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ARTIRILMIŞ GERÇEKLİK TEKNOLOJİLERİNİN KULLANIMI MÜZELERDE ARTIRILMIŞ GERÇEKLİK ÇALIŞMASI

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(MASTER THESIS)

USAGE OF AUGMENTED REALITY TECHNOLOGIES A CASE STUDY: AUGMENTED REALITY IN MUSEUMS

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Bornova-İZMİR

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This study titled “Usage Of Augmented Reality Technologies A Case Study: Augmented Reality In Museums” and presented as Master Thesis by Deniz Aydoğdu has been evaluated in compliance with the relevant provisions of Y.U Graduate Education and Training Regulation and Y.U Institute of Science Education and Training Direction and jury members written below have decided for the defense of this thesis and it has been declared by consensus / majority of votes that the candidate has succeeded in thesis defense examination dated June 17, 2013.

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Rapporteur Member:	**………………..**	**…………………**
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ÖZET

ARTIRILMIŞ GERÇEKLİK TEKNOLOJİLERİNİN KULLANIMI
MÜZELERDE ARTIRILMIŞ GERÇEKLİK ÇALIŞMASI

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Yüksek Lisans Tezi, Bilgisayar Mühendisliği Bölümü
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Haziran 2013, 70 Sayfa

Artırılmış Gerçeklik (AG), 1970'li yıllardan günümüze teknolojininde gelişmesiyle değişmiş ve evrimleştir. Bu tez, AG dünyasına girmek isteyen araştırmacılar için rehber niteliğinde bir yol sunmayı ve kültürel alanlarda Artırılmış Gerçeklik uygulamalarının durumu ve geleceği ile ilgili bilgi vermeyi hedeflemektedir.

Tez, Artırılmış Gerçeklik teknolojisinin nasıl çalıştığıyla ilgili bilgilendirmekte, uygulama alanlarına göre irdelemekte ve tarihten bugüne gelişimini özetlemektedir. AG teknolojisinin kültürel alanlarda mevcut sunum ve kompozisyonunu temelli değiştirebileceğini tartışmakta ve ARGuide prototip uygulamasını sunmaktadır. Sonuç olarak, AG teknolojilerinin yeni doğan bir alandan emeklemeye başlayan bir konuma geldiğini belirterek, bu ilginç alanda yakın zamanda birçok örnek göreceğimizi ve bunun geniş kitlelere yayılacağını belirtmektedir.

Anahtar sözcükler: Augmented Reality, Museum, Exhibit, Augmented Reality Guide

ABSTRACT

USAGE OF AUGMENTED REALITY TECHNOLOGIES
A CASE STUDY: AUGMENTED REALITY IN MUSEUMS (ARGUIDE)

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Supervisor: Prof. Dr. Mehmet Cudi OKUR
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Augmented Reality (AR) technologies, developed since 1970's has evolved and advanced with today's technological advances. This thesis aims to guide researchers who wants to engage in AR technologies and will provide about the current status and future of cultural information presentation innovation with augmented reality.

Thesis, explains how AR technologies work, expresses and explains fields of application and gives a summary from history to present time. It discusses the AR technologies that can enhance how cultural presentation and experience is created in museums and how it can be modified and improved with AR technologies. ARGuide prototype application has been done and presented. As a conclusion thesis indicates, AR technologies are clearly moved on from infancy to maturity a beginning stage where many innovative opportunities for presenting information is possible and human kind will be witnessing more fantastic applications in near future for public masses.

Keywords: Augmented Reality, Museum, Exhibit, Augmented Reality Guide

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While writing my thesis, that is my last formal tie to the academic life, I have had good time, even though I spent sleepless and tiring days. People told me not to work on a subject I like due to the possibility of hating it, however, I did not listen to them, and I am happy to choose Augmented Reality. As an engineer who is very found to obtain new skills, I am very grateful that I have added this very important skill to my knowledge base.

If we come to thanking part, my sister Dilay Aydoğdu and my partner Ali Akdurak deserve most of it. I thank my mother for her encouragement, my father for his passive support and for their beautiful wishes for me. I thank my close friend group members Ayça Pınar Akdurak, Nuray Karagöz, Gözde Küsmüş, Anıl Yılmaz, and Berkay Üner for their interest and support on me.

