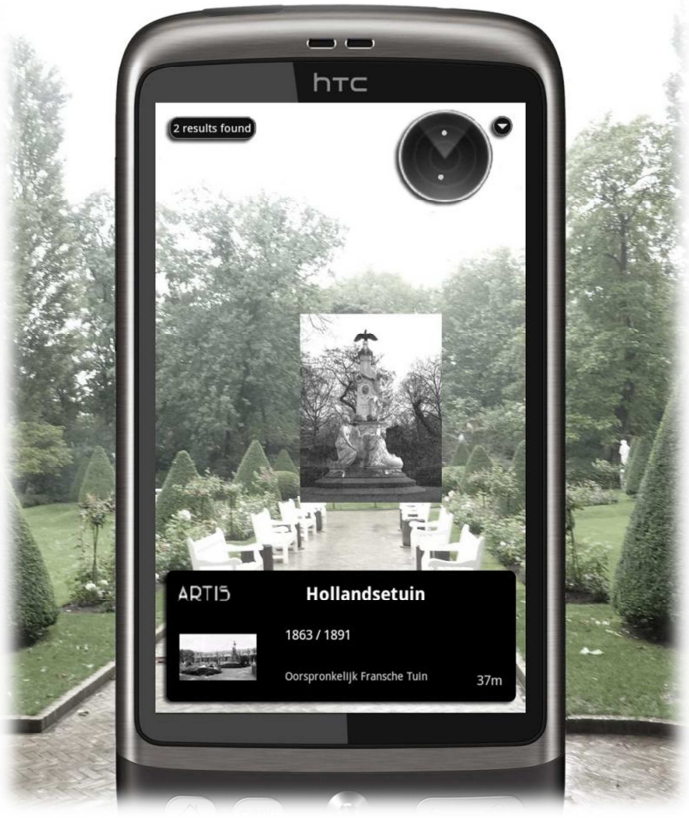
Centre for Geo-Information

Thesis Report GIRS-2011-08

LOOKING BEYOND REALITY

The use of augmented reality to enhance people's experience of the landscape
The case of Natura Artis Magistra, Amsterdam

Jaap van der Mijden



April 2011

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natura ARTIS magistra

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A thesis submitted in partial fulfilment of the degree of Master of Science
at Wageningen University and Research Centre,
The Netherlands.

April 2011

Wageningen, The Netherlands

Thesis code number: GRS-80436
Thesis Report: GIRS-2011-08
Wageningen University and Research Centre
Laboratory of Geo-Information Science and Remote Sensing

ACKNOWLEDGEMENT

This research would not have been possible without the support of many people. First of all, I would like to thank my supervisors Dr. Ir. Arend Ligtenberg, Dr. Ir. Ron van Lammeren and Prof. Dr. Erik de Jong for their assistance, support and guidance. I am very grateful to both Erik de Jong and the Natura Artis Magistra Education Department, represented by Eveline Wisse Smit, for giving me the opportunity to do this research within Artis. Then I would like to thank, Henriette Plantinga of the Artis Archive for providing me with the necessary data for the application, and Jappe Franke of Alterra for his support on the development of the augmented reality application. Finally yet importantly, I want to thank all the people that participated in either the user or the expert survey, for their critical feedback on the application providing me with results for my research.

ABSTRACT

Augmented reality (AR), a new technique that combines real world view with virtual images, is mainly used as information provider. People's experience and awareness of the surroundings are, however, an important issue when dealing with AR. Moreover, to find out whether GPS-based AR enhances the experience and awareness of people's surroundings a pilot application is developed and tested in the Artis zoo in Amsterdam. The application focuses on making the invisible visible, by presenting the cultural heritage of Artis to the people, and alerting people of points of interest through a trigger sound. From a software quality analysis the Layar Augmented Reality Browser with the PorPOIse tool turns out to be the best to develop the application. While, a developed framework for AR development, based on theories from landscape psychology, film and geo-visualisation, contributes and supports the development of an application that enhances experience. Results from the user-survey demonstrate that people are willing to use an AR application and are eager to learn more from their surroundings. Users become more aware of their location, and even start to explore their environment for themselves.

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CHAPTER 1 - INTRODUCTION

"I reject your reality and substitute it for my own."
Adam Savage (1967-, co-host of television series MythBusters)

1.1 Background

In this part a description of the context and background of the research is given. First, the principle of augmented reality is explained. Secondly, there is a brief overview of the study area, the Zoo of Natura Artis Magistra in Amsterdam.

1.1.1 Augmented Reality

Augmented reality (AR) is a technique that combines a live view in real-time with virtual computer-generated images, creating a real-time 'augmented' experience of reality (Kleef 2010). Augmented reality, as we know it today, has been around since the 1990s, when more and more papers were published in the first international conferences and journals (Kleef 2010; Huang 2010). According Azume (1997) augmented reality should include the following three characteristics: combines real and virtual, is interactive in real time and registers in 3-D. Today, these characteristics are not exclusive. Mobile phone applications that give information based on the user's location could be considered augmented reality, but it might not be interactive or register in 3-D.
A new way of using augmented reality is the so-called 'Augmented reality browser' such as Layar Reality Browser (commonly referred to as Layar) and Wikitude World Browser (Layar 2010a; Mobilizy Corporation 2010). These mobile phone applications show you what is around you by displaying information about your surroundings on top of reality (Layar 2010a). It uses a phone's GPS (Global Positioning System) connection to check the user's location, and its compass and accelerometer to check in what direction the user is looking (Kleef 2010). Devices used for these applications are mobile devices with build-in camera such as 'Apple iPhone', 'Nokia Smart Phone' and 'Android' (Hayes 2009; Ruffner 2010).

1.1.2 Artis

Nature is the tutor of the art and science, with this message in its name Natura Artis Magistra (Artis in short) was founded in 1838 in the Plantage-neighbourhood of Amsterdam. It is the oldest zoo in The Netherlands and one of the oldest in Europe. Artis developed, in about 170 years, from a small garden with animals to a unique institute, a knowledge-garden with trees, plants, animals, people, museums, stones and a planetarium (Artis 2009). The variety of animals in an atmospheric nineteenth century park with several protected monuments makes this zoo a distinctive garden. Although, a lot of what once was built is demolished in the meantime and are only known from images, there is quite a lot preserved, where by Artis breaths a real historical atmosphere. This heritage is for Artis a guide for modern contemporary developments (Stokroos 2009).

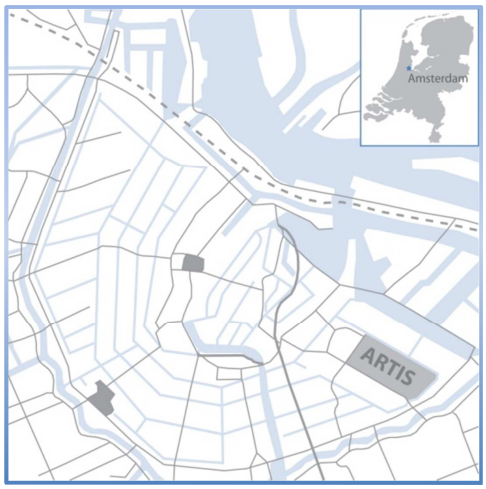


Figure 1-1. Location of Artis in Amsterdam

1.2 Problem definition

This part describes the problem concerning both augmented reality and Artis.

1.2.1 Augmented Reality

A lot of research has been done on the use of augmented reality as information provider (Wagner 2007; M.L. Huang 2010). The GPS-based augmented reality, one of the recent developments in the field of AR, is mainly focussed on providing on-site information to the user, like finding cheap Mexican restaurants in an unfamiliar city (Scott, 2010) or getting an onsite history lesson in an ancient Greek city in Calabria (Cutrí 2008). One can find hundreds of these kinds of applications using an 'Augmented reality browser'. Neither of these AR applications stimulate people's awareness of the surroundings, by triggering the people's senses or emotions. However, there a few AR-games that can be played during a walk, which might make people more aware of their surroundings (Layar 2010b, MIT 2010).
Nevertheless, the question remains if augmented reality can be further exploited, by going beyond the information provision and trying to play with people's senses and emotions. Thus, can AR be used as more than an information provider, but as a trigger to activate people's awareness or to enhance their experience of their surroundings by pointing out things in the landscape, playing music and sounds or by showing images of history, art or other places? In this context awareness is, most simply put, knowing what is going on around you. Awareness contains besides perception of the current situation also the integration of information pieces and the ability to forecast future situation events and dynamics (Endsley 2000). When sense is mentioned; the way people perceive and respond to their external environment is indicated. This research will look at the possibility to enhance people's perceiving of their external environment, into a so-called 'sensation'. Experience in this research can be defined by the apprehension of an object, through the senses or mind. This experience can be enhanced when there is more awareness of the existence of an object.

1.2.2 Artis

Artis is currently working on the renewal of the zoo; they are creating more space for animals and vegetation but also for education and heritage (Artis 2009; Artis 2010a). Artis wants the visitors of the zoo to familiarize with the animals, plants and heritage in easy accessible and inspiring way (Artis 2010a). The use of modern visualisation techniques can be a way to do this. Augmented reality applications for smartphones can give visitors, by means of mixing the reality with the virtual reality (Huang 2010), a new and refreshing look at Artis as a garden. As Wagner (2007) states: 'AR as a new medium is attractive for education institutions such as museums aiming at increasing the interest in their traditional exhibits through technology'. By focussing the education not only on informing, but also on making curious and experiencing, should make people more conscious of their understanding of place (Artis as a zoo, a park, a collection of living nature and heritage), and by extension of their attitude towards and position regarding nature in the widest sense (the world as place and habitat of nature including man) (Artis 2010b). Currently there are 26 monuments, of which several are in restoration, which can play a significant role in the people's perception of the park. According to the Dutch ministry of education, culture and science (2007), monuments cannot be seen separately from the shared experiences and sensations of the viewers and the story told about it. The monuments of Artis all have their own stories. Currently there is no way to let people experience these monuments or the other (cultural) heritage of Artis.

To summarise, this research contemplates if augmented reality could reveal the memory (i.e. history) of a place and be a guide to Artis, as a 'lieu de memoire', revealing past into the present or to help reading and understanding the present reality through revealing the past in its appearances, functions, histories and stories

1.3 Research objective and research questions

With the problem described in previous part a research objective can be formulated. From this research objective, several research questions are defined.

1.3.1 Research objective

The research objective of this research project is: "To find out if GPS-based augmented reality can be used to enhance people's experience and awareness of their surroundings, by developing and testing an augmented reality smartphone application for Artis".

1.3.2 Research questions

With the aim of achieving the research objective, the following research questions are analysed and answered.

The application for Artis is mainly focused on visualising the 'invisible' reality, the history of Artis. This can be done by implementing visualisations like images, objects; multimedia such as sounds, music and spoken text. With this in mind, the first research question that is answered is:

> *What aspects are important to enhance the experience and awareness of people's surroundings using AR*

People mainly use an AR application at one location and have a quick view. They tend not to walk around continuously looking through their smartphones, not inside a museum but especially not outside in the landscape. However, there are applications with a specific route or with multiple points of interest (POIs), these should have something to keep people using the application. Therefore the second research question is:

> *What types of AR application do exist and what do they contain to be attractive for users to use it?*

Currently there are several AR development packages available for both Apple iPhone and Android phones. However, not all of these have the desired settings, considering easy usage of the package, programming language and extensiveness of the AR application. Knowing this, the third research question that needs answering is:

> *Which AR development package is most suitable for developing the application for Artis?*

An augmented reality application is a new technology, which is not yet common for ordinary people. People could be unfamiliar with the technology or even suspicious towards it. So, the fourth research question is as follows:

> *What is the people's opinion on the use of an AR application in Artis and are they willing to accept and use such application?*

After developing the application for Artis a user test is applied, to test if the application is understandable for people and if it enhances people's environmental awareness. Therefore, the final research question is:

> *Do people understand the application and does it have an effect on their awareness of the surroundings?*

1.4 Methodology

For each research objective and question defined in section 1.3, the research steps are described to realise the formulated objectives; both in text and in scheme. The methodology scheme is presented in Figure 1.2

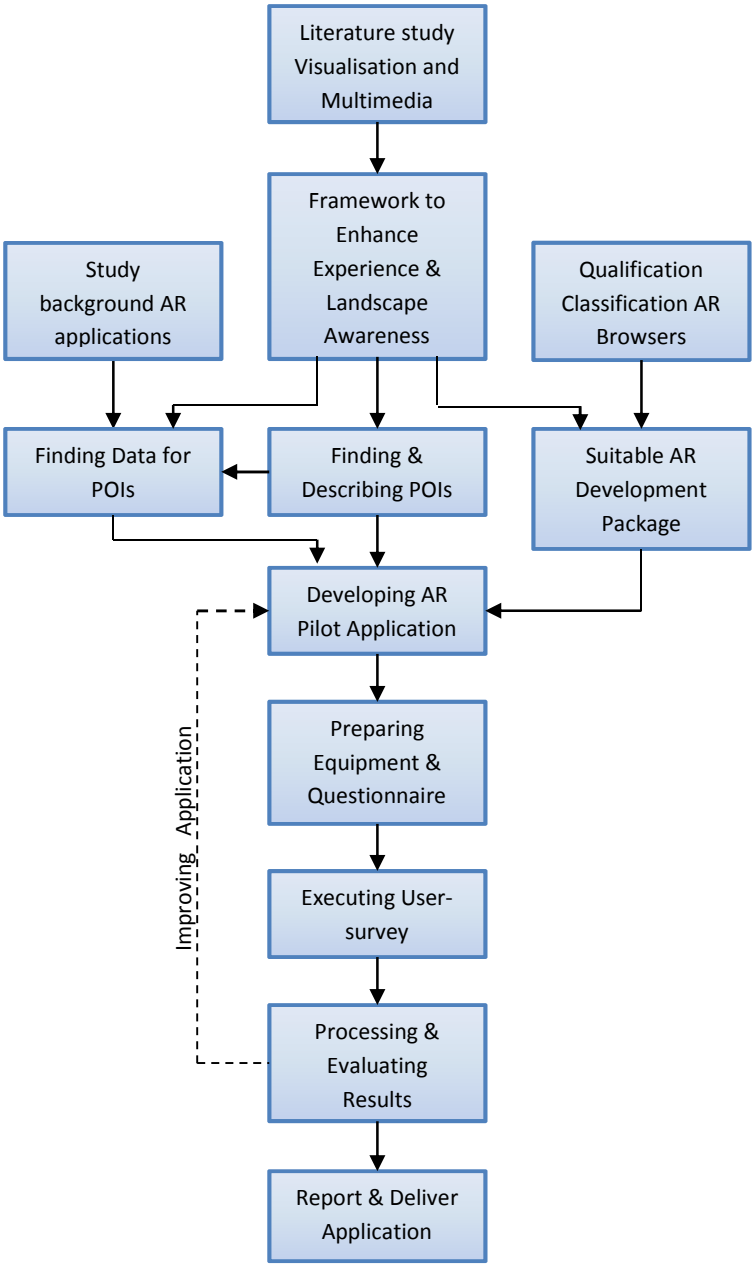


Figure 1-2. Methodology Scheme

1.4.1 Literature studies

To find out if visualisations and multimedia in an AR application can enhance people's awareness of their surroundings, a literature study is done. Literature from both the AR-field of study and from other study areas, such as film and cinema, are used. This study leads to basic information on what is required for AR to able to enhance people's landscape awareness and to a framework of AR landscape awareness. Further, a literature study is applied to find the different types of AR applications currently in use, and to find out what they contain to keep people attracted to it. For the different types one has to think of application using 2D or 3D, or both, the way sounds are used, etc.

Both the literature study results and a brainstorm on the content of the Artis application are input for a pilot application for Artis. Together with 'Artis-experts' a concept description of the POI is made. Describing what kind of POIs are in the application and what data it contains. The pilot application is leading in answering the rest of the research questions. Artis already specified beforehand that they liked to have the 26 national monuments in the application, with as potential user-group: the average Artis-visitor (12+) who wants to learn more about Artis, besides its animals and the park.

1.4.2 Suitable AR development package

To find the most suitable AR development package, currently available GPS-based AR development packages are looked at, which are: Layar, Wikitude, Junaio. For each package a software non-functional requirements classification (or quality classification) is made. The ISO/IEC 9126 (2001) distinguishes four types of quality levels: quality in use, external quality, internal quality and process quality. Based on these the FURPS+ model, developed by Hewlett-Packard, emphasises various attributes (Chung, 2009):

> Functionality - Feature set, Capabilities, Generality, Security
> Usability - Human factors, Aesthetics, Consistency, Documentation
> Reliability - Frequency/severity of failure, Recoverability, Predictability, Accuracy, Mean time to failure
> Performance - Speed, Efficiency, Resource consumption, Throughput, Response time
> Supportability - Testability, Extensibility, Adaptability, Maintainability, Compatibility, Configurability, Serviceability, Installability, Localizability, Portability

Using this list plus the consumer-oriented attributes defined by the Rome Air Development Center (Bowen, 1985; Myopoulos, 1992), in Table 1-1, and some extra, more GIS related, attributes, a fairly good quality checklist is provided (Table 1-2).

