
   - Other: __________________________

3. Which of the following suggestions best describes your area of employment at Humbly? *
   Mark only one oval.
   - Upper management
   - Project management
   - Web development
   - Creation/design
   - Digital strategy
   - Economy/finances
   - Client management
   - Other: __________________________

Knowledge and Experience
The following section contains questions regarding your current knowledge and experience of Augmented Reality (AR).
4. On a scale of 1-10 (where 1 is the lowest, and 10 is the highest), how much knowledge do you consider yourself to have about Augmented Reality? *
Mark only one oval.

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5. How many times in the last week have you used mobile applications that use Augmented Reality? *
Mark only one oval.

- Not at all
- 1-5 times
- 6-10 times
- More than 10 times

6. How often have you been involved (in any capacity) in the development process of an Augmented Reality application? *
Mark only one oval.

- Never
- 1-3 times
- 4-6 times
- More than 6 times

Attitude Toward Augmented Reality
The following section contains questions regarding your attitude toward Augmented Reality (AR).

7. What is your general attitude regarding the use of Augmented Reality applications for communication purposes? (This can include promotions, campaigns, advertisements, or any other form of information distribution and consumption) *
Mark only one oval.

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<tr>
<td>Not at all useful</td>
<td>Very useful</td>
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8. What benefits can you think of from a user perspective regarding the use of Augmented Reality applications? *

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
9. What disadvantages can you think of from a user perspective regarding the use of Augmented Reality applications? *

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

10. What is your general attitude regarding the idea of creating more Augmented Reality applications for communication purposes? *
Mark only one oval.

________________________________________________________________________

Very negative  □  □  □  □  □  Very positive

________________________________________________________________________

11. What positive effects do you think that developing an Augmented Reality application would have for yourself, given your role in the development process? *

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

12. What difficulties do you think would arise for yourself when developing an Augmented Reality application, given your role in the development process? *

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

13. Is there anything else you would like to add?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
B Follow-up survey

Experience and Attitude About Augmented Reality
This is a form to analyze the current attitude present at Humbly regarding the technology of Augmented Reality (AR). Please read over the questions carefully, and answer them as truthfully as possible. The survey is anonymous, and the results will only be used in this study and the associated master’s thesis by Niclas Drugge.

*Obligatorisk

General Information
The following section contains questions regarding general information about you.

1. Which of the following suggestions best describes your area of employment at Humbly? *
   Markera endast en oval.
   - Upper management
   - Project management
   - Web development
   - Creation/design
   - Digital strategy
   - Economy/finances
   - Client management
   - Övrigt: ________________________________

Attitude Toward Augmented Reality
The following section contains questions regarding your attitude toward Augmented Reality (AR).

2. After learning about the development process of the AR app and seeing the results, what is your general attitude regarding the use of Augmented Reality applications for communication purposes? (This can include promotions, campaigns, advertisements, or any other form of information distribution and consumption) *
   Markera endast en oval.
   1  2  3  4  5
   Not at all useful  Very useful

3. What is your general attitude regarding the idea of creating more Augmented Reality applications for communication purposes? *
   Markera endast en oval.
   1  2  3  4  5
   Very negative  Very positive
4. Is there anything else you would like to add?

________________________________________

________________________________________

________________________________________

________________________________________

Tillhandahåls av

Google Forms
C Survey responses

C.1 What benefits can you think of from a user perspective regarding the use of Augmented Reality applications?

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Answers provided by the respondents of the first survey (in both Swedish and English).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Makes learning more fun and interactive.</td>
</tr>
<tr>
<td></td>
<td>I de fall AR är väl utnyttjat och informationsbärande så kan det ge en upplevelse/askådliggörande som är svårt att få till annars. T ex riktning i en navigationssåp eller storlek i en inredningsåp/måtningsåp.</td>
</tr>
<tr>
<td></td>
<td>Support in real life problems</td>
</tr>
<tr>
<td></td>
<td>Inredning med möbler, skicka paket (visa storlek), lek/spel.</td>
</tr>
<tr>
<td></td>
<td>Hightened awareness about security issues for instance while driving.</td>
</tr>
<tr>
<td></td>
<td>Simulerar olika scenarion/produkter för nytta/nöje</td>
</tr>
<tr>
<td></td>
<td>Making the experience fun, exploratory and making it possible for more content depending on the user’s actions/choices/position.</td>
</tr>
<tr>
<td></td>
<td>Generellt en bättre och roligare upplevelse oavsett typ av app.</td>
</tr>
<tr>
<td></td>
<td>Förenklar vardagen, förenklar fritiden/resor</td>
</tr>
<tr>
<td></td>
<td>I believe AR can create a better and deeper engagement with the product, being this an app, a game, an experiment or merely an ad. AR it’s fun.</td>
</tr>
<tr>
<td></td>
<td>Det finns alla fördelar i världen, det är generiskt roligt, konstant tillgängligt och det förändrar vad vi ser utan negativ fysisk påverkan. Borde bli en naturlig del av kommunikationsvärlden.</td>
</tr>
<tr>
<td></td>
<td>Possibility to emphasize important stuff. Intreresting new technology.</td>
</tr>
<tr>
<td></td>
<td>New ways to communicate and design which will give the user a stronger sense of reality which can be applicable in new products with totally new value for the client/user</td>
</tr>
</tbody>
</table>
C.2 What disadvantages can you think of from a user perspective regarding the use of Augmented Reality applications?