I thank my supervisors Prof. Dr. Aydın Öztürk and Prof. Dr. Mehmet Cudi Okur for their support and guidance.

TEXT OF OATH

I declare and honestly confirm that my study titled "Usage Of Augmented Reality Technologies A Case Study: Augmented Reality In Museums (ARGuide)" and presented as Master's Thesis has been written without applying to any assistance inconsistent with scientific ethics and traditions and all sources I have benefited from are listed in bibliography and I have benefited from these sources by means of making references.

07 / 06 / 2013

Deniz AYDOĞDU

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ABBREVIATIONS	EXPLANATION
AR	Augmented Reality
AV	Augmented Virtuality
MR	Mixed Reality
VR	Virtual Reality
HMD	Head Mounted Display
GUI	Graphical User Interface
PDA	Personal Digital Assistant
GPS	Global Positioning System
QR Code	Quick Response Code
GPU	Graphic Processing Unit
CPU	Central Processing Unit
LAN	Local Area Network
DOF	Degrees Of Freedom
SDK	Software Development Kit
GPL	General Public License

1 INTRODUCTION

In Today's World, technology has an ongoing changing and developing dynamic. Within this development and with the help of smart phones and tablets that have a big role in our social lives, mobile applications has turned into a separate technology development area. Thanks to mobile applications, people have the possibility to meet their needs of daily life by using their telephones and without forced to be in an office or home environment. Surprising increase of mobile applications caused AR technologies to gain the spotlight and advanced these technologies forward. Applications in various areas have been developed with AR which presents an augmented world view on a real world image by using media elements that can also include 3D models.

AR is an information technology that occurs with the gathering of virtual information and its integration with reality which brings a new point of view to the reality. 3 dimensional graphics that have been generated while scanning the QR Code of the products may have been observed and experienced by the consumers. The mentioned technology used in the area of advertising, entertainment, and science has been continuing to improve rapidly.

Before appearing on market, AR, has improved year by year with the theoretic research labor, many different algorithms and researches has been made in hardware and software domains. One of the popular subjects of AR applications is historical artifacts and their presentation. Museums being the main place for such artifacts to be exhibited have a very unique role in development of such AR applications.

The primary aims of this research are to serve as a guideline for the new researchers of AR technology and to help them that would like to do AR projects.

1.1. Research Questions

- What is Augmented Reality, how does it work, what are their usages of areas?
- How did AR technology start and how is it used today?
- What are the main limitations of AR technology?
- How is AR technology used in museums and how can it be used?
- What is the benefit of augmented reality guide application for museums?

1.2. Thesis Outline

This part gives a general view of the chapters that constitutes this thesis work by briefly referring the contents.

Chapter 1 – In Introduction part, the information about the development of AR with the improving technology, answers of certain questions and the general flow of the thesis can be found.

Chapter 2 – In Augmented Reality part, the information about the different definitions of AR technology, brief explanation of how it works and its area of usage and example applications will be mentioned. The chronological explanation of AR technology process from past to present and the main problem faced while developing AR application within the process can be reached, as well.

Chapter 3 – A Case Study: AR in Museums part consists of AR study examples made in museums, technical information about ARGuide application and the prototype implementation details are presented.

Chapter 4 – Conclusion and Discussion concludes the thesis with discussion and future work.

2 AUGMENTED REALITY

AR is another way to enrich the information by virtually superimposing augmentations to the real environment view. Initial aim of this virtual superimposition is to give extra information by using media elements at the object seen directly. The discovery of AR has started by searching for an answer to the question of forming an interaction with the virtual world in 1968s. Today, it confronts many areas of usage which encompasses from socioeconomic standard of living to common entertainment.

AR provides a simultaneous integration between the 3 dimensional objects that have been created by computer and real world objects. It can provide service in many areas from education to amusement, from medical areas to industry with this integration.

While referring to AR, four main features will give us the definition. Processing virtual data over physical world, providing extra information, presenting what is unseen to the users and providing real-time interactivity are AR's main features.