Table 1-1. The RADC software quality consumer-oriented attributes (Myopoulos, 1992)

Acquisition concern		Quality attribute
Performance	**How well does it function?**	**Efficiency, Integrity, Reliability, Survivability, Usability**
Design	**How valid is the design?**	**Correctness, Maintainability, Verifiability**
Adaptation	**How adaptable is it?**	**Expandability, Flexibility, Interoperability, Portability, Reusability**

Table 1-2. Software quality checklist

Acquisition	Quality attribute	Concern
Function	**Accessibility**	**Availability and ease to get the software**
	Generality	**Overall functionality**
	Security (Integrity)	**Security of the system/software**
Usage	**Consistency**	**Is the software consistence is working**
	Usability	**Easy to use**
	Documentation	**Enough documentation to get acquainted**
Performance	**Reliability**	**Does it do what it should do**
	Efficiency	**Utilisation of a resource**
	Resource Consumption	**Handling of workload**
Adaptation	**Flexibility**	**Easy to change or update the application**
	Reusability	**Ability to use the software after time of leave**
	Configurability	**Set the software to own needs**
Support	**Open Source**	**Free to use**
	Extensibility	**Software's support for map-services, GIS extensions, etc.**
	Platform Compatibility	**Compatible with what Smartphones?**
	Testability	**Ability to test the application**
	Installability	**Installation requirements**
	Maintainability	**Ability to maintain and/or repair application**

After describing these attributes for each package, the most suitable AR development package is determined, keeping in mind the requirements of the concept-application.

1.4.3 Develop AR pilot application

The first step in developing the AR application for Artis is to find the suitable data for the POI described in the concept-application. These data are texts, such as general information, a speech or a poem; images: historical or art; music or sounds. Most of this data is found in the Artis library, collections and archives. Other data is searched for in other sources, like Amsterdam's city archive.
The second step is implementing this data in the development of the application, using the determined development package.

1.4.4 User survey

To find out if people are willing to use the technology and if it does enhance their awareness of the surroundings, a cross-sectional survey is conducted. For this survey the technology acceptance model (TAM) of Davis (1989) and Davis et al. (1989), combined with the Hedonic Information Systems (van der Heijden, 2004) is used, as used by Goossen et al. 2008 for their project 'De Digitale Wichelroede' (english: The Digital Dowsing Rod).

Davis' model distinguishes two user acceptance beliefs: perceived usefulness and perceived ease of use. Davis later added the belief of perceived enjoyment (Davis et al., 1992). Van der Heijden also uses the dimension of intentional behaviour from Venkatesh and Davis (2000), and replaces Davis' perceived enjoyment belief with ones of past enjoyment studies from Cheung et al. (2000) and Igbaria et al. (1995) (van der Heijden, 2004) Perceived usefulness focuses to what extent the application is useful when visiting the park. Perceived ease of use looks at the effort it takes to use the device/application. And perceived enjoyment concentrates on the pleasure and experience one can derive from the walk with the application. The intentional behaviour measures what people planning to do with the subject after the survey.

For the study of the enhancement of the awareness and experience, a method is investigated to measure this enhancement. The participants have to fill in a questionnaire before and after use of the application. The survey itself is conducted in Dutch. The questionnaire, in Dutch, can be found in Appendix I. For the

survey, about 15 participants are randomly selected, since this is still an exploratory study this number is enough to get workable results, although not statistically sufficient. These participants are also asked some background questions concerning their education level, experience with smartphones and augmented reality, and their opinion on the technological development. This last part is asked to determine whether participant are compliant or reluctant concerning the technological development and with that the use of an AR application.

Besides testing potential users, a survey is held among experts to get their opinion about the application. These experts look at different aspects of the application. The so-called content-experts look at the type of information that is presented in the application and give their judgement on the way this information is presented. The technical experts evaluate the technical aspects of the application, how the application is build and the way information is presented. Main questions for these experts contain these aspects and can be found in Appendix II.

CHAPTER 2 – ASPECTS OF AUGMENTED REALITY

"The unreal has about as much influence on them as the real..."
Gustave Le Bon (1841-1931, French social psychologist)

2.1 Introduction to the subject

In this chapter a framework of awareness in the context of location based services and augmented reality will be defined, answering the first research question. This framework will contain basic principles for designing an AR application. In addition, suitable data for an AR application for enhancing landscape awareness is investigated. When talking about awareness in the context of people's environment one deals with both experience and information and people's responses to and assessment of those two features.

Bachelard wrote already in 1958: 'An image is created through co-operation between real and unreal, with the help of the functions of the real and the unreal.' And where Bachelard was talking about the imagination of people, unreal these days might also mean the virtual reality, enhancing people's imagination. The functions of the unreal are than the applications creating these realities. Augmented reality stimulates co-operation between real and unreal.

2.2 Background on visualising landscapes

Kaplan (1979) describes four components of landscape preference for people to pursue the purposes of 'making sense' and 'involvement' in a landscape. These components are related to how people relate information of the landscape, both to two-dimensional patterns, as a flat picture, as well as to the three-dimension space. The first two components are related to the two-dimensional pattern. The first component is ***complexity*** and refers to the diversity or richness of a scene; how much is going on. Less diverse scenes will likely have a low preference. The second component Kaplan is mentioning is ***coherence***. It includes those factors that make the picture plane easier to organise, to comprehend, to structure (Kaplan, 1979). In addition, change in texture or brightness is associated with something important going on in the scene. In other words, if an object draws one's attention in a scene, it should turn out to be an important object. The other two components ***mystery*** and ***legibility*** relate to three-dimensional spaces. Scenes high in ***mystery*** are characterised by continuity; there is a connection between what is seen and what is anticipated (Kaplan, 1979). Put differently, there is more information just around the corner. Mystery in this context arouses curiosity (Kaplan, 1979). ***Legibility*** deals with the organisation of the 3D-space, from the foreground to the horizon. A highly legible scene is one that is easy to oversee and to form a cognitive map of. Smooth textures aid in this and so do distinctive elements well distributed throughout the space that can serve as landmarks (Kaplan, 1979).

Alfaro et al. (2005) describe the concept of situation-aware content to increase the personalisation aspect. Information can be most effective if presented in a cohesive way, building on previously delivered information, and in accordance with the physical location of the user. On the other hand, cohesion requires that the information at location is presented flexible nevertheless coherent with respect to the user's physical location and the overall flow of information. The overall experience and absorption of new information is thus maximized (Stock and Zanof, 2002 in Alfaro et al. 2005), while also stimulating the user's interest along with the desire to inquire, analyse, and learn (Alfaro et al. 2005).

Velema (2005) presented guidelines for geo-visualisation derived from film theory. These guidelines contain at first ***activity***; because moving objects make the scene more interesting and they give many possibilities for various manipulations of the image. Movement of objects is always measured relative to something else. This can be relative to other objects, relative to the camera (viewer's point of view) or relative to the light source. Movement of light sources can simulate time lapse.
The next guideline is ***montage***, montage makes it possible to only show the most interesting parts to the user, and discard the boring in-betweens. The main spatial manipulation of images is by means of the Kuleshov effect. Suggesting a spatial relation between parts of a dataset that are far apart, but its usefulness is disputable (Velema, 2005) because in AR only one scene is presented, with both the real world location as a virtual overlay. However, montage makes it possible to manipulate travelling time or time travelling.
The subsequent guideline is ***voice-over***, which can provide information about the picture that can bias the understanding of it, and it is relatively simple to add to the scene. Voice-over can guide the interpretation of images.
The final guideline is s***uspense***, to catch the attention. Suspense integrates the previous three guidelines. Suspense depends on development, which demands activity and can be structured in time using montage, but is also fuelled by extra information through voiceover (Velema 2005). Curiosity, surprise and suspense can be used to aid the choice how and which the information is presented. This applies to presenting any type of information: images, text, sound, voice, etc.

2.3 Aspects of visualisation

Besides these main guidelines, in literature descriptions can be found of several aspects to keep in mind when working with both real and virtual worlds. These aspects may have similarity with the main guidelines in visualisation.

2.3.1 Organisation

In addition to Kaplan (1979), Golledge (1999), Darken and Peterson (2001) and Liarokapis et al. (2006) all describe the use of landmarks, to give people a better orientation and understanding of their surroundings. Landmarks can focus people on objects in the landscape. Golledge (1999) also points out that a hierarchical organisation of the objects in the environments give people an easy way to get acquainted with the environment. This corresponds also with what Kaplan (1979) described in his components.

2.3.2 Level of detail

Bishop and Rohrmann (2003) and Appleton and Lovett (2003) investigated up to what realism level people would accept a representation of reality. Participants preferred increased level of detail or a photorealistic level best, this helped them best imaging the presented landscape. Liarokapis et al. (2006) made a mixed reality system for exploring urban environments. In their user-study they found that texture based models would be more appropriate for navigating in a real-world environment. Even so in Oh's research of the perceptual evaluation of computer-based landscape simulations (1994), people appear to prefer more detailed simulations, as those gave them more site familiarity. That is also what Ghadirian and Bishop (2008) say, when discussing augmented reality and geo-information systems: 'Photorealistic AR techniques are able to represent alternative landscape changes realistically so that non-expert audiences can interpret the imagery as easily as they interpret a photograph.'
Appleton and Lovett (2003) also mention that not all visualised elements are of equal importance in helping viewers to imaging the landscape. Especially foreground elements are important in imaging the presented landscape, so using increased realism here would be a great benefit. Velema (2005) seconds this when he emphasis to choose the details wisely, because the details make a scene interesting. Using detail the maker can show some things and not others (Velema, 2005).

Effect of detail level on a 3.5-inch smartphone screens on users

The general statement is, higher level of detail gives people a more realistic feeling and should only be used on the element one wants to show the viewer. But would having a small screen have any effects on how people perceive detail? On a 3.5-inch screen it is not possible to show a lot of detail. The maximum resolution on the new iPhone 4 is 940 by 640 pixels, while the older versions have half this resolution. It is assumed that highly detailed virtual layers, on a smartphone, might be very distracting.

2.3.3 Size and distance

Perception of size and distance is a major issue when designing virtual environment. As Drascic and Milgram (1996) describe in their study that when the objects are correctly perceived at the right depth, they are perceived as being a little bit smaller than they really are. They also point out the absence of shadows in most AR systems. Shadows play a very important role even with stereoscopic video. Their absence from mixed reality systems can greatly impair performance in the field (Drascic and Milgram, 1996).

Another issue is field of view (FOV). The smartphones used in this research have a relative small screen and therefore create a limited FOV. The larger the field of view, in general, the more complete and accurate depth perception will be (Drascic and Milgram, 1996).

There has already been some empirical research done of the FOV of PDAs, which can equally be treated as smartphones. For example, Liarokapis et al. (2006) used PDAs to let people explore their application in urban environments. Their conclusions were that 'all participants appreciated the user-maintained field of view' and 'most users agreed that the functionality of the VR interface provides a wide enough viewing angle able to recognise some of the surroundings' (Liarokapis et al. 2006). This gives reason to believe that people do not really bother about the small screen and that the presented information can give them a clear enough image.

2.3.4 Long take

A related issue to previous presented topic comes from the world of film and cinema, it is called long take. A long take is a single piece of unedited film, which may or may not constitute an entire sequence (Henderson, 1976). Here, the director also has to note of the width of the screen. An augmented reality scene could be compared to a long take in a film, since one is also looking at a single scene for a longer period of time using a 'screen'.

In addition, long take plays with depth in a presented scene. As Velema (2005) states it: 'An important way to make a long take appealing is to introduce depth, which is to show pieces of information together, that are at different distances or scales, or that are of different importance.' The composition of the scene is important when using long take, the arrangement of objects within the scene. The long take makes mise-en-scène possible (Henderson, 1976). Furthermore, when composing depth in a long shot, the spectator needs a longer time to discover all the details and their relation (Velema, 2005). This makes long shot interesting for AR; people are triggered to explore the scene. When having time to look around in the scene, new things can be discovered in the scene. Moreover, it can force the spectator to ponder over an implied notion or meaning of the image (Bordwell, 2001 in: Velema 2005).

2.3.5 Sound

One thing to keep in mind is that the screen may be the border of the visual scene but not that of the soundscape. As Jones (2005) formulates it: 'the audience may be viewing the narrative/story/experience through the hard borders of a visual frame but there is no illusion or pretence of the frame presenting any sense of a totality of vision because of a larger composition constructed for the viewer through spatially

specific sound. The viewer accepts that the frame is just a small part of the composed scene, not the scene in its entirety.' The end of the image is no longer the edge of the screen. We are completely immersed in a sound universe and feel as if we are actually in the space of the action, because we can hear the action surround us (Yu, 2003). Once sound however is expanded beyond the framed screen the audience is shifted from their traditional role and placed into the film's environment (Jones, 2005). Jones (2005) also points out that this shift of position of viewers is absolutely central to a large section of gaming genres in the composition of an imaginary 'world' rather than an imaginary scene. People are becoming part of the presented world instead of only looking at it from the outside.

When planning soundscape for virtual environment, it is necessary to distinguish among ambient sound and sound events, which are also known as Foley effects. Sound events include both predictable and user-triggered sounds. Ambient sounds are background sounds that are used to create a sense of atmosphere (Serafin, 2004).

2.3.6 Voice-over

Adding voice-over narration to a film creates a fascinating dance between pose and actuality, word and image, narration and drama, voice and 'voice' (Kozloff, 1988). There are two major types of voice-over narrators, the first-person or character narrators; these are narrators that take part in the story, and the third-person or authorial narrators, which are external storytellers. The narrator could be an omniscient, therefore reliable, character that guides us through the model and gives us all the details we might want to know or that it chooses to tell us (Velema, 2005).

Kozloff (1988) also emphasis the use of voice-over for showing instead of telling the scene, in telling a scene the narrator would give away every detail in the scene and leaves nothing to explore for the viewer. In showing a scene, the narrator guides as it were the viewer through the scene pointing out important elements but leaves things to explore for the viewer. Velema (2005) supports this, saying that voice-over can be used to guide the interpretation of images.

2.4 Framework principles

Most of the previously described guidelines and principles are especially applicable for geo-visualisation using virtual reality. In this research is dealt with both reality and virtual reality in one application. Therefore, below an attempt is made to describe basic principles to create an augmented reality application to enhance people's awareness of their surroundings.

The four components of Kaplan (1979) and the guidelines from Velema (2005), plus the previously described aspects, can be used in creating a for people interesting AR application.

Complexity, getting people involved in the landscape

- > choose interesting scenes to show people
- > add interesting overlay information, enriching the scene
- > moving objects make the scene more interesting
- > use sounds (e.g. to attract attention)

Coherence, making sense in the landscape

- > well organised scene, do not want show too much in one scene
- > make use of light, texture and colours
- > draw attention only on the important objects in the scene
- > use of voice-over can make the scene more clear

Mystery, getting people involved in the landscape

- > suggest there is more in the scene
- > make people believe there is more information around the corner
- > present information in a specific order to obtain (curiosity, suspense, surprise)

Legibility, making sense in the landscape

- > have a comprehensive / legible scene where people can orientate themselves
- > make use of landmarks in the scene
- > overlay information should be able to be localised

The above-proposed guidelines for augmented reality are only related to the information section of the landscape awareness issue. Yet, the experience part needs development. Experience is formed because people respond to the information part and from their experience; people derive a certain assessment of the application. Bishop and Rohrmann (2003) used a framework for their study to subjective responses to simulated and real environments. They used several types of responses defined by environmental psychologists (Gaerling and Golledge, 1993; Gifford, 1997; Kaplan and Kaplan, 1982; Nasar, 1988; Stokols, 1988; Ulrich, 1986 in Bishop and Rohrmann, 2003). From their list the most important and useful ones are adopted to be used in this research, these responses are:

- > ***Identification***, for objects and structures, according to existing knowledge
- > ***Orientation***, depending on the 'legibility' and the novelty of the environment
- > ***Evaluation***, perceived beauty and congruity according to personal standards
- > ***Personal liking***, subjective pleasantness, familiarity, historical and symbolic value, which can be changed to ***Sensation***, creating a more intense experience.

People have these responses to the given information from the AR application. Based on these four responses people would have an experience and use this experience to assess the presented information in the application, which is based on the four guidelines. The framework, containing both the information and experience part, is presented in Figure 2-1.