Table 2 Answers provided by the respondents of the first survey (in both Swedish and English).

<table>
<thead>
<tr>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>The technology can be excluding for certain groups, eg. older people, people who doesn’t own smartphones etc.</td>
</tr>
<tr>
<td>Det finns fortfarande inget enkelt sätt att konsumera AR – det kräver flera aktiva handlingar från användarens sida innan man när fram.</td>
</tr>
<tr>
<td>Not very useful in some cases</td>
</tr>
<tr>
<td>Over use of AR that makes it feel like spam.</td>
</tr>
<tr>
<td>Om kund upplever en simulation men sen återspeglas det inte i verkligheten vid t.ex produktlantering</td>
</tr>
<tr>
<td>There could be a higher threshold for some users to use the application or campaign. New techniques might not attract all users. If there are any technical issues with the application it would lower the experience.</td>
</tr>
<tr>
<td>”Storebror ser dig.”</td>
</tr>
<tr>
<td>I don’t see any disadvantages.</td>
</tr>
<tr>
<td>1. Energikrävande applikationer = kort batteritid. Förhoppningsvis sker det förändring där lika snabbt som AR blir naturligt.</td>
</tr>
<tr>
<td>2. Informationssäkerhetsskäl antar jag, om allt märks ut och definieras i en AR-miljö finns det antagligen säkerhetsrisiker med det. Å andra sidan är ingenting säkert i grundform, så det är bara spekulationer.</td>
</tr>
<tr>
<td>Tech failure. Bad interfaces.</td>
</tr>
<tr>
<td>Don’t know</td>
</tr>
</tbody>
</table>
C.3 What positive effects do you think that developing an Augmented Reality application would have for yourself, given your role in the development process?

<table>
<thead>
<tr>
<th>Table 3 Answers provided by the respondents of the first survey (in both Swedish and English).</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think I would learn a lot, considering that I know so little about AR today.</td>
</tr>
<tr>
<td>Utökad kunskap i ett fält som kommer att bli allt viktigare ju enklare det blir för användaren att ta till sig det.</td>
</tr>
<tr>
<td>To learn new stuff</td>
</tr>
<tr>
<td>Ökad kunskap inom området.</td>
</tr>
<tr>
<td>Broadening my understanding.</td>
</tr>
<tr>
<td>Visualisera produkter som tas fram i olika miljöer</td>
</tr>
<tr>
<td>It would definitely have a positive effect on my professional development, I would learn a lot and be put in a position where I would lead a new type of work.</td>
</tr>
<tr>
<td>Det bästa vore om våra nuvarande eller potentiella kunder får upp ögonen för tekniken vilket kan medföra nya typer av projekt för oss som utvecklare.</td>
</tr>
<tr>
<td>Se bredden av möjligheter</td>
</tr>
<tr>
<td>It is really inspiring to think about an idea and its development with AR. Being inspired by technology is priceless but content must always come in the first place.</td>
</tr>
<tr>
<td>Det skulle få mig att tänka om vår omgivning på ett annat sätt, tror jag. Se alltting som ytor och möjligheter.</td>
</tr>
<tr>
<td>Forefront dvelopment. Client value. Exploring new areas.</td>
</tr>
<tr>
<td>Client satisfaction</td>
</tr>
</tbody>
</table>
C.4 What difficulties do you think would arise for yourself when
developing an Augmented Reality application, given your role
in the development process?

Table 4 Answers provided by the respondents of the first survey (in both Swedish
and English).

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Swedish Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have very limited knowledge about the technical aspects, what possibilities and limitations there are to consider.</td>
<td>Konkurrerande standarder, omogen plattform, svårt att testa.</td>
</tr>
<tr>
<td>Deciding what AR library to use and make it work as expected</td>
<td>Ny designmiljö att röra sig i (faktisk miljö), har dålig koll på den tekniska sidan.</td>
</tr>
<tr>
<td>Handling customer expectations</td>
<td>Inte känna till tekniken bakom kanske?</td>
</tr>
<tr>
<td>Since I don’t have that much knowledge of the technique behind AR it would be a challenge to plan the work and to identify potential problems early on. Setting a price on the application would also be difficult since we haven’t done anything like that before. Another challenge for me would be to make sure that the client’s expectations would be set on the right level since I’m not 100 % sure what we would be able to achieve.</td>
<td>Svårt att göra teknikval i detta läge då området fortfarande känns relativt nytt.</td>
</tr>
<tr>
<td>Dålig insyn i processer</td>
<td>I generally don’t like to take a NO as an answer. As we are in a very early stage of developing AR in the agency I know I’ll get a lot of NOs in the beginning. But I know that AR has almost no limits so I’m happy to see how far we can push ourselves and no get disappointed.</td>
</tr>
<tr>
<td>Understanding tech- possibilities and limitations</td>
<td>Don’t know enough to really give the clients a fair view of the possibilities</td>
</tr>
</tbody>
</table>

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