2.1 A How Does AR Works?

AR, which combines virtual objects with the real world objects, can use accelerometer, GPS, head-mounted display with camera, eyeglasses, eye tap, and computers as hardware platforms. In modern mobile devices (smartphones, tablet computers), it works with camera and microelectromechanical systems (accelerometer, GPS and solid state compass).

AR systems work by image processing real time video to get location and position information. This information is used to generate 3D graphics and media elements that are correlated to real environment. Whole operation can be summarized as getting the real environment image, tracking image markers / sensor devices, and displaying augmented information.

Figure 2-1 System setup for Augmented Reality (Metaio, -)

2.2 Fields Of Application

If the studies in AR field are examined on a general ground, the titles can be seen as they are grouped in Figure 2-2. (Caspari, 2013)

Studies in AR field that started in 1968s and come to modern-day has continued to offer service in many areas by bringing future ideas herewith. As it is mentioned under the titles of AR history, its present, and future, AR is going to grow and improve rapidly by interacting with the user in terms of visual and psychological points of technology.

The progress and researches made in the field of AR can be followed under four different titles; social applications, service applications that present information, real-time location detection and navigation application, graphical presentation based applications.

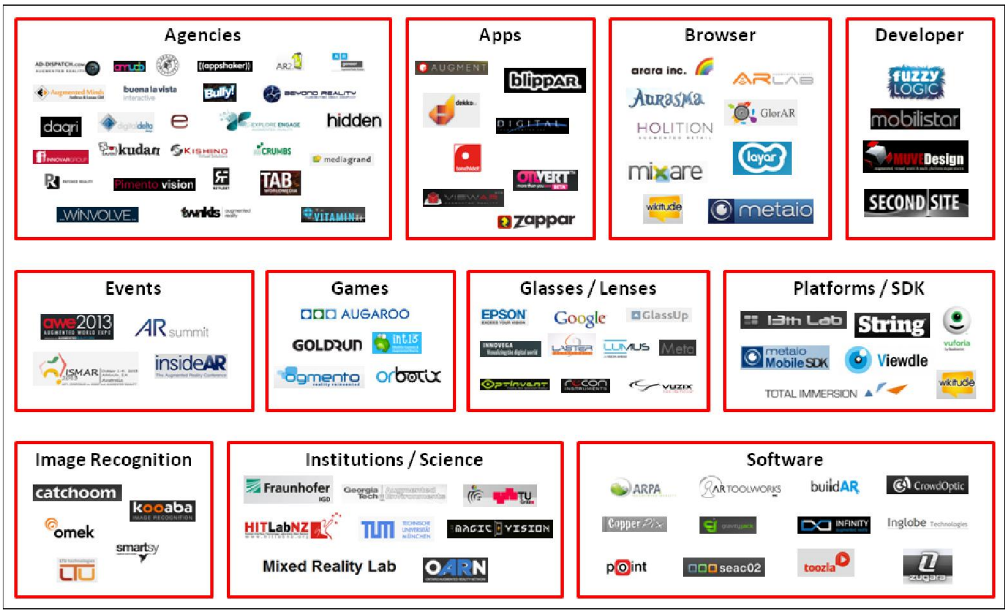
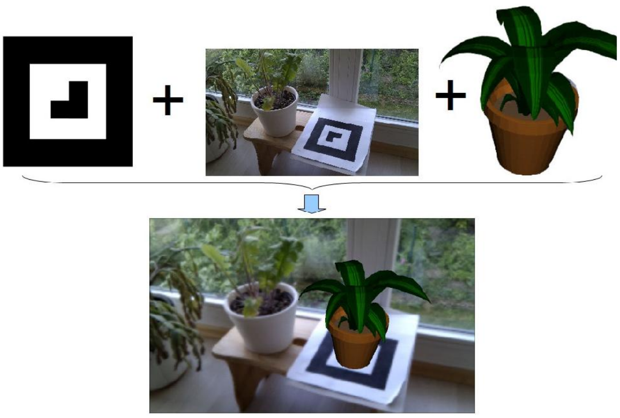


Figure 2-2 Augmented Reality Landscape

Social network games and advertisement applications are implementations that include graphic integration and QR code detection algorithm as it is seen in Figure 2. For instance, 3D models are used with



barcode reading technique in AndAR - Android Augmented Reality project.