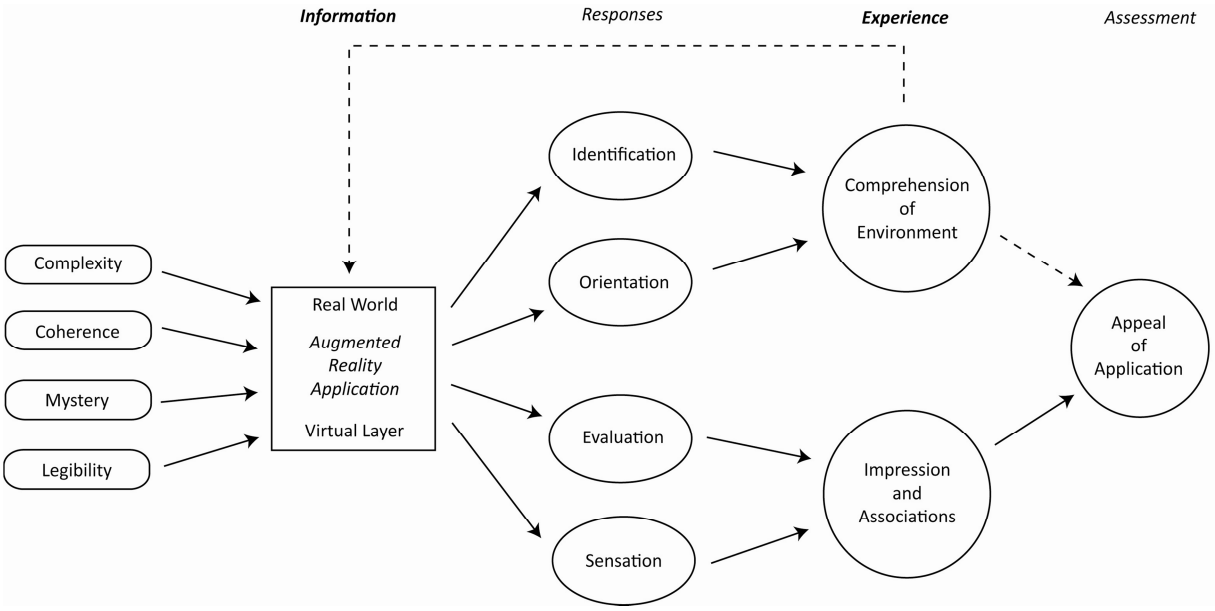


Figure 2-1. Framework for AR development (based on Bishop and Rohrmann, 2003)

The four information components (complexity, coherence, mystery and legibility) are input for the development of the AR application, and have effect on both the real world view as on the virtual layer. The application has both the real world view, through the smartphone's camera and the virtual overlay, projected in the smartphone's camera. All the circles presented in figure 2-1, are action and reactions from application users. When users use the application, they have different responses towards the application. Both the identification and the orientation lead to an experience of comprehension of the environment. They would better understand their surroundings. Kaplan et al. (1998) describe that understanding refers to the desire people have to make sense of their world, to comprehend what goes on around them. Having only an understanding of the surroundings, however, is not enough. People want to explore, to expand their horizons and find out what lies ahead. They seek more information and look for new challenges (Kaplan et al. 1998). That is why people also have responses in evaluation and sensation, leading to an impression and even associations of the application. Finally, in their assessment, users can say something about the appeal of the application.

CHAPTER 3 – BACKGROUND ON AUGMENTED REALITY

"Reality isn't what it used to be."
Walter Truett Anderson (1933-, political scientist and social psychologist)

In this chapter will be looked at the background of GPS-based AR. In 3.1, a description is given of different types of AR, found in scientific literature. 3.2 describes and analysis the currently existing AR browsers.

3.1 Types of augmented reality

As already mentioned in chapter 1.3, people mainly use an AR application at one location and have a quick view. However, people tend not to walk around continuously looking through their smartphones, not inside a museum but especially not outside in the landscape. Though, this issue has never been researched, and there is only one concern found in literature by Narzt et al. (2005). Nonetheless, there are applications with a specific route or with multiple points of interest (POIs), these should have something to keep people using the application and keep them attracted to the application. In this chapter a closer look will be taken at the AR applications found in literature, at what kind of applications exist and what they contain to be attractive for users to use it.

The definition of AR from chapter 1 is the criterion for the applications to be considered AR: Augmented reality is a technique that combines a live view in real-time with virtual computer-generated images, creating a real-time 'augmented' experience of reality (Kleef 2010).

One thing to keep in mind is that this research uses smartphones to run the AR application. While most studies, found in literature, use more sophisticated systems like head-mounted displays or wearable computers. Since only few researches use contemporary GPS-based smartphones like the Apple iPhone, also older smartphones or similar systems, like PDAs, are considered in the below described applications.

In literature, different types of augmented reality applications used for different kinds of studies can be found. The types range from plain 2D AR to fully 3D with voice and sound effects. Also a distinction can be made between applications that have an informative and/ or navigational purpose or an entertainment and/ or educational purpose (Carmigniani et al., 2010).

3.1.1 Basic augmented reality

The first type that can be found in literature is the basic augmented reality with 2D overlay images. For example, Hong et al. (2010) developed an application for asthmatic children to educate them about the triggers that may cause asthma attacks or worsen the symptoms. Their educational AR application is used indoors and therefore makes no use of the GPS but uses marker tags (so-called QR-codes). At locations with a marker tag the screen renders a direct view of a physical real-world environment whose elements are merged with virtual imaginary (e.g. virtual dust mites is animated on the real stuffed toys) (Hong et al., 2010). At those locations the device gives information about the trigger and the player is asked to answers questions about how to reduce the trigger in the environment.

Pachler et al. (2010) describe several mobile learning applications; a couple of these are AR applications. One is the Urban Education for Trainee Teachers project, to support student teachers in exploring their knowledge and understanding of urban education in a meaningful context (Pachler et al., 2010). The project uses a complex interplay between mobile learning technologies, iconic physical infrastructures and

educational discourses to visualise urban education through various collective images and representations (Pachler et al., 2010). During the tour, students are asked key questions about the location they visit.

3.1.2 Advanced augmented reality

The previous described applications are clear examples of basic AR applications having as main purpose educating. The following applications are more elaborated and can contain, besides 2D images, also 3D objects and/or, voice and sound. Furthermore, these applications have various purposes, ranging from the above-mentioned main purposes to a mixture of purposes.

An idea that is already further developed by for example Wikitude (2010), is the idea of augmented reality navigation. Narzt et al. (2005) did research in this field of AR. They used a sophisticated system setup but the main principle is almost the same as a smartphone with accelerometer and GPS. The application projects a 3D route in the drivers view. Calculation of this route is done by means of a calculated route from a conventional navigation system, the current GPS position and orientation, and information about the topography. This application makes it also possible to alert drivers to hidden (e.g. obstructed vision by trucks) junctions or highway exits (Narzt et al., 2005).

Another project of interest is the 'CONTSENS' project, which explains different ways of context sensitive education and training. One of their projects was the Cultural Heritage Learning work package, extending an earlier Cistercian Chapels project. Consortium members created new environments and visualisations to make the physical and digital worlds interact. Virtual reality representations of heritage sites can offer innovative solutions to the challenges that exist when learning about our cultural heritage. In order to allow for the greatest degree of flexibility in learning, the outputs of the Cistercian Chapels project are visualised in multiple ways (Pachler et al., 2010).

Cutrì et al. (2008) also created an application for an archaeological site. Locri is one of the most important Greek poleis of Calabria. The application reconstructs parts of the ancient artefacts in the park, showing people how it could have looked like years ago. When the user is close to a particular object, the display shows a virtual reconstruction. The user can see the real object while comparing it to the reconstruction in the mobile device. The user can play the object (as a game) and he can choose to listen to historical data, or information about the structure or manufacturing process, read the text or visualise other multimedia information (Cutrì et al., 2008).

The field of archaeology is rather advanced in using modern visualisation techniques, as there is another article on AR in this area, this time from Vlahakis et al. (2001). The Archeoguide is an AR application that is implemented on three different mobile systems, the laptop, pen-PC and palmtop computers. The 'guide' offers 3D reconstructions of monuments and artifacts of Olympia in Greece. Users can view reconstructions of buildings and the Ancient Olympic Games with avatar athletes competing in the stadium (Vlahakis et al., 2001). This AR is a good example on how to use 3D for reconstruction and to tell history. A disadvantage of the Archeoguide is that it uses rather old and expensive systems to show the AR, and only the large systems have a GPS, where nowadays a simple smartphone would be enough to run this application.

The Massachusetts Institute of Technology (MIT) Scheller Teacher Education Program (STEP) has been developing and researching AR simulation games since 2003 (MIT, 2010). AR simulations embed participants inside lifelike situations and help them understand the complex scientific and social dynamics underlying authentic problems in a variety of subject areas including the sciences as well as more diverse content areas including history, economics, local sociology, math and language arts (MIT, 2010a). They developed already several indoor and outdoor AR applications. Most of these applications make use of 2D

images only, but since they are simulation games, they might stimulate users to explore and think of solutions.

Brenner et al. (2006) describe in their article the development of GeoScope, a mixed-reality system for planning and public participation. The system makes it for the public possible to see future plans in their surroundings, but the possibilities for this system are endless. One can envision many display and interaction techniques for the GeoScope. Simple examples are text labels, 2D icons, or 3D models that are superimposed in real time over the video image. In addition to mixed reality contents, purely virtual data can be shown such as panoramic views, 3D scenes, 3D virtual flights, or 2D top views such as satellite or aerial images, as well as topographic or thematic maps (Brenner et al. 2006).

An interesting AR application is the AR museum guide of Miyashita et al. (2008) for the Louvre. This is an indoor application, so it does not utilise GPS, but is interesting because it makes excellent use of 3D models and storytelling. They learned from the application developed by Wagner (2007), and used a 3D animation character as a guide. This character, Hubert Robert (1733–1808), a painter who is known for landscapes with ruins, shares a sense of 'familiarity', 'surprise', and 'wonder' with the user (Miyashita et al. 2008). To hide the limitations of the hybrid tracking in respect to translation, animations of floating balloons were used to indicate the position of the next point of interest. The only disadvantage is that people have to carry a rather heavy system around.

3.1.3 Conclusion

Most of the described applications are developed as prototypes. The majority are only used by specialists or by people to test the application. No examples are found involving users preferences for the development of the applications, or other aspects to keep in mind when developing an application. Most developers may take people automatically into account, but they forget to mention that and may even have a wrong view of the potential user. For commercial applications no development information is available, so for these apps it is not clear if they involved user preferences in the development of the apps.

Particularly for an entertainment and/or educational purpose attraction to the application is important. Making use of quizzes and questionnaires attach people to an application, but might make people less interested in other things in their environment. It is assumed that the MIT's simulation games attract people to fully play the game, but for an AR guide next to other interesting spots, it will not be an option. Artis does not want its visitors only focussed on the application, because there are other things to see without it. Miyashita et al. (2008) did good work, using the balloons to direct people to the next location. But people still need to use the screen to find the next POI. It should be possible to attract people's attention when they are near a POI, and that they then start looking at the screen to find out what the POI is. A sound signal could be an option to redirect people's attention back to the AR application.

Sounds in AR should be more exploited. Most AR applications, also the ones described above, are still too much focussed on the visual aspect, while sound can play a significant role in AR (Rozier, 2000). Sound is part of the complexity and coherence aspects of the, in chapter 2, proposed framework. Human memory consists of 2 stores: the acoustic linguistic store, for linguistic information, and the visual spatial store for pictorial information (Velema, 2005). For people to remember what they experienced, the information stored in the short term memory should be transferred to the long term memory. Making maximum use of the two storage capabilities makes it possible that people will remember easier what they experienced.

3.2 Augmented Reality Browsers Analysis

A closer look is taken at the different augmented reality browsers, which might be considered for developing an augmented reality application. For the quality classification of the augmented reality browsers, the current well-known, most used and free available browsers are taken into consideration. Which are the Dutch Layar augmented reality browser, the Wikitude browser of Mobilizy from Austria and the Junaio AR browser by the Metaio Company from Germany.

3.2.1 Augmented reality browser quality matrix

Table 3-1 below gives an overview of the classification of the three AR browsers.

Table 3-1. Augmented reality development package quality matrix

	Layar	Wikitude	Junaio
Function			
Accessibility	Free download, account required	Free download, account required	Free download, account required
Generality	Besides tagging of POI, also possibility to create extensive AR applications with 2D in 3D space and 3D objects. Also, provides possibilities for paid layers, if it has exclusive content. A layer can be written in various programming languages. Provides tools for non-technical or newcomer developers .	Mainly tagging of POIs, kind of Wikipedia on location. Providing four ways to add content to Wikitude World Browser: geo-tag on location, POIs as KML, as content-service provider, as content-developer. Some tools are available.	Works less with GPS, still a lot with markers. 3D option possible, not used much. Ranging from tagging of locations to extensive AR, with 3D objects.
Security			
Usage			
Consistency			
Usability	The possibility to use various programming languages makes it ideal for different developers	Everybody can add POIs and information to the Wikitude World Browser.	Quite complicated because of the different possibilities, the use of GPS or markers for information providing.
Documentation	Extensive wiki documentation page with tutorials (http://layar.pbworks.com/w/page/7783228/FrontPage). Possibility to chat with developers.	Documentation available for download but files are illegible	Documentation page with tutorials (http://www.junaio.com/publisher/main)
Performance			
Reliability			
Efficiency			
Resource Consumption			
Adaption			
Flexibility	Content can easily be changed or updated by developer. Possibility to change from developer.	Content can easily be changed or updated by content-service provider or content-developer.	Content can easily be changed or updated by developer.

		For the other two options it's not clear how flexible it is.	
Reusability			
Configurability	Lots of options to configure to own needs	Simple and straight forward, no extensive configuration options	Possibility to configure some setup options to own needs
Support			
Open Source	Yes, within Layar's environment	Yes, within Wikitude's environment. Since March 2011 member of W3C.	Yes, within Junaio's environment
Extensibility	No direct possibility for GIS extension, although map link to Google Maps	Ability to use ARML & KML	No direct possibility for GIS extension
Platform Compatibility	Apple iPhone (3Gs, 4) and all Android devices, from March 2011 also Nokia Symbian devices	Apple iPhone (3Gs, 4), Android devices starting from version 1.5 and Nokia Symbian devices with compass	Apple iPhone devices starting 3G, iPad, iPod (3rd Generation+) and Android devices starting from version 1.6.
Testability	Able to test the application using developer account, multiple testers possible through account access.	Able to test application, will have 'Beta' watermark	Able to test the application, needs developer login.
Installability			
Maintainability	Developer has all possibilities to maintain application	Developer has possibilities to maintain application	Developer has all possibilities to maintain application

Performance test cannot yet be done, because it requires an application to be build and fully running. In addition, time does not allow this to do this for the three software packages. It is possible to do it for the one chosen for developing the Artis-application.

The following attributes are left out in this quality check because they could not be tested:

Security – Main security is done by registration and login of users and developers. Layar provides security for separate layers, by giving developers the possibility to ask users for a login. Further security is not visible for users and developers.

Consistency – Should be tested with long term use

Reusability – The ease of using the software after some time of leave should be tested over time.

Installability – These software packages do not require installation on computer. However, a web-server and a connection with the software package have to be set up.

3.2.2 Augmented reality browsers

Layar

Layar is rather complicated for starters, but it provides well-explained tutorials and has many options in adding content. There are also third-party toolkits where non-technical people can easily create their own layer or newcomers can get basic scripts for setting up a layer. However, most of these services are rather basic, and if one wants are more complex layer, one still need to do it themselves with the help of the documentation. Layar, as a big player in AR, offers options for 2D images in 3D space and even full 3D options. The Layar Api runs on both the iPhone and Android without adjustments to the layer. Moreover, they were the first to introduce paid-layer for layers with exclusive content. On 27 January 2011, Layar launched the Layar Player, this is a software development kit (SDK) that allows anyone to include AR experiences with their own iPhone applications (Layar, 2011a). And with the availability of Layar for Nokia's Symbian platform in March 2011 (Layar, 2011b), and the new 5.0 beta-version, where animations and sharing through Facebook or Twitter become possible, Layar takes the lead in commercial augmented reality (Layar, 2011c).

Wikitude

Wikitude have the best potential with regard to user input and community building. People using Wikitude can easily add information or create an own application based on Google Earth. They may also provide better option for third-party add-ons or modifications, and even provide some tools for easier development. However, good documentation on development could not be obtained. Since March 2011 Wikitude is member of the World Wide Web Consortium (W3C), which helps them establish a foothold in the standardisation of augmented reality.

Junaio

Junaio's company Metaio does very good work with the old method of augmenting reality using markers and QR-codes. They are, however, not strong enough to compete with GPS-based AR. The applications are still Wikipedia-on-location, providing information about cities, buildings or attractions, like Wikitude, but less innovative. There are possibilities for 3D objects but not that widely used yet. Their documentation, however, is really good and explaining

3.2.3 Artis application development

The AR Browser for the pilot application has to comply with the four aspects of the framework. It mainly should be able to include multimedia like movies and (trigger) sounds. Besides that, it should be able to implement Artis' wishes for the application. Other aspects, like textures, colours or animations, might be of importance for further development of the application, but is not of interest for the pilot application.

Table 3-2. Requirement table.

Requirements	Layar	Wikitude	Junaio
Objects in 3D-space	++	+-	++
3D objects	+	-	+
Animations	+	-	+-
Sounds/music	+	+-	+-
Proximity trigger	+	-	-
Website links	+	+	+
Texturing	+	-	+
Colouring	+	+	+
Ordering of POIs	+	-	-

As for now, it seems that Layar has the best potential when developing an AR application (Table 3-2). It gives the most options, for content and configurations; to create one's own application, even though it is within their development environment. Inclusion of multimedia in Layar is already well developed and

there are even possibilities for animation. Layar has the best and most extensive (online) documentation and tutorials. In addition, the maintenance of the application is well organised at Layar, developers can easily change or update their application. Layar also gives to possibility to change an application from developer, which might be ideal when the test version for Artis is a success. Furthermore, knowledge about Layar within the Centre of Geo-Information makes it ideal to use this package.

3.2.4 Future perspective

Overall, the software is subject to continuous development. Layar in this case might become a world leader in commercial GPS-based AR. Wikitude may stay the innovator in AR, having already developed the WikitudeDrive and the community AR. And Juniao needs to work really hard to keep up with the bigger two, because there is even a new player in the arena. The Georgia Institute of Technology has developed a new platform for augmented reality, called KHARMA. KHARMA, which stands for KML/HTML Augmented Reality Mobile Architecture, provides multichannel information display for users. Besides that, developers use a combination of GoogleEarth, Google Sketchup and a modern web browser for development of the AR channel (Georgia Tech, 2011a). Their AR browser Argon, which is the reference implementation of KHARMA, is completely open standards (Georgia Tech, 2011b).

CHAPTER 4 - NATURA ARTIS MAGISTRA PILOT CASE

"Zoo: An excellent place to study ..."
Evan Esar (1899 – 1995, American humorist)

4.1 Introduction to the subject

This chapter describes the development of a pilot application for Natura Artis Magistra. Figure 4-1 shows the development scheme for this application. 4.2 describes how the framework is implemented in the development of the pilot application. 4.3 continues describing the software used for the development, where in 4.4 a look is given at the application and the data used for it. The user survey is placed in chapter 5, due to the overload of results. Requirement for the implementation of the application are described in 4.5.

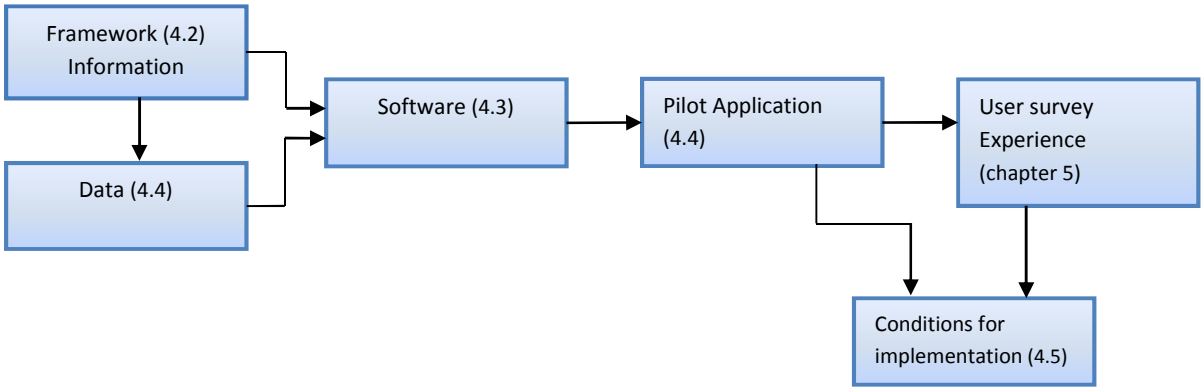


Figure 4-1. Development scheme pilot application

4.2 Implementation of the framework

From the guidelines described in chapter 2, the four components are transferred into the development of the application. Not all guidelines are used in the application development due to time limits and suitability of the guideline in this case study.

Use of Complexity
Most of these aspects are already chosen. As described in chapter 1, Artis want more emphasis on the national monuments. The 26 national monuments of Artis serve as basis for the AR application (these can be found in Appendix III). Due to limitations, moving objects are not included. In this study more attention is given to the use of sounds to attract attention, called trigger sounds.

Use of Coherence
Most scenes are good visible from multiple directions, however there are a couple of scene where the overlay image is hard to localise from certain directions. Some scenes (POIs) are rather close together, this may be confusing for the user, to see the overlays close together and sometimes overlaying each other. Since the Artis application is a pilot application no custom objects are made or included, so the issue of light texture and shadow does not apply. However, there are some images included that have a certain level of transparency. The Artis colour scheme is used for the layout. Music is included to enhance the sense of the scene. Due to limitations, voice-overs are not included yet.

Use of Mystery

Showing details or interiors of buildings might awaken people's interest in having a peek through the windows to see what it looks like in reality. To raise the suggestion of more available information, POIs only become visible within a certain range (about 50 meters) from the smartphone. The trigger sound, when in proximity of a POI, should stimulate mystery and exploration.

Presenting information in an order would only be interesting if there is some kind of predefined route or story. This application has, however, nothing like that.

Use of Legibility

Some monuments are rather close together; this makes it difficult to create a legible scene. This is, however, not a major problem, since users are only looking at one scene at the time,. Finding the right scene at locations would be more challenging. Most of the scenes include an historic image and a short description of the monument. Extra information is added if available, this contains separate information tabs about exterior and interior, sound fragments or movies from the monument.

4.3 Software setup

The software setup consists of four main components, and some additional components (Figure 4-2). The Layar application is the client users have on their smartphones. This uses GPS data to locate nearby POIs, and requests them from the Layar server, which is the heart of the service, providing the interface to the Layar application PorPOIse is a tool used to connect the Layar server with the POIs database (more about this tool later in this chapter). The database, in this case an XML database, contains the locations (POIs) and content to be viewed in the Layar application This can be extended with a link to a website.

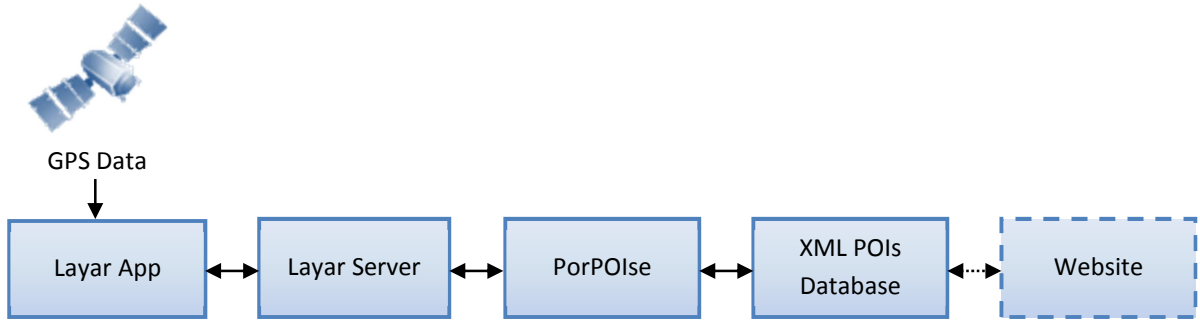


Figure 4-2. Simplified Layar architecture scheme

For the development of the application a tool, called: PorPOIse for Layar (2011), is used. PorPOIse, abbreviation for Portable Point-of-Interest Server, is a server for Layar clients and it converts datasets of POIs into responses to the Layar client. This tool was already used in several project of the Centre for Geo-information (CGI) of the Wageningen University, including an application for Natura 2000-area's in the Netherlands commissioned by the Dutch ministry of Agriculture (Wageningen World, 2010).

Some changes are made in the tool, for example, the standard refresh time of the POIs is changed. Refresh time means after how many seconds the application is going to ask the server for an update of the POIs, receiving new and updating the location of existing POIs. The default setting of five minutes, or 300 seconds, is not convenient for the Artis application because there are lots of POIs close together, and people are almost always in motion. To change this time to about two minutes, some programming is done, since this is not a feature implemented in the older Layar versions. This change was not ready before the user-survey; therefore, the survey was conducted with the old setting of five minutes.

For creating the dataset with the POIs, the scripting language XML is used. A part of the script, describing one POI, can be found in Appendix IV. XML is a fast and easy way to create a simple database. One does not need an extensive database programme; just a scripting tool is good enough. To add the descriptions of the monuments a simple XHTML file is used, which is website viewable on smartphone web browsers and within Layar.

There were some problems encountered when developing the application. One major problem concerns inclusion of background music. Android supports HTML5 Audio tag but not the audio formats. It is a bug (or actually a feature that is not yet implemented) within Android web browser (Textopia, 2010); custom web browsers like Firefox or Safari 5 do not have this problem. Google would solve the bug and the new Android versions will support HTML5 Audio formats, however for the time being no background sound can be heard on an Android phone. Apple's iPhone does not have this problem, but no iPhones are available for in study. Nevertheless, in the application some background music is included that can be played using an iPhone.

4.4 Pilot application

4.4.1 Content

The 26 monuments are entered as POI's into the database. The POIs contain coordinates of the monuments and some background information with multimedia. Additional information is presented on a website.

For the points of interests coordinates are collected using Google Earth, these coordinates are checked in the field using the smartphones used in this research. These coordinates had to be converted from degrees, minutes, seconds to decimal degrees. To do this, a conversion website is used, hosted by the US Federal Communication Commission (FCC, 2011).

The Artis application contains different types of information, such as texts, images and movies. Also, a trigger sound is included in the application. Most of the information was obtained from the Artis archives. The texts are composed of descriptions from the monuments from Henriette Plantenga, the Artis archivist, and of descriptions from the Rijksdienst voor de Monumentenzorg (english: National Department for Monument Conservation).

Not for all monuments, enough interesting information is found, to be in line with Artis' educational message (See 1.2.2). The application, as for now, is still considered a concept. For further development of the application more information in accordance with the educational message should be found.

Below an example is given of information available at a POI, in this case the 'Kerbert-terras' (english: Kerbert-terrace) (Figure 4-3 & Figure 4-4). Additionally, Figure 4-5 shows the Kerbert-terrace in the pilot application.

Images: both drawings/etches and historical photographs of the monuments.

Figure 4-3. Panorama picture of the Kerbert-terrace, used as overlay image in camera view

Texts: descriptions and stories of the monuments.

Dutch text:

Het eerste Artis-dierverblijf (B.J. Ouëndag en A.F.J. Portielje) dat volgens moderne inzichten is gebouwd. Voorbeeld waren de zogenaamde Frei-Anlagen in de dierentuin van Carl Hagenbeck. Bij dit leeuwenterras - vernoemd naar de tweede Artis-directeur Dr. C. Kerbert (1890-1927) - nemen een gracht en een muurtje de functie van tralies over.

English translation:

The first animal residence (B.J. Ouëndag and A.F.J. Portielje) that is built according to modern concepts. Examples were the so-called Frei-Anlagen in Carl Hagenbeck's Zoo. At this lion terrace - named after the second zoo director Dr. C. Kerbert (1890-1927) - a moat and a wall take over the function of bars.

Film: scenes from a historical film from 1938, depicting the animals in the context of the monument.

Figure 4-4. Screenshot from the Kerbert-terrace movie

Music: fragments from 'Le carnaval des animaux' (The carnival of the animals) from the French composer Camille Saint-Saëns and parts from Beethoven's sixth Symphony 'Pastoral'.

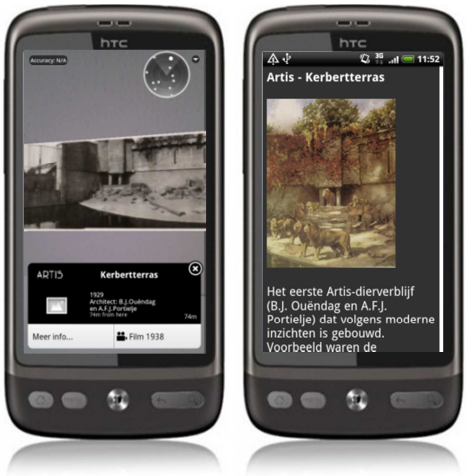


Figure 4-5. Screenshots Kerbert-terrace in application

4.4.2 User interface

The original Layar interface is as far as possible adjusted to the Artis styling. This includes applying the Artis colour scheme and the addition of the Artis logo. Figure 4-5 gives an overview of the different screens present in the application and their layout and styling.

Figure 4-6. Screenshots interface of the application

4.4.3 Service

The specific data (POI, texts, images, sounds, etc.) are on a server in Wageningen. It is possible to offer the total application via a different server. The applications on the provider side are developed and tested, primarily the software that handles the requests for information (like the texts or images).

The smartphones that are used in this study are of the brand HTC, types Hero and Desire (see figure5.2). Both smartphones have internal GPS, accelerometer and compass. These phones are equipped with a data SIM card, for unlimited internet access.

Figure 4-7. Smartphone models HTC Hero (left) and Desire (right)

4.5 Conditions for implementation in Artis

These are the requirements for implementation of the application in Artis. There should be a webserver available to run the application. Someone should be maintaining this and regularly update the information. The information in the application should be linked to the Artis website for a more integrated system. Besides the technical requirements, promotion of the application to the people is important for success of the application.

Some considerations before implementing and publishing the Artis application are described below. The improvements suggested in the user survey should be implemented. From the survey, it is clear that people would have more information than currently is provided. The location of additional information or a possibility to take information home should be provided. Also, further exploitation of possibilities within Layar and the application, like addition of more 2D and 3D content in 3D-space, should be investigated and implemented.
An example mentioned by both users and experts is the one application with multiple themes (e.g. a historical layer, an animal layer, etc.). Within Layar, there is a possibility to make such an application using radio buttons or checkboxes. The user can then select which theme they want and the application will request the corresponding POIs from the server. This will also work with different languages, making a choice with radio buttons between an English or Dutch languages version.
In addition, users would like a map with all the POIs. This is however not an easy issue, since the option provided by Layar directs to Google Maps which is not detailed enough for usage within Artis. Inclusion of a custom map in Layar as a separate action is for now only possible. This is quite some work to implement. For now, the part of exploring and finding the POIs is still a necessity.

In next chapter, the full outcomes of the user survey with the application, conducted in Artis, are described.

CHAPTER 5 - NATURA ARTIS MAGISTRA USER SURVEY

"It's not denial. I'm just very selective about what I accept as reality."
Calvin ("Calvin and Hobbes")

5.1 Framework experience testing

Testing of the responses, presented in the framework (chapter 2.4), should give results on the experience people are having, using the application. Moreover, whether there is a change in experience and awareness, because of using the application.

5.1.1 Identification and orientation

To ask what the place represents for people or letting them describe the location they are in, is a way to test identification and orientation of the user. When also tested afterwards one gets a better understanding of the users' change of view and increase in awareness of the location. The main goal is to know if there is a change in understanding of the environment, an enhanced awareness, or as in the framework a change in experience of the comprehension.

5.1.2 Evaluation and sensation

These can be tested with TAM (See 1.4.4), where enjoyment and additional questions concerning the application are included. Other open questions are asked for a detailed description of their evaluation and sensation. Here again the goal is to know if there is a change in experience of the impressions and associations of the environment.

5.2 Participants

The user survey was conducted on 21 February 2011. The weather conditions were cold, with a maximum temperature of 3ºC, a low sun and no clouds. Participants were given about one hour to use and explore the application and to fill in the questionnaire.

In total 14 people participated in this exploratory survey. Their average age was about 28 years old; the oldest participant was 54 years old and the youngest 14. Notably, they have a relative high education level, 43% of the participants finished a university degree and about 36% finished higher vocational education (Appendix V, table V-1). 6 out of the 14 participants are employees of Artis. The main reason why most people visit Artis is still to see the animals (Figure 5-1). For the reasons given under 'other' are the voluntary work and the guided tours those participants give.

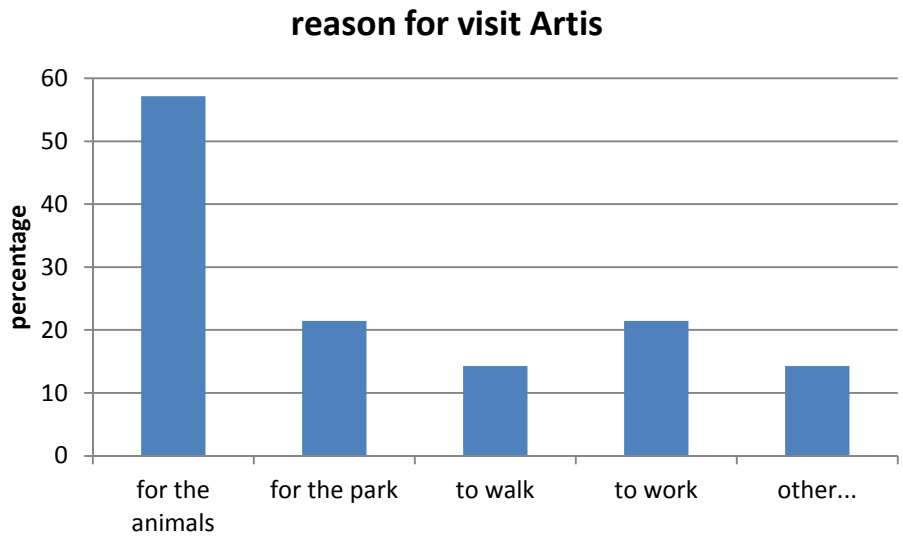
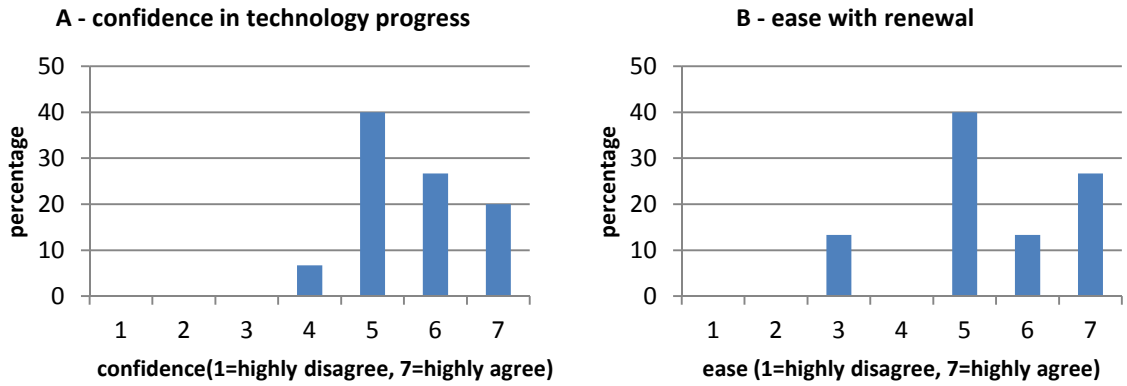


Figure 5-1. Reason for visit Artis (in %)

5.2.1 Technological development

In a couple of statements, participants were asked how they look at the current technological developments and whether they are compliant or adversary with it. All of the participants have a certain confident in the technological development (Figure 5-2A). Although not all of them are easy going with renewal and change (Figure 5-2B). According to at least 13%, everything changes too often and too fast (Figure 5-2C). There is however no relation with age or sex. Although most participants agree with the increasing influence of technology, they will not be the first in line for e.g. the newest phones or gadgets (Figure 5-2D & E).