Figure 2-3 AndAR – Android Augmented Reality Example (AndAR,-)

Another example for AR application is used as a smart marketing tool called “I Live Umbria”. The application is a t-shirt, a portal and a social network at the same time and in this way, it turns into a living space in which sharing, conversation, experience and emotion can be organized. The application is used by the sequence of buying a T-shirt, downloading the application, applying the print on the T-shirt, reading over the application, and watching the intended video.

Figure 2-4 I live Umbria Example (IliveUmbria,-)

Service applications that offer information provide complex information to be presented via 3 dimensional images. Additionally, these applications provide a practical usage by classifying educational demands into process steps in mechanical area. With the help of these kinds of applications, it is aimed to create an interactive environment with real world objects. For example engineering applications developed by Metaio are established for the subjects like productivity increase, planning, and education in the industry field.

(a) (b) (c)

Figure 2-5 Industrial AR (a) Comparison of States (b) Design Check (c) Facility Planning

The examples pictured in Figure 2-5(a) removes prototype phase in multi-stage production by giving its users ability to see modeled production on site. 3D representation of designed product additionally provides benefits of understanding collisions (before they even happen) and help production analysis. Figure 2-5(b) gives information about different design alternatives, visualization of simulation results and general design appearance. The picture in Figure 2-5(c) gives information about environmental planning representing what is suitable to use in many areas from architectural to mechanical. It enables to compare alternatives about planning and provides information about layouts and operative spaces that are necessary in order to reach optimum running parameters. (Metaio, -)

AR that appears in the areas of real-time location detection and navigation makes it possible to determine user's current place, direction, and pathway. Analyzing this data AR systems can lookup to GIS databases for various data. Also these data can be processed at a data-center or on-site for guidance. Related example application Wikitude Drive allows navigation options by obtaining location data over GPS. It works by taking real time video of the road and superimposing 3 dimensional pathways on the screen. Please see Figure 2-6. (Flatley, 2010)

Figure 2-6 Wikitude Drive Interface

Graphic based applications appear generally in advertisement and game areas. Many firms present 3 dimensional visual mascots/characters to their users by showing special predefined markers to the firm's application.

Application for Adidas is enhanced by using Metaio Web SDK to make advertisement effective, enjoyable, and cool by allowing customers have close contact with more media. (Sung, 2011)

Figure 2-7 Adidas Originals Neighborhood (Wachelka, 2013)

AR applications are directly related to the media content. For a case study please consider this scenario; the user is looking for a house for rent or sale while wandering around the neighborhood. The information about whether the house is for sale or rent, the pictures of it and cell phone number of the owner appear on mobile devices' screen without spending time for searching houses on the internet. A simple frame marker outside the house would be just enough. AR system allows user to gain much more information about the real estates than before while just wandering around.

Figure 2-8 Danberry Real Estate

AR appears with two different experience fields in its current state of art. First one is location detection (geo-location) and second one is vision-based AR. Geo-location based AR processes GPS and electronic accelerometer data –obtained from user's mobile device- on the image received from the camera.

Main constraints such as poor precision and accuracy, world-centric data, non-ubiquitous -GPS access problems (indoors and settled city areas) can be problematic for work in Geo-location-based AR field.

Vision-based AR renders the 3D images on the display by using relative camera position. This is to prevent the precision limitation that emerges from geo-location-based AR applications. Main features of Vision-based AR are precision, being object-centric, ubiquitous, and visibility-aware. (Ashbrook, Ballinger, 2011)

Figure 2-9 Thodolite User Interfaces

AR applications also take place in art works and domains with its spatial concept of augmented reality. It presents the interaction between virtual and real world to the audience over the environment they stand by using computer graphics and advanced presentation technologies. It improves quite rapidly by involving people who work in art and media fields. (Bimber and Raskar, 2005)

When the question of whether 3 dimensional projection mapping is an AR application or not is analyzed, it is thought that a new definition should be added to the definitions of AR. (Szymczyk, 2013) In addition, when the animated live video application is projected on to the building, what is seen is the addition of the augmented reality on real world.