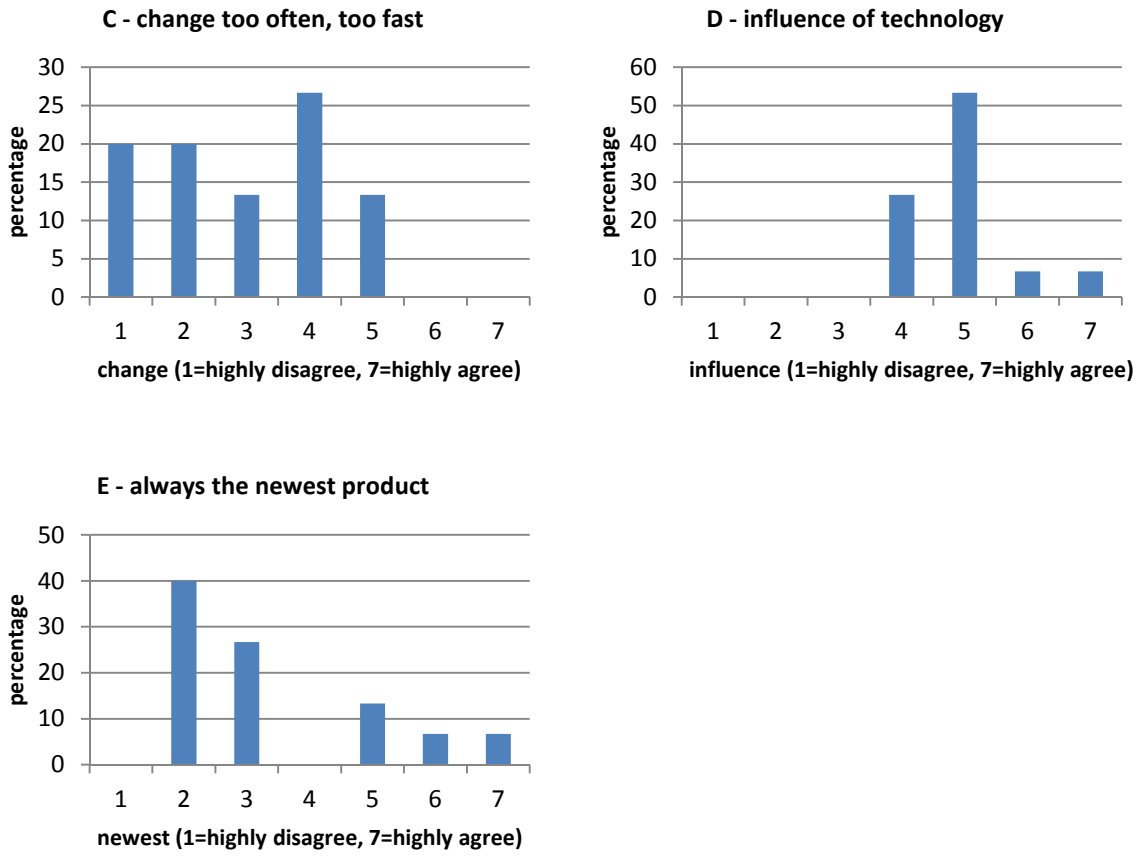


Figure 5-2. Distribution of different aspects of technological development (in %)

5.2.2 Experience with systems

52% of the participants have (very) little experience with smartphones and even 79% of the participants have no experience with Layar (Figure 5-3). It is obvious that when participants do not have any experience with smartphones, they certainly will not have any experience with Layar. The once that have experience with Layar also indicated that they have an above average experience with smartphones.

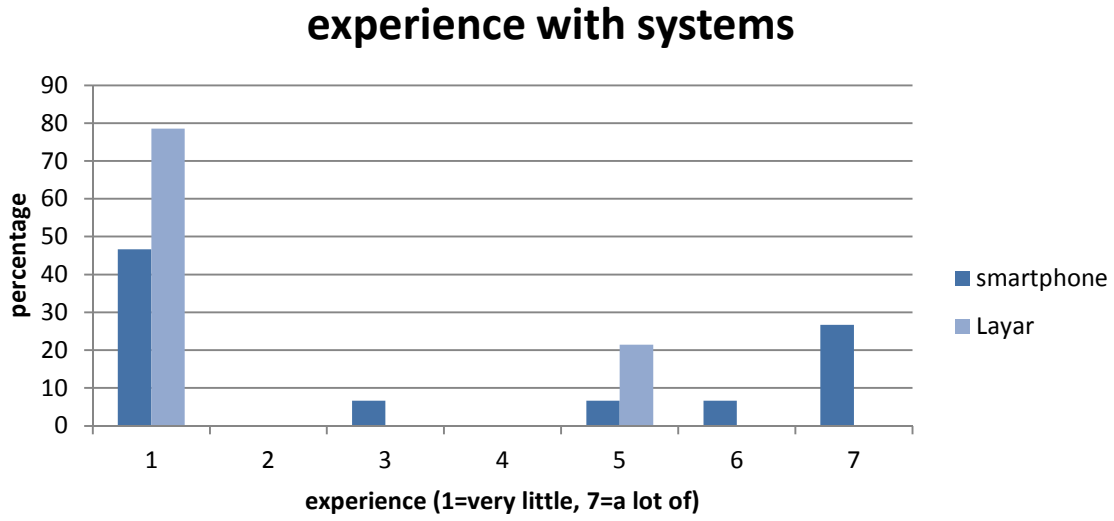


Figure 5-3. Distribution of experience with the systems (in %)

5.2.3 Technical functioning

As already mentioned in chapter 4 the refresh rate of the POIs was about five minutes, when conducting the survey. This is too long for the Artis application, since people are more moving around in the park. This issue also played a role during the user survey. However, participants adjusted to it, and afterwards made a note of it.

Besides this simple problem, 79% of the participants encountered other problems with their smartphone or the application. Table 5-1 gives the percentage of each problem encountered by the participants.

Table 5-1. Distribution type of problems (in %)

Type of problem	Percentage
GPS failed	21.4
had to restart	21.4
did not get information at POI	28.6
sun-glare made reading impossible	57.1
slow connection	42.9
other	14.3

When outside the obvious problem of sun-glare that makes reading impossible is hard to counter. The new smartphones have very shiny screen and therefore reflect a lot of light. The best way to counter this problem is to ensure a high contrast in the provided information.

For problems under heading 'other' mainly the slow POI refresh interval was mentioned. Another problem participants encountered, but did not mention it such as a problem, was the problem of the GPS deviation of the participants position. The application sometimes showed POIs of another part of the park, then where the participant currently was located. This can happen when the GPS loses its signal, for example when the participant goes inside. When the participant comes back outside the GPS is going to look for its location again, meanwhile the application updates its POIs and this can cause the wrong showing of POIs.

5.3 Usefulness

Because usefulness is a rather broad concept and participant can interpret it differently, it is worked out in several dimensions. Participants gave their judgement on the usefulness on the basis of these dimensions using the statement: "To explore Artis, I find my experience with the AR application …". A seven-point Likert-scale is used to give a judgement, where 1 stands for highly disagree and 7 for highly agree, a 4, the middle, can be considered as neutral. In addition, an overall judgement of usefulness was given.

Nearly 85% of the participants are positive about the usefulness of the application (Figure 5-4). The average judgement is 5.4 (standard deviation of 0.7280). No participant gave a negative judgement on the usefulness of the application, although 14% was neutral about the usefulness of the application.

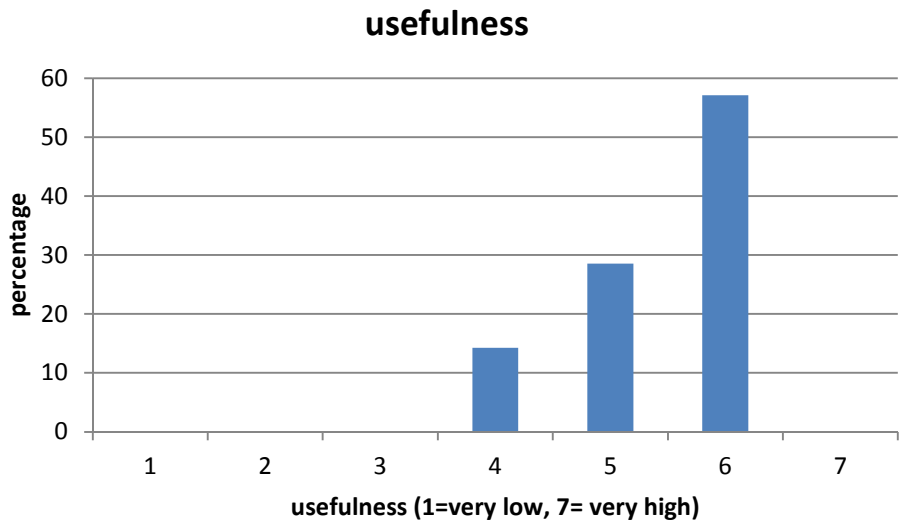


Figure 5-4. Distribution usefulness (in %)

The most important dimensions on the usefulness are special, useful and helpful (Table 5-2). 93% of the participants (highly) agree that the application is special and useful, while 71% (highly) agree with the statement that the application is helpful (Appendix V, figures V-1, V-2 & V-3). The rest of the dimensions are also positively rated.

Table 5-2. Average judgement on the usefulness dimensions (7-point Likert-scale)

Dimension	Average judgement
useful	5.6
practical	4.5
handy	4.7
helpful	5.1
efficient	4.6
special	5.6

The usefulness is partially depended on the content. Therefore, participants were asked questions about the presented information and the quantity of information. 77% of the surveyed people consider the load of information of the application to be right and as expected, not too much, not too less (Figure 5-5). Only males gave the negative judgement and they are all employees or regular visitors of Artis. They state that the presented pieces of text are too short; they would like to continue reading, and they also mention that some text pieces might be too difficult for common visitors.

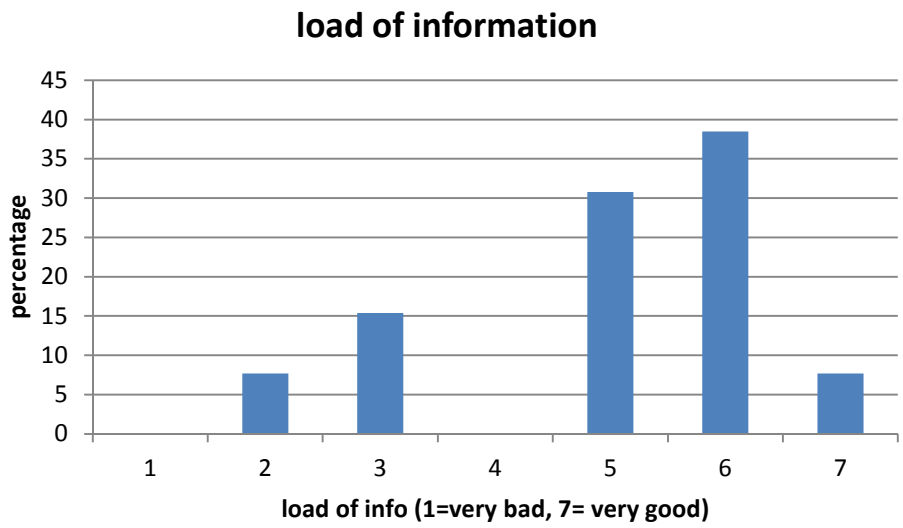


Figure 5-5. Distribution scores on load of information (in %)

All the participants indicate they got information they did not know yet (Table 5-3). The information is thought of as being understandable and definitely not superfluous. However, the information is not considered profound or holding any attention. That the information is not very profound might be considered a good thing, since ordinary people should also be able to understand the information.

Table 5-3. Average score on the content of the information (7-point Likert-scale)

Content of information	Average judgement
holds the attention	4.1
got info I did not know	5.3
understandable	4.7
superfluous	2.6
profound	4.3

5.4 Ease-of-use

Here the same applies as for the usefulness that everybody has a different interpretation of ease-of-use. Therefore, also for ease-of-use participants gave their judgement on the basis of predefined dimensions on the statement: "In use the smartphone is …". Here the same seven-point Likert-scale is used, where 1 stands for highly disagree and 7 for highly agree, A 4, the middle, can be considered as neutral. And again, an overall judgement was given by the participants.

About 86% of the surveyed people think the smartphone is easy in its use (Figure 5-6). The average judgement is 5.2 (standard deviation of 0.6739). No participants gave a negative judgement on the ease-of-use of the smartphone, but 14% was neutral about its ease-of-use.

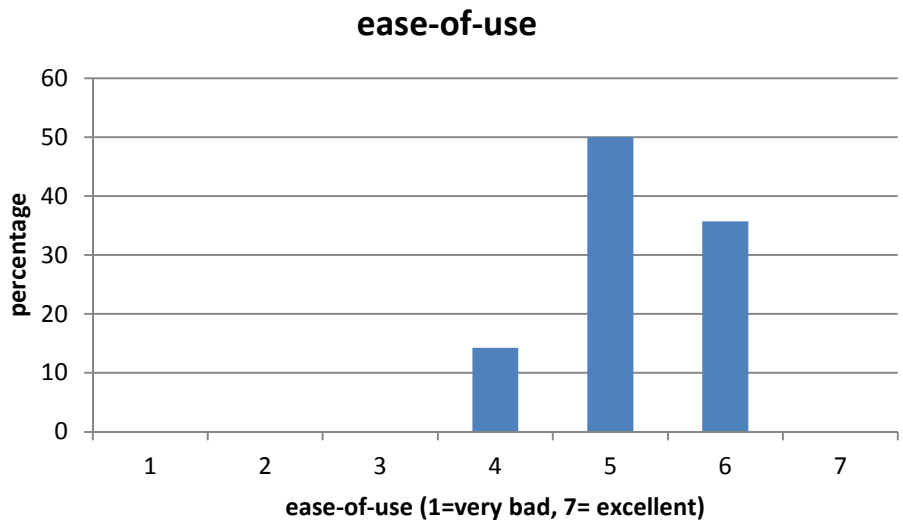


Figure 5-6. Distribution ease-of-use (in %)

The highest rated dimensions on the ease-of-use are understandable, need less knowledge of system and easy in use (Table 5-4). This is surprising because 52% of the participants had (very) little experience with smartphones and even 79% of the participants had no experience with Layar before the survey. This would mean that both the use of a smartphone and the Layar application are easy in its use and people can easily learn to use it. The dimension tiring to always carry it scored relatively high, partly because of the cold weather on the survey day. Participants mentioned that it is cold to keep the smartphone in your hands and when having cold hands it is harder to touch the screen of the smartphone.

Table 5-4. Average judgement on the ease-of-use dimensions (7-point Likert-scale)

Dimension	Average judgement
clear	5.1
understandable	5.2
need less knowledge of system	5.2
easy in use	5.2
does what I want	4.1
could do more, considering the technological development	4.4
tiring to always carry it	4.9

5.5 Enjoyment

The concept of enjoyment is worked out in different dimensions as well. Participant gave their opinion on the enjoyment they perceived during their tour through Artis using a number of dimensions on the statement: "The Artis application is…". Again the seven-point Likert-scale was used, where 1 stands for highly disagree and 7 for highly agree, a 4 for neutral. And like the other two concepts here the participants gave also their overall judgement.

86% of the participants perceived some kind of enjoyment or pleasure using the application (Figure 5-7). The average judgement is 5.2 (standard deviation of 0.6739). This is the same as for the ease-of-use, however it were not all the same people who gave the same answers for both concepts. Still 14% is neutral about the enjoyment given by the application, but no one is negative about it.

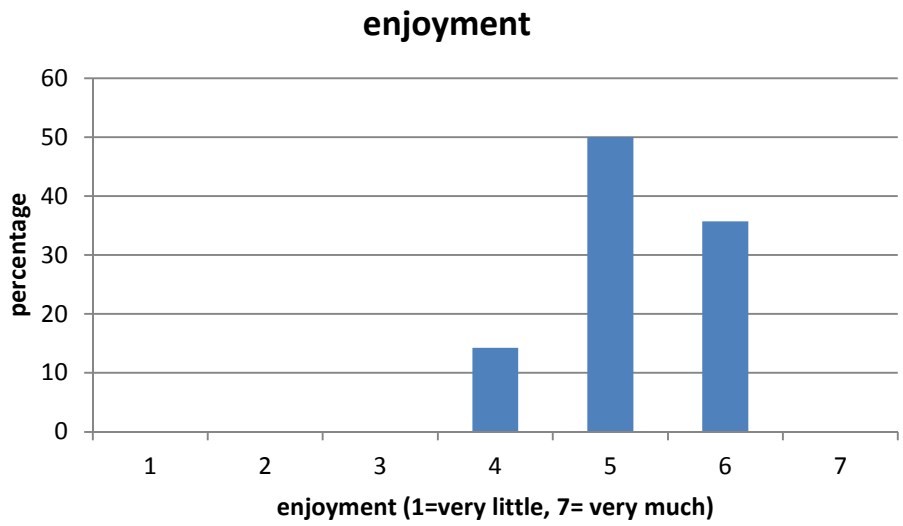


Figure 5-7. Distribution enjoyment (in %)

The dimensions that were highest rated by the participants are suitable to discover new things in the surroundings, interesting and unique (Table 5-5). Not suitable in combination with children also received high ratings. Participant stated that the information is not suitable and too difficult for children and that maybe a game element should be included to attract children. People did not agree that the application is boring (average of 3.2), but agreed that the application might be only fun for the one holding the device (average of 4.6). Although participants commented that when the letters are larger, information can be more easily shared. The other dimensions were judged rather neutral.

Table 5-5. Average judgement on the enjoyment dimensions (7-point Likert-scale)

Dimensions	Average judgement
adventurous	4.2
boring	3.2
only fun for the one holding the device	4.6
exiting	3.7
not suitable for groups	4.1
not suitable in combination with children	4.8
unique	4.8
interesting	5.4
too much present	4.7
suitable to discover new thing in the surroundings	5.5

Another comment made by the participants is that the application might not be suitable for groups. The participants that worked in couples however, were positive about using the application in pairs. In combination with little children, the application might not be so suitable.

Enjoyment is largely depends on the content of the information. The content is generally considered positive (Table 5-6). The presented information is not boring, but rather entertaining and interesting.

Table 5-6. Average score on the content of the information (7-point Likert-scale)

Content of information	Average judgement
boring	3.4
entertaining	5.2
interesting	5.3
have liked more	3.9

All participants indicate that they prefer a variety of media type to present the information. A combination of text and images get the highest score, although some would like some more audio commentary or movies.

5.6 Overall view on the Artis application

Besides giving judgements on separate concepts, participants were asked to give their overall view of the application. Again on a seven-point Likert-scale, where 1 stands for a very bad application and 7 for an excellent application, a 4 for neutral.

86% of the participants thought that the application is a good application (Figure 5-8), with an average judgement of 5.1 (standard deviation of 0.5933). 14% of the participants were neutral about the application. Older users were relatively more negative than younger users (Appendix V, table V-2). Participants above the 40 years old gave an overall average score of 4.2 out of 7 to all the questions, while participants younger than 30 years old gave an average score of 5.0. The low score can be explained, firstly that the older users have less experience with smartphones and, had to learn to use it during the survey, as confirmed by statements of the older participants. Secondly, the older participants are employees or volunteers of Artis and might see themselves replaced by technology.

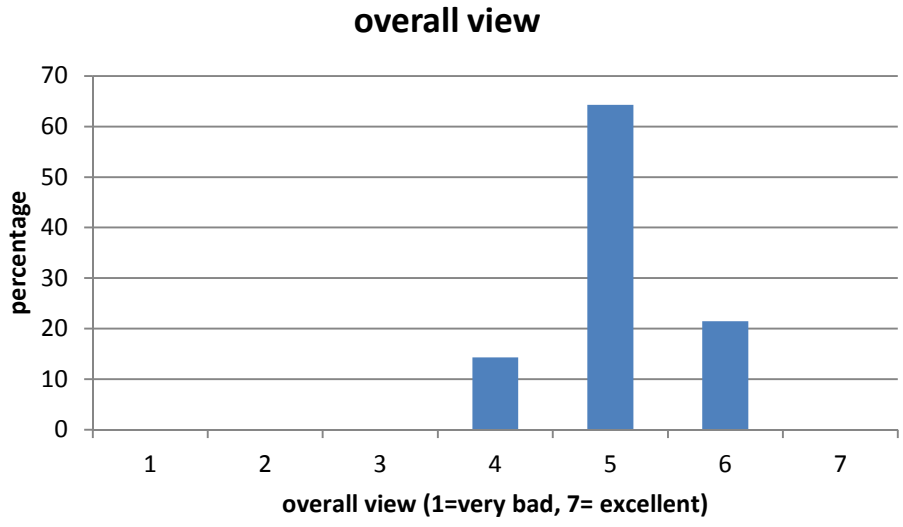


Figure 5-8. Distribution overall view (in %)

In addition to the overall view of the application participants were asked to give their opinion on a couple of statements. Once more a seven-point Likert-scale is used to give a judgement, where 1 stands for highly disagree and 7 for highly agree, a 4 can be considered as neutral.

93% of the surveyed people (highly) agree that the application has an added value when visiting Artis (Figure 5-9). The remaining 7% gave a neutral judgement. The average judgement is a 5.5 (with a standard deviation of 0.7319).

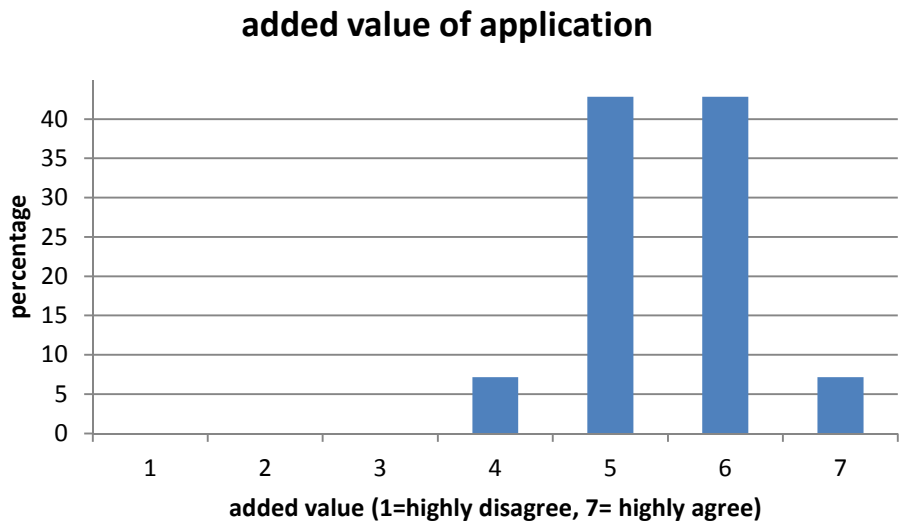


Figure 5-9. Distribution added value of the application (in %)

On the statement whether the application is a good way to highlight the monuments, 86% of the participants gave a positive answer, 7% remained neutral and another 7% gave a rather negative answer (Figure 5-10). The average judgement is a 5.6 (with a standard deviation of 1.1089).

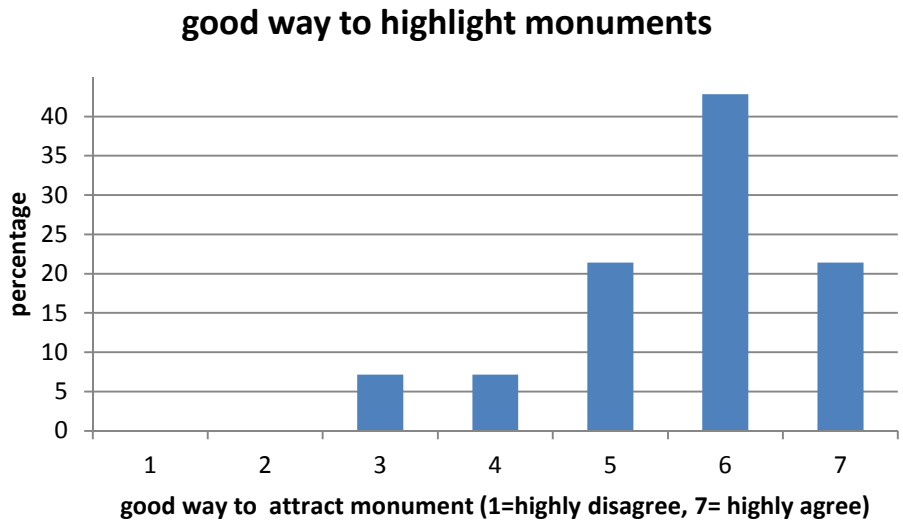


Figure 5-10. Distribution good way to highlight monuments (in %)

People were also asked to give their opinion on the statement whether or not the application contributes to their own experience of Artis. Here 93% agrees with the statement, while 7% rather disagrees with the statement (Figure 5-11). The average judgement on this statement is 5.2 (standard deviation 0.7726).

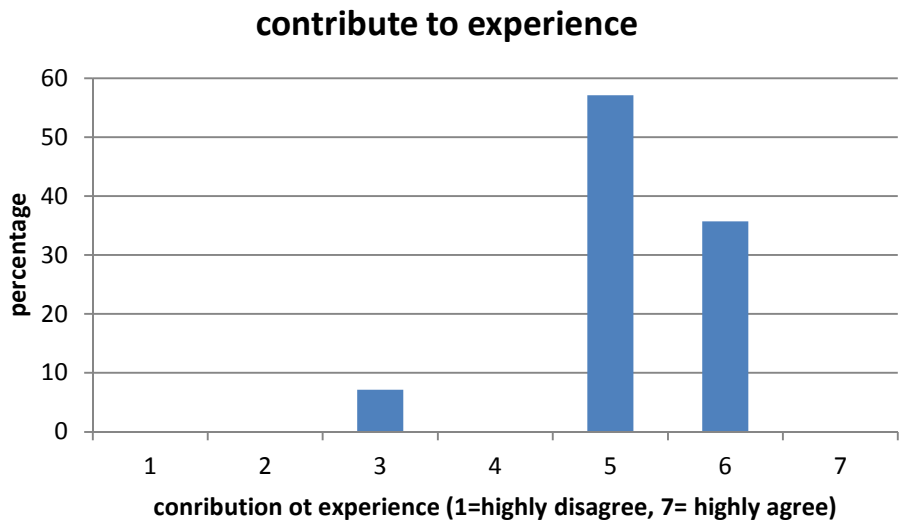


Figure 5-11. Distribution of contribution to experience (in %)

The final statement the participants were asked is whether the application gives them a better understanding of where they are. The people gave really different answers to this statement. 57% agrees with the statement, while 36% disagrees with the statement, and the remaining 7% stays neutral (Figure 5-12). The average opinion is 4.0 (standard deviation 1.6475). The participants that disagreed with the statement are the Artis employees, who have already more knowledge of Artis than the average visitor.

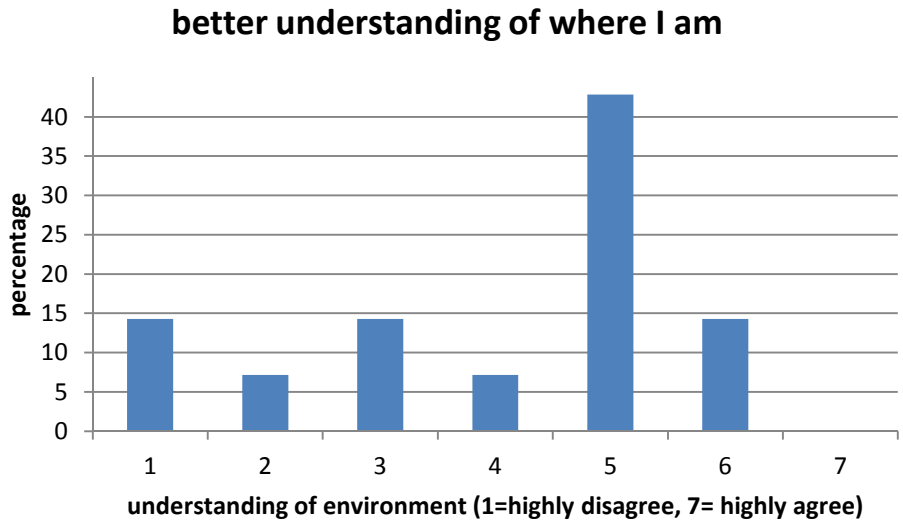


Figure 5-12. Distribution of better understanding of where I am (in %)

Intended use

Some concluding questions were asked if the participant would intend to use the application more often or that they might like to bring some information back home. About 64% of the participants intend to use the application more often during a visit to Artis, when the application gets regular updates (Table 5-7). None of the surveyed people excludes the intension of ever using the application again.

Table 5-7. Intension to use the application more often (in %)

Intend to use more often	Percentage
yes	14.3
yes, provided that the information is regularly updated	64.3
maybe	21.4
no	0

71% of the people would like to stay informed of changes in Artis, using an AR application (Table 5-8). The 29% that would not like to stay informed are mostly employees of Artis. They probably have already some kind of update from Artis, by means of an email newsletter.

Table 5-8. To stay informed of changes in Artis (in %)

	Percentage
yes	71
no	29

Again, 71% of the participant would like to be able to read or view information back at home (Table 5-9). Some people mention also that they would like to be able to reading more background stories of the viewed location back home. Here some potential for the Artis website comes in.

Table 5-9. Read or view information back at home (in %)

	Percentage
yes	71
no	29

5.7 Experience enhancement

5.7.1 Pre-application-use

Before the participants went into Artis with the application they were asked to answer some questions about their view and experience of Artis.

As is already visible in Figure 5-1, people mainly come to Artis for the animals. On the question: "Can you describe your view of Artis?", most people answered that it is primarily a zoo (Table 5-10). Employees mention that it is also a place for learning, working and sharing knowledge, like in giving tours to visitors.

Notable are the adjectives the people used to describe their views. They used words like: old, beautiful and nice.

Table 5-10. View of Artis before application

Current view	Times mentioned
(city)zoo	5
place to share knowledge, learn and work	3
park (with animals, for common people)	2
meeting place (with animals and colleagues)	2
resting place, escape from busy city life	2
a kind of family	1
my garden	1

To measure change in awareness and experience participating people were asked for their knowledge of the Artis heritage. 57% of the surveyed people have (very) little knowledge of the Artis heritage (Figure 5-13). These people are mainly visitors. Especially the Artis volunteers indicate to have quite some knowledge of the heritage. This is not surprising, because these people tour visitors around in the park. However, the extent of these volunteers' knowledge may be less than they think themselves. Therefore, a subsequent question was asked to mention monuments of Artis.

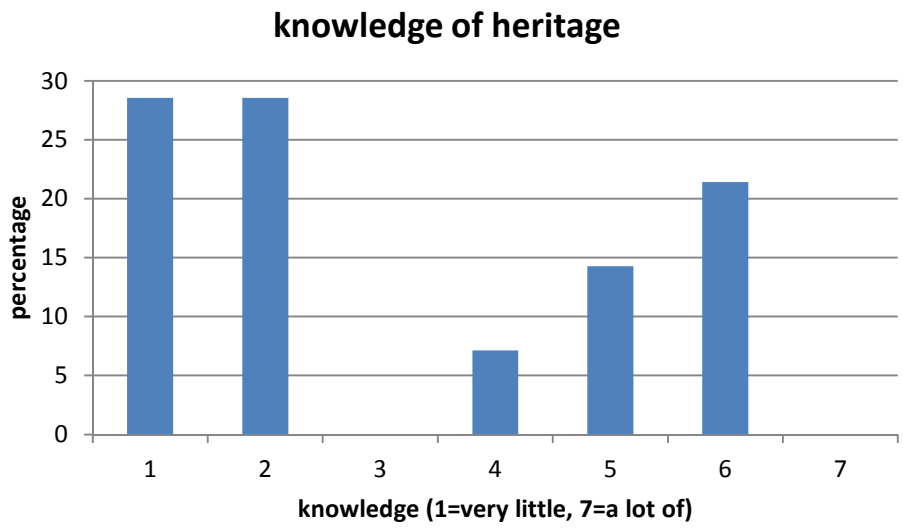


Figure 5-13. Distribution of knowledge of Artis heritage before application use (in %)

The majority of the participants can hardly mention any monument of Artis. Only four people could mention five or more monuments, and these people are employees or volunteers of Artis (Table 5-11). None of them mentioned more than eight monuments of the more than 26 monuments that are present in Artis. One participant probably gave the best answer, stating: "*I think almost everything in Artis is a monument.*".

Table 5-11. Number of monuments mentioned by the participants

Nr. of monuments mentioned	Times mentioned
0	5
1	2
2	1
3	1
4	1
≥5	4

5.7.2 After-application-use

Only employees answered with no, on the question whether their view of Artis was changed (Table 5-12). This might be explained that employees have more knowledge of Artis than common Artis-vistors, as a result of their daily work for Artis.

Table 5-12. Change in view of Artis (in %)

View of Artis changed	
yes	57
no	43

When there was a change in view, participants most often mentioned that they did not realise there was so much more to Artis. Even people who knew already something about the history of Artis indicated that there is more history to Artis than they knew before. Participants indicated that when using the application they were given a different view at Artis, a deeper and more detailed view. As a result, they saw more of Artis, besides the animals and the park.

Especially the number of monuments was an eye-opener to the people; even Artis-employees did not know there are so many monuments. This was already visible in Table 5-11 where only four people mentioned five or more monuments.

To the question if they learned anything from using the application, all, but one person indicated that they learned something more about Artis (Table 5-13). The most frequent answer was that Artis has a rich history, which they did not know or never heard of in such detail.

Table 5-13. Indication of things learned during use of application

Learned	
more to offer	7
more than a zoo	57
rich history	71
nothing	7

The participants were also asked to tell things that were standing out or worth mentioning from using the application. Both positive and negative comments were asked.

For the positive comments, people mention that it is really another way of visiting the zoo. Receiving additional information of the zoo, a broader view is given. The interesting (background) stories are often mentioned by the participants, some information was even surprising for people. Also the looking around and searching for the locations is mentioned as entertaining. A nice comment from one of the participants, who states: "Ordinary things become extraordinary.".

More technical, people were pleased with the rather unique materials of images and film, and the fast connection of the phones.