Figure 2-10 3D Projection Mapping

In Figure 2-11, the digital model of the box is calibrated to the physical model by using embedded light sensors. In this way, position of sensor is determined within the scope of reference projection. Using this information 3D box model texture is rendered on the physical 3D box according to the reference information coming from the projection frame. (Määttänen, 1999)

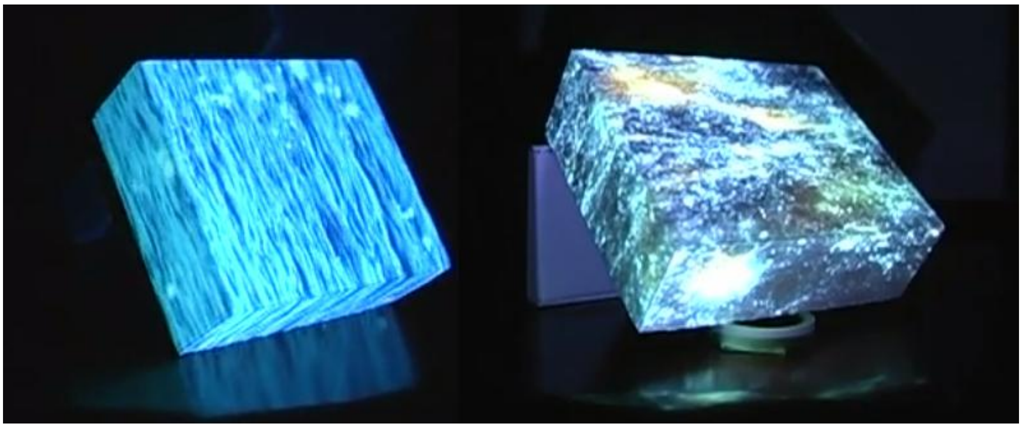


Figure 2-11 Re-implementation of Projector Calibration with Embedded Light Sensors

2.3 History Of Augmented Reality

AR term was mentioned in 1990s for the first time; however, this does not mean that it had not been known previously. In 1957, Morton Helig, opinion leader of Virtual Reality technology, named the machine he developed Sensorama. It was designed to make the user experience a full cinematic practice and it provides this experience in a way that all of the sense organs can detect- air, vibration, sound- with a stereoscopic 3 dimensional ambient area projected to the back and front parts of the head. (Heilig, -)

Figure 2-12 Sensorama Machine

In 1966, the research made by Ivan E. Sutherland is about the changeability of 3D world image reflected on glasses equipment with the movement of the user by using head mounted display. Harvard University professor Sutherland contributes to the researches on this field by inventing the first HMD which has a significant role in AR and VR fields. (Sutherland, 1965)

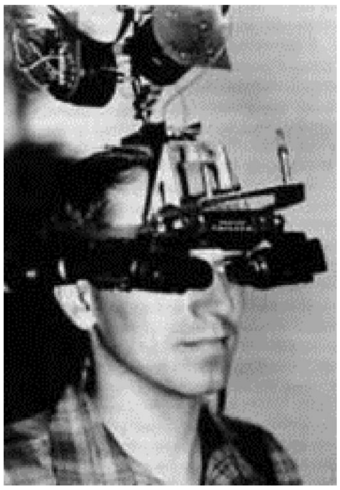


Figure 2-13 Sutherland’s Head-Mounted Display

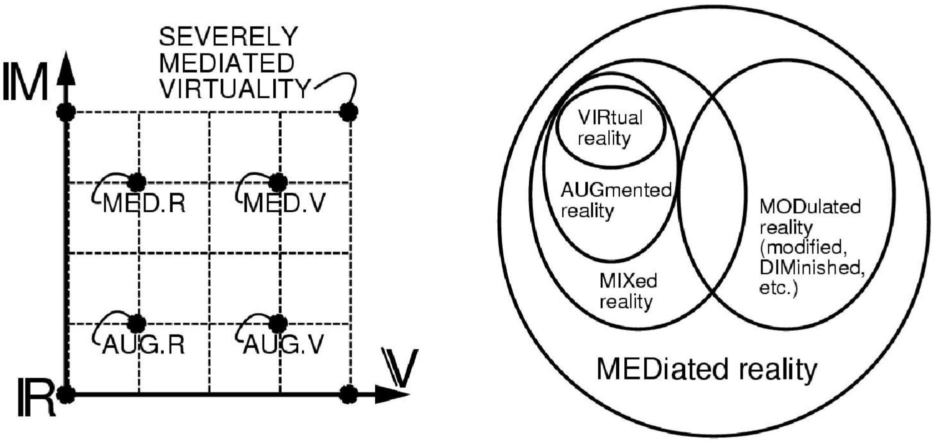
Augmented Reality term is first defined in 1922 by Ton Caudell and David Mizell as rendering a computer based image over the real world. Caudell and Mizell made researches about the advantages and disadvantages between AR and VR and since AR enable to overlay by using less pixel, it is decided to be more advantageous. In addition, they worked on position detecting and integration on real world by mentioning design and prototype steps of heads-up, head mounted display applications. (Caudell, Mizell, 1992)