Participants find that they were automatically looking at the smartphone screen and therefore missing the surroundings, but they comment that this might be partly familiarisation and self-discipline. Furthermore, because the trigger sound was not always heard (due to confusing sound), they had to keep an eye on the application to know whether there were new POIs. Another negative comment is that everybody is looking for himself or herself, there is no encouragement to look together or share the information.

5.7.3 Ideas for development

To finalise, the participants could give their opinion on things that should have been included or new ideas for further and future development.

Content wise potential users would like to be able to zoom in on the presented images and have some kind of voice-over commentary. A map within the application with the locations of the POIs is also preferred by most of the surveyed people.

Changes they would like to make contain changing the trigger-sound, because the current is hardly audible in the zoo, and as already mentioned a larger font size for when sharing a smartphone and for elderly people who otherwise need their reading glasses. Furthermore, some parts of information were considered to be too difficult for the ordinary Artis visitor and might need revision.

The participants also mention that a 'read more' button should be included, for people who really want more information than what is now presented; possibly linking to the Artis website. And to make optimal use of the camera view, more images and 3D object should be included in the camera view. Some would like to be able to share their favourite location on Facebook, which is actually already possible with the new 5.0 beta-version of Layar. This new version makes it possible to share the apps with your social media accounts of Facebook and Twitter.

When the participants saw what AR can do, they presented lists of new ideas for other applications. Theme apps, like Artis during World War II, Artis by night or periodical apps (e.g. with festivities); and an app for the animals, especially for the ones with changing populations like the Aquarium and Vogelhuis, were brought forward.

To make the applications more interesting for children games could be included, however for this study a user group of 12 years and older was chosen. Nevertheless, for future applications attractions for children could be included.

5.8 Experts

Three experts tested the application and gave their judgement on it. Two experts are so-called content-experts, they looked at the information content and if AR is a good way to present this information. The other expert is a technical expert, he looked at how the application is build, the way of presenting the information, and it is potential for Artis.

5.8.1 Information

Overall, the presented information is considered as very good and correct. Some minor issues, like some texts, that should be told differently and the movies should be purposeful and significant. Information in Artis should surprise people, containing surprising facts, enough facts and a relation with nature or Artis.

The way of presenting the information is judged really well. The experts like the diversity in material. The change in images between photos and drawings is found to be a good way to show different aspects of the heritage of different dates. All the information is considered as convincing and entertaining. The given information is accessible and clear, users will not get lost in a maze of buttons. The included movies are rather dark and therefore not always well visible outside. If these movies can be enhanced in quality, they are a good variety in presenting information.

5.8.2 Experience

Whether or not the application enhances the experience of the people's surroundings is rather clear for the experts. The experts agree that providing on-location-information contributes to an enhanced experience of the surrounding. They mention that it enhances the experience even on different levels. Firstly, people get unknown information of their surroundings. Secondly, the trigger, when working properly, is a good way to notify people of other things in the park than currently visible. Finally, the awareness creation, the application is than part of a whole. People would start at home looking at the website of Artis, learn about the application, go to Artis and using the application, and when back home they are able to read more of the application's content through the website.

5.8.3 Use of AR

The use of augmented reality was also a subject the experts had to give their judgement on. The question was whether AR has an added value in this application. The experts had different opinions on this. Some locations had a good way of using the AR, but most still use a simple marker to show the location of the monument. The technical expert believes that the augmented reality part can be further exploited, by adding more 2D and even 3D objects in the camera view. However, he also mentions that not all locations are suitable to have a custom marker, these locations should retain their current marker.

The content-experts share the opinions of the technical expert, and even wonder if AR is really necessary to present the information or that or an application without AR can do the same. Nevertheless, they see potential in AR, when better used in the application, as explained before. The images in the camera view enrich the environment and are good to compare the location in his current and past state. Even the simple markers are good for pointing out the monuments to the users, but they agree with the potential users that inclusion of a map would make things even easier. They also mention that when using AR, you see things that you will not see without AR. It is not a substitution but an addition; and you might even let people focus on details.

5.8.4 Additional comments

An interesting note is that the experts are even convinced that an application such as this is also suitable in combination with children. As they say it: children are really easy with new technologies, so using an AR application is not a big issue. The content, however, could be made more children friendly, some texts are rather difficult. Inclusion of games or quizzes would attract children's attention even more.

Some ideas from the experts contain multiple applications, like an exploration tour. Even the possibility of having one application with multiple themes is suggested. Then people only have to open one application and can choose what theme they want for their visit in Artis. The application might even contribute to the city development project "Plantage aan de Amstel" (Gemeente Amsterdam, 2010).

5.9 Conclusions on the Natura Artis Magistra pilot application

This case study with user survey is applied to answer two important research questions; first, to know people's opinion on the use of an AR application in Artis and if they are willing to accept and use such application and second, whether people understand the application and if it has an effect on their experience and awareness of the surroundings.

The surveyed users are positive about the use of an AR application in Artis. In their opinion, it has an added value to a visit to Artis. It gives them more unknown information about Artis, both in background information and in recent developments. The application, when ready for publishing, will be accepted and used by the people. They even would like to have more detailed information or information about other items of Artis. However, some of the tested people, employees of Artis, are a bit sceptical about it, but not denying its usefulness.

The expert are even more positive about it, and do not exclude the possibility that the application is going to be used in the future. Technically it still a rather basic application and understandable for the user to use it. The content as it is now is entertaining and convincing but can be extended with links to other information sources. However, the use of AR is questioned, some experts really like it to compare old and new statuses of the monument. Other experts think that the information can also just be presented in an separate App or with QR-codes. However, a Layar application is rather easy and fast developed and even free. While creating a separate App with location determination, it will cost a lot more resources, the same with QR-codes.

The surveyed people agree that the application contributes to an enhanced experience of the environment and that it has an effect on their awareness of the surroundings. As they say it: "you become more aware that there is more around you than you first knew about". Giving people information of things not directly visible in the surroundings enriches their visit to Artis. Common things become uncommon, and ordinary objects become extraordinary. People are going to think about their environment and starting to wonder what else has an interesting story. The experts agree with the users that the application gives people a new and refreshing look at their environment. The application is an addition to what is already present, not a substitution of the present. In the opinion of some users and the experts augmented reality in the application should be further exploited. Nevertheless, the application in its current state already does a good job in informing people about the unseen.

CHAPTER 6 - CONCLUSION AND RECOMMENDATION

"Reality is what you make of it."
'Prot' in K-PAX a 2001 science-fiction comedy-drama film

The main research objective of this research project is: "To find out if GPS-based augmented reality can be used to enhance people's experience and awareness of their surroundings, by developing and testing an augmented reality smartphone application for Artis". Now it is time to give an answer to this objective.

6.1 GPS-based augmented reality in general

Quite some researches have been looking at the potential of augmented reality and the usability of GPS-based AR for science. There is enough knowledge on how to develop and create an AR application. There is, however, still a lack of knowledge about the users, knowledge on how they use AR and knowledge about how to attract them to the application.

The use of multimedia in AR is rather new and not yet exploited much. Some studies use voice-overs for explanation of scenes, but inclusion of film and music is mostly not done yet. Even so, the use of a sound signal to attract people to the AR application, if something interesting is around. These last elements are included, and the trigger is also tested, in the Artis case study.

For developing both a basic or extensive AR application, Layar is still the best option. They are rapidly developing and improving their software and application, and are by far the best-known AR-browser. For experimenting and innovating, also other AR-browsers are useful; however, the extensiveness of Layar is not met, yet.

6.2 GPS-based augmented reality in Artis

To use a location-based application in Artis has future potential, users are willing to use such application. Whether it is an AR or not is discussable. GPS-based AR is good for exploring larger areas, like cities or the countryside, though, for smaller areas it might give some difficulties. For example at locations that are rather close together, for AR this might be a problem. Because of the close POIs, overlay information may overlap in the camera view. Locations that are close together may also not be seen separately or even wrong located by the application, due to the accuracy of the smartphones' GPS. When AR is only used to find locations, using one symbol or marker, it would be clear for the user.

AR can be used to enhance people's awareness of their surroundings. But from the case study no clear evidence was found. The pilot application as a whole has a positive influence on the experience and awareness of people's surroundings, but whether or not AR contributes to the enhancement is not clear. It is quite certain that it plays a role in the enhancement of awareness and experience, but the most significant role is played by the texts and images. When the images are presented as overlay in the camera view, people have a good comparison of old and new statuses of the objects. In that case, it has a good influence on the environmental awareness and experience of the user.

The implementation of the trigger sounds help to inform people of nearby POIs. Moreover, users are, in that way, not obliged to continuously watch their smartphone. In the user survey, this sound was not always heard, but after changing the sound, the trigger became more present and better heard.

6.3 Reflection and recommendation

The research itself gives a quick view on both the technical and user aspects of an AR application. The small user survey was good for a first impression on the application. Further developing and testing of the application needs to be done to ensure a solid and quality application

In the relative short period that the application was developed, not everything could be implemented. More time would grant the application to be more extensive and contain more information. More AR in the Artis application would make it more attractive and have an increased added value for the users. More Framework elements, like voice-overs and animations should be implemented and tested for their effect on people's awareness and experience. From the current user test, no solid data according the enhancement in experience and awareness by AR was obtained. A better separation between AR enhancement and others enhancement effects in the user survey should improve the current results.

Yet, GPS-based AR is rather new, especially with the use of smartphones, therefore, still not a lot of research has to be done to investigate its potential and its users. Questions that arise are for example how people use AR, only for looking up a location or also as a guide.

There were some questions from experts and participants whether an application for Artis could also be without AR. There are several options for applications without AR. The use of QR-codes is one of the possibilities, although it is not recommended to use them outside. Inside buildings, QR-codes can be, however, very useful. Another option that does not require location determination, through GPS, would be an interactive map application. People can ask information on location by interacting with the map on their smartphone. This option would also provide the possibility for people to take information back home.

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> http://www.layar.com/

Mobilizy – Wikitude:

> http://www.wikitude.org/

Metaio – Junaio:

> http://www.junaio.com/
> http://www.metaio.com/

Georgia Tech – Argon (KHARMA):

> http://argon.gatech.edu/
> https://research.cc.gatech.edu/polaris/content/home

GLOSSARY

Android	A mobile operating system marketed by Google
Api	Application Programming Interface, a particular set of rules and specifications that a software program can follow to access and make use of the services and resources provided by another particular software program that implements that API.
App	Application for smartphones
AR	See Augmented reality
Artis	Natura Artis Magistra, the zoo in Amsterdam
Augmented reality	A technique that combines a live view in real-time with virtual computer-generated images, creating a real-time 'augmented' experience of reality
Augmented reality browser	Browser, like Layar, Wikitude and Juniao, where you can find various augmented reality information layers worldwide.
CGI	Centre for Geo-Information of the Wageningen University
FOV	See Field of View
Field of View	The observable world seen at given moment (in this case) through a smartphone
GPS	See Global Positioning System
Global Positioning System	The system of user, space, and control segments providing position, velocity, and time service
iPhone	Apple's mobile operating system originally developed for the iPhone.
Layar	See Augmented reality browser
PDA	Personal digital assistant, an electronic device which can include some of the functions of a computer, a cell-phone, a music player, and a camera
POI	See Points of interest
Points of interest	A specific point location that may be useful or interesting
QR-code	A specific 2-dimensional barcode that can be read by dedicated QR barcode readers and camera phones. QR is the abbreviation of Quick Response.
Smartphone	A mobile phone that offers more advanced computing ability and connectivity, like GPS, compass and internet, than a contemporary basic feature phone.
TAM	See Technology Acceptance Model

Technology Acceptance Model	An information systems theory that models how users come to accept and use a technology
VR	See Virtual reality
Virtual reality	Computer-simulated environments, simulating real world places or imaginary worlds
XHTML	eXtensible HyperText Markup Language, family of XML, that extends version of Hypertext Markup Language (HTML), the language in which web pages are written
XML	Extensible Markup Language, a set of rules for encoding documents in machine readable form.

APPENDICES

Appendix I - Questionnaire Artis augmented reality survey

(after: van der Heijden, 2004 and Goossen, 2008)

Vragenlijst

Geachte deelnemer,
U gaat Artis doorlopen met een 'augmented reality' applicatie (in het vervolg Artis-applicatie genaamd), dat meer informatie zal geven over bepaalde locaties in Artis. Als onderdeel van een onderzoeksproject wil ik graag gegevens verzamelen. De onderstaande vragenlijst bestaat uit drie onderdelen. Deel 1 bevat algemene vragen over uw achtergrond. Deel 2 bevat vragen die u dient te beantwoorden voordat u met de applicatie Artis in gaat. En deel 3 bevat de vragen die beantwoord dienen te worden nadat u met de applicatie Artis in bent geweest. Ik vraag u vriendelijk om onderstaande vragenlijst in te vullen.
Alvast hartelijk dank voor uw medewerking.

Deel 1 - Algemene vragen

1. Wat is uw leeftijd?
   …… jaar

2. Wat is uw geslacht?
   - O man
   - O vrouw

3. Wat is uw hoogst voltooide opleiding?
   - O Geen of alleen basisonderwijs (lagere school)
   - O Lagere algemene opleiding (VGLO, LAVO)
   - O Lagere beroepsopleiding (LBO, VBO, LHNO, LEAO)
   - O Middelbare algemene opleiding (MULO, MAVO, VMBO)
   - O Middelbare beroepsopleiding (MBO, MTS, UTS, MEAO, INAS)
   - O Hogere algemene opleiding (HAVO, MMS, VWO, Atheneum, Lyceum, Gymnasium)
   - O Hogere beroepsopleiding (HBO, HTS, HEAO)
   - O Hoger wetenschappelijk onderwijs (universitair)

4. Hoe vaak per jaar komt u in Artis?
   - O ……keer
   - O dit is de eerste keer
   - O ik ben medewerker

5. Heeft u ervaring met…

	zeer weinig						zeer veel
Smartphones	O	O	O	O	O	O	O
Layar	O	O	O	O	O	O	O

6. In hoeverre bent u het eens met de volgende stellingen?

	zeer mee oneens					zeer mee eens	
Ik heb vertrouwen in de vooruitgang van de technologie	O	O	O	O	O	O	O
Ik ga gemakkelijk om met vernieuwing	O	O	O	O	O	O	O
Ik moet altijd het nieuwste product hebben	O	O	O	O	O	O	O

Alles verandert te vaak en te snel	O	O	O	O	O	O	O
De invloed van technologie neemt exponentieel toe.	O	O	O	O	O	O	O

Deel 2 - Vragenlijst voor gebruik Artis-Applicatie

1. Waarvoor komt u normaal gesproken naar Artis?
   - O voor de dieren
   - O voor het park
   - O om te wandelen
   - O om te werken
   - O anders nl …

2. Kunt u beschrijven wat Artis voor u is?

3. In hoeverre bent u bekend met het erfgoed van Artis.

Ik weet er…	zeer weinig van						zeer veel van
	O	O	O	O	O	O	O

4. Kunt u enkele monumenten van Artis noemen?

Deel 3 - Vragenlijst na gebruik Artis-Applicatie

Geachte deelnemer,
U heeft net Artis doorlopen en gebruik gemaakt van de Artis-applicatie. Ik vraag u vriendelijk om ook onderstaande vragenlijst in te vullen.
Alvast hartelijk dank voor uw medewerking.

Smartphone nummer : ……
Huidig tijdstip : ……

GEBRUIK

1. Hebt u alle locaties (POIs) bezocht?
   - O Ja
   - O Nee

2. Hebt u onderweg problemen met de Artis-applicatie ondervonden?
   - O Ja
   - O Nee (ga naar vraag 4)

3. Wat voor problemen waren dat (meer antwoorden mogelijk)
   - ☐ GPS viel uit
   - ☐ Batterij was leeg
   - ☐ Moest opnieuw opstarten
   - ☐ Geen verbinding met internet
   - ☐ Kreeg geen informatie op POIs
   - ☐ Geluid viel weg
   - ☐ Door zonlicht slecht leesbaar
   - ☐ Traagheid bij het binnenhalen van informatie
   - ☐ Anders nl…

NUTSWAARDE
4. In hoeverre bent u het met betrekking tot de nutswaarde eens met de volgende stellingen.
Om Artis op een andere manier te leren kennen, vind ik mijn ervaring met de Artis-applicatie …

	zeer mee oneens						zeer mee eens
Nuttig	O	O	O	O	O	O	O
Praktisch	O	O	O	O	O	O	O
Handig	O	O	O	O	O	O	O
Behulpzaam	O	O	O	O	O	O	O
Efficiënt	O	O	O	O	O	O	O
Bijzonder	O	O	O	O	O	O	O

5. Wat is uw totaaloordeel over de nutswaarde van de applicatie?

zeer laag						zeer hoog
O	O	O	O	O	O	O

GEBRUIKSGEMAK
6. In hoeverre bent u het met betrekking tot het gebruiksgemak eens met de volgende stellingen.
In het gebruik vind ik de smartphone…

	zeer mee oneens						zeer mee eens
Overzichtelijk	O	O	O	O	O	O	O
Begrijpelijk	O	O	O	O	O	O	O
Weinig kennis vragen van techniek	O	O	O	O	O	O	O
Makkelijk in gebruik	O	O	O	O	O	O	O

Doe wat ik wil	O	O	O	O	O	O	O
Meer moet kunnen, gelet op de technische vooruitgang	O	O	O	O	O	O	O
Vermoeiend om steeds vast te houden	O	O	O	O	O	O	O

7. Wat is uw totaaloordeel over het gebruiksgemak?

zeer slecht						uitstekend
O	O	O	O	O	O	O

PLEZIER

8. In hoeverre bent u het met betrekking tot het plezier eens met de volgende stellingen.
De Artis-applicatie is …

	zeer mee oneens					zeer mee eens	
Avontuurlijk	O	O	O	O	O	O	O
Saai	O	O	O	O	O	O	O
Alleen leuk voor degene die het apparaat vast heeft	O	O	O	O	O	O	O
Spannend	O	O	O	O	O	O	O
Voor groepjes niet geschikt	O	O	O	O	O	O	O
Samen met kinderen niet geschikt	O	O	O	O	O	O	O
Uniek	O	O	O	O	O	O	O
Interessant	O	O	O	O	O	O	O
Te veel aanwezig, beleef de omgeving hierdoor niet	O	O	O	O	O	O	O
Een geschikt middel om nieuwe dingen in de omgeving te ontdekken	O	O	O	O	O	O	O

9. Wat is uw totaaloordeel over het plezier waarmee u de Artis-applicatie heeft gebruikt?

zeer weinig						zeer veel
O	O	O	O	O	O	O

TOTAALOORDEEL

10. Wat is uw totaaloordeel over de Artis-applicatie?

zeer slecht						uitstekend
O	O	O	O	O	O	O

11. In hoeverre bent u het met de volgende stelling eens?
De Artis-applicatie biedt een meerwaarde bij een bezoek aan Artis.

zeer mee oneens						zeer mee eens
O	O	O	O	O	O	O

12. In hoeverre bent u het met de volgende stelling eens?
De Artis-applicatie is een geschikt middel om de monumenten van Artis onder de aandacht te brengen.

zeer mee oneens						zeer mee eens
O	O	O	O	O	O	O

13. In hoeverre bent u het met de volgende stelling eens?
De Artis-applicatie levert een bijdrage aan mijn beleving van Artis.

zeer mee oneens						zeer mee eens
O	O	O	O	O	O	O

14. In hoeverre bent u het met de volgende stelling eens?
De Artis-applicatie geeft mij een dieper inzicht in waar ik ben.

zeer mee oneens						zeer mee eens
O	O	O	O	O	O	O

INHOUD

15. Wat vindt u van het onderdeel informatie?

	zeer slecht						zeer goed
Hoeveelheid informatie	O	O	O	O	O	O	O

16. Wat vindt u van de inhoud van de informatie

	zeer mee oneens						zeer mee eens
Houdt de aandacht vast	O	O	O	O	O	O	O
Kreeg informatie die ik							
Nog niet wist	O	O	O	O	O	O	O
Saai	O	O	O	O	O	O	O
Begrijpelijk	O	O	O	O	O	O	O
Overbodig	O	O	O	O	O	O	O
Diepgaand	O	O	O	O	O	O	O
Leuk	O	O	O	O	O	O	O
Interessant	O	O	O	O	O	O	O
Had meer gemogen	O	O	O	O	O	O	O

17. Welke informatie typen heeft u gebruikt? (Meerdere antwoorden mogelijk)

- Tekst
- Afbeelding
- Video
- Muziek

18. Wat vindt u van de geluidsfragmenten?

	zeer mee oneens						zeer mee eens
Verstaanbaar	O	O	O	O	O	O	O
Duidelijk	O	O	O	O	O	O	O
Kwaliteit van het geluid							
Was goed	O	O	O	O	O	O	O

19. Wat vindt u van de foto-en/of videobeelden die getoond zijn?

	zeer mee oneens						zeer mee eens
Scherp	O	O	O	O	O	O	O
Overbodig	O	O	O	O	O	O	O
Leuk	O	O	O	O	O	O	O
Interessant	O	O	O	O	O	O	O
Had meer gemogen	O	O	O	O	O	O	O

20. Welk type media heeft uw meeste voorkeur?

- O Tekst
- O Afbeeldingen
- O Video
- O Geluidsfragment
- O Afwisseling van type media
- O Geen voorkeur

TOEKOMSTIG GEBRUIK

21. Zou u de Artis-applicatie vaker gebruiken?
    - O Ja
    - O Ja, mits de informatie regelmatig bijgewerkt wordt
    - O Misschien
    - O Nee

22. Zou u op de hoogte willen blijven van veranderingen in Artis?
    - O Ja
    - O Nee

23. Zou u thuis informatie terug willen lezen / zien?
    - O Ja
    - O Nee

24. Zijn er nog dingen die u mist of heeft u nog ideeën?

.....

.....

.....

.....

Nu volgen enkele vragen over uw beleving van Artis.

1. Kunt u vertellen wat u is opgevallen (zowel positief als negatief) tijdens het gebruik van de applicatie.

Positief:

.....

.....

Negatief:

.....

.....

2. Kunt u aangeven wat u geleerd heeft tijdens het gebruik van de applicatie. (Meerdere antwoorden mogelijk)
    - ☐ Artis heeft meer te bieden
    - ☐ Artis is meer dan een dierentuin
    - ☐ Artis heeft een rijke geschiedenis
    - ☐ Anders nl.

.....

.....

3. Is uw beeld van Artis veranderd?
    - O Ja
    - O Nee

Kunt u uw antwoord uitleggen?

.....

.....

.....

.....

Appendix II - Questions Artis augmented reality expert survey

1. Wat vindt u van de gepresenteerde informatie?

2. Wat vindt u van de manier van presentatie?

3. Verhoogt de applicatie de beleving van de omgeving?
   - O Ja
   - O Nee

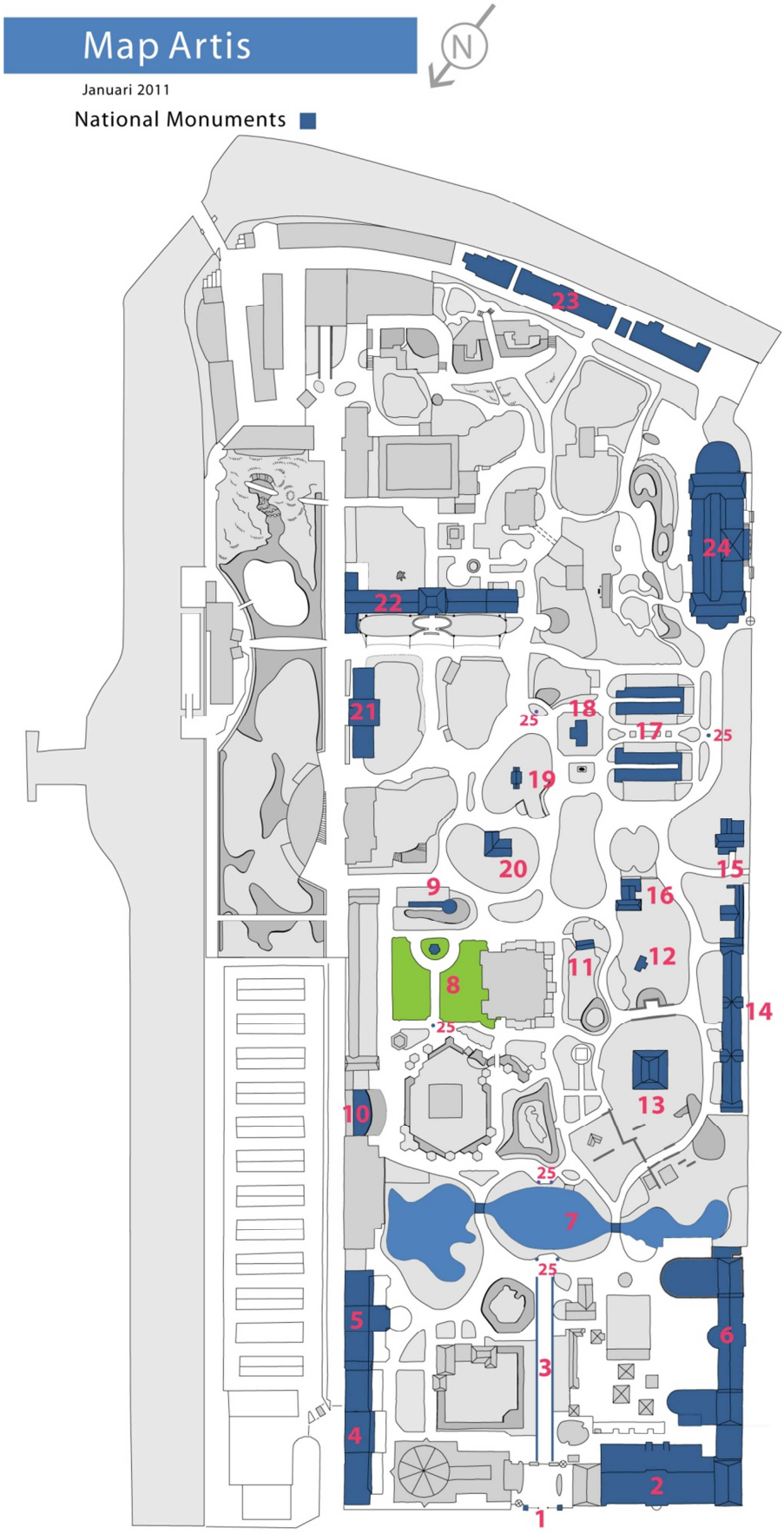
Kunt u uw antwoord uitleggen?

4. Heeft Augmented Reality een meerwaarde, of kan het ook zonder?
   - O Ja
   - O Nee

Kunt u uw antwoord uitleggen?

5. Zijn er nog dingen die u mist of heeft u nog ideeën?

Appendix III - National monuments of Natura Artis Magistra



The names of the monuments can be found on the next page

Nr	Nederlandse naam	English name
1	Hoofdingang	Main entrance
2	Ledenlokalen	Office building
3	Papegaaienlaan	Parrots lane
4	Vogelhuis	Bird house
5	Voormalige Apenhuis	Former Monkey house
6	Zoölogisch museum	Zoological museum
7	Artis vijver met bruggetjes	Artis pond with bridges
8	Hollandse tuin	Dutch garden
9	Uilenruïne	Owls ruin
10	Kerbertterras	Kerbert-terrace
11	Moeflonstal	Mouflon stable
12	Indische Antilopenstal	Indian Antelope stable
13	Eenhoevigenhuis	Equidae house
14	Artis Bibliotheek	Artis Library
15	Directeurswoning en Buitenhuizen	Manager's house and County houses
16	Duivenhuis	Pigeon house
17	Fazanterie	Pheasantry
18	Ronde volière (Masmanhuisje)	Round Aviary (Masman house)
19	Minangkabausehuis	Minangkabause house
20	Wolvenhuis (oorspronkelijk café 'Eik en Linde')	Wolves accommodation (original café 'Eik en Linde')
21	Giraffenstal	Giraffe stable
22	'De Volharding'	'De Volharding'
23	Geschakelde magazijnen en werkplaatsen	Linked warehouses and workshops
24	Aquarium	Aquarium
25	Verschillende beelden: Twee tuinvazen, twee bronzen hondenbeelden, twee natuurstenen beelden die stroomgoden voorstellen en het Kerbert grafmonument	Several sculptures: Two garden vases, two bronze dog statues, two natural stone statues depicting stream gods and the Kerbert cenotaph

Appendix IV - XML script POI

```
<poi>
  <id>arkerbert</id>
  <title>Kerbertterras</title>
  <line2>1929</line2>
  <line3>Architect: B.J.Ouëndag</line3>
  <line4>en A.F.J.Portielje</line4>
  <attribution>%distance% from here</attribution>
  <imageURL>
        http://alterra0125s.wur.nl/porpoise/artis/kerbertterras/kerbertterrasverkadetn.jpg
  </imageURL>
  <lat>52.36708889</lat>
  <lon>4.91568889</lon>
  <type>2</type>
  <dimension>2</dimension>
        <alt></alt>
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              <angle>0</angle>
              <scale>1</scale>
        </transform>
        <object>
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              <full>kerbertpanoramatn.jpg</full>
              <size>7000</size>
        </object>
  <action>
    <uri>http://alterra0125s.wur.nl/porpoise/artis/kerbertterras/kerbertterras.html</uri>
    <label>Meer info...</label>
  </action>
  <action>
    <uri>video://alterra0125s.wur.nl/porpoise/artis/kerbertterras/leeuwen.mp4</uri>
    <label>Film 1938</label>
  </action>
  <action>
    <uri>audio://alterra0125s.wur.nl/porpoise/animals/roodborst.mp3</uri>
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    <autoTriggerOnly>true</autoTriggerOnly>
  </action>
 </poi>
```

Appendix V - Additional results user survey

Table V-1. Highest completed education of participants

Education	Percentage completed
university	43
vocational	36
higher secondary	7
elementary	14

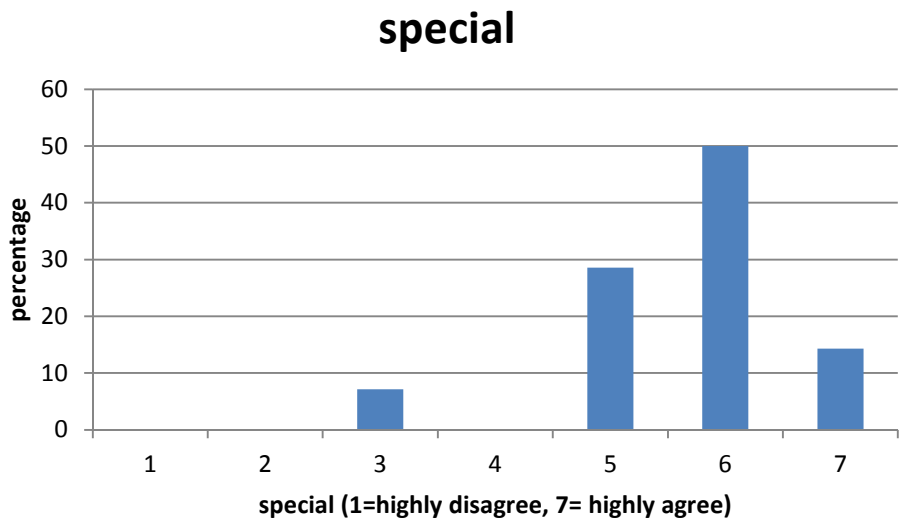

Figure V-1. Distribution of the dimension special (in %)

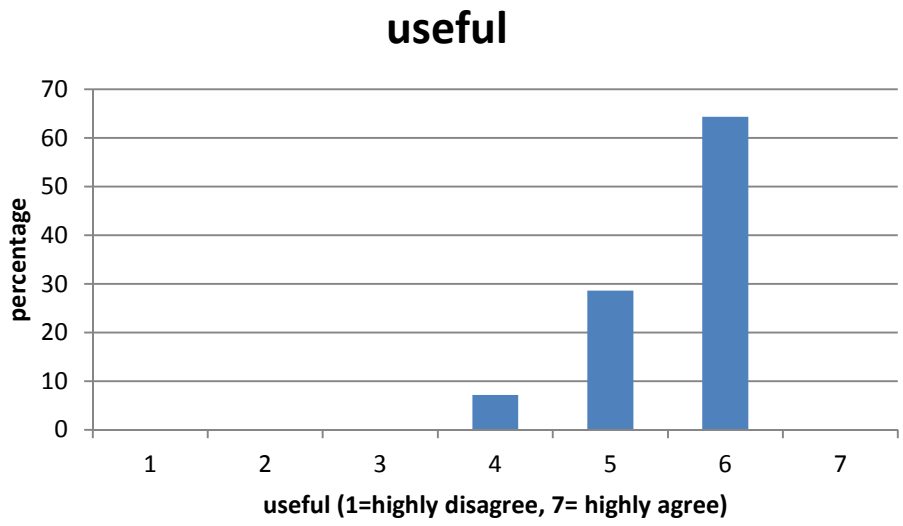

Figure V-2. Distribution of the dimension useful (in %)

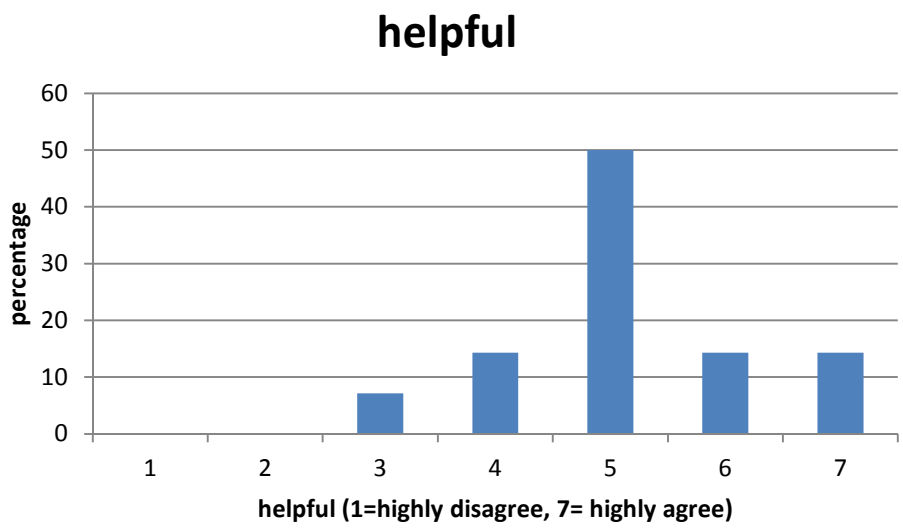

Figure V-3. Distribution of the dimension helpful (in %)

Table V-2. Average score per age category

age	average score
>40	4.2
30-40	4.8
20-30	5.0
<20	5.0