Loomis, Golledge and Klatzky's "Personal Guidance System for the Visually Impaired using GPS, GIS, and VR Technologies" study is designed to provide help for blind people to find their way by using geographic information systems and virtual sound techniques as a research and mobile computer application. (Loomis, Golledge, Klatzky, 1993)

After the studies mentioned above, in 1994 Milgram and Kishno brings Reality-Virtuality process forward with their article "Taxonomy of Mixed Reality Visual Displays." As it is seen in Figure 2-14, all the area between real and virtual environment is separated as augmented virtuality and augmented reality depending on AR and proximity. (Milgram, et al. 1994)

Figure 2-14 Milgram's Virtuality Continuum

In Figure 2-15(a) R point represents unaltered basic reality. On V line, various mixtures of graphics in reality and augmented reality are shown. When 3 dimensional graphics enrich reality further to the point where reality is less than virtuality, this point can be named as augmented virtuality. However, taxonomy both includes reality, virtuality or a combination of any sort at the same time. If it is gone on the mediation line of M, it is started to mediate reality in 3D representation which shows mediated reality. In Figure 2-15(b), virtual world, a changed version of reality is pictured. (Fung, Tand, Mann,2002)



a) b)

Figure 2-15 Mediated Reality with implementations for everyday life

AR is in the area that is closer to the reality in mixed reality line. Situated between real and virtual, AR is supposed to have more real elements than virtual augmentations. As a consequence, instead of virtualizing the whole universe like virtual reality, it aims to increase the information support visually in real world. It is also important to know how much knowledge of real environment is needed to provide accurate augmentations. Figure 2-16 can be considered as an expansion of Figure 2-14. (Milgram, et al. 1994)

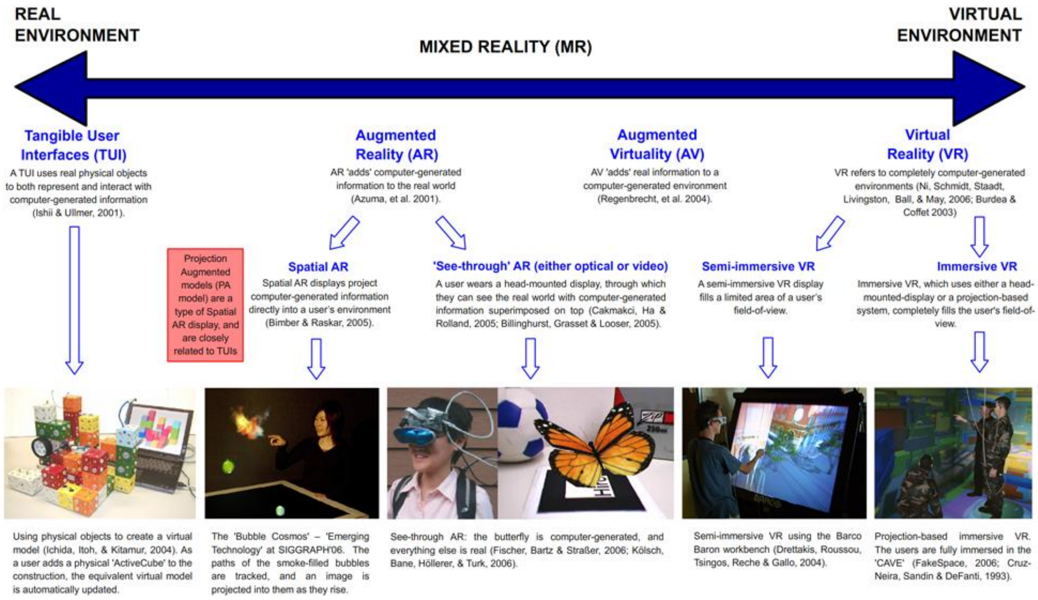


Figure 2-16 Adapted Milgrams VR-AR Continuum

In history of AR research, a very important milestone is development of 2D matrix markers (square-shaped barcodes). This important development is made in AR field by Jun Rekimota in 1998. It is one of the first tracking systems that allow tracking camera with a 6 degree of freedom. Thereby, coordination of real world objects can be determined simultaneously. (Rekimoto, 1998)

First written study about AR technology was written by Roland Azuma in 1997. Azuma focused on three factors in his study; the combination of virtual and real objects in real environment, real-time interactivity, and adaptation of real and virtual objects. (Azuma, 1997)

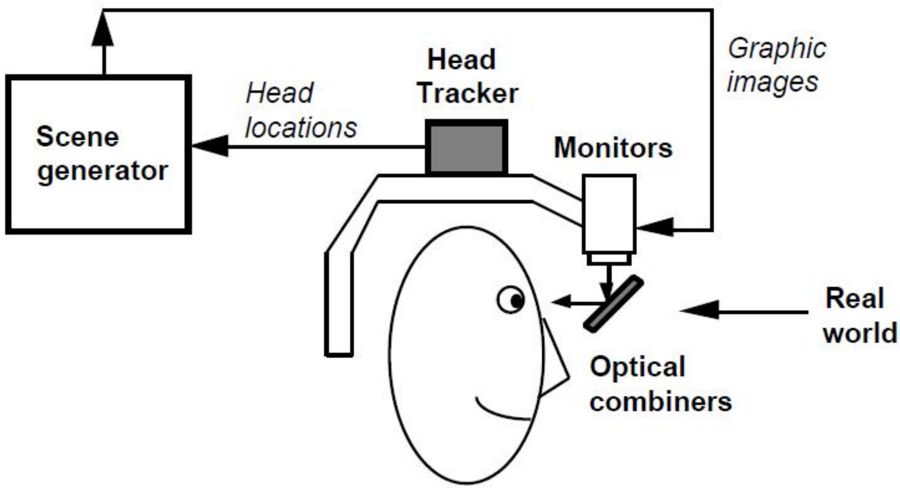


Figure 2-17 Optical see-through HMD conceptual diagram

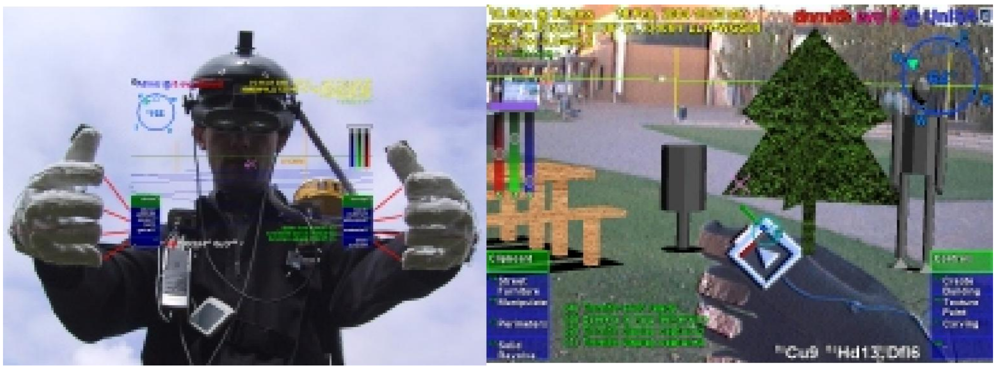
“Touring Machine” the study presented as a mobile computer application in the leadership of Steve Feiner in 1997, is known as the first mobile AR system. With a wearable computer equipped with GPS, radio and Wi-Fi, Steve Feiner created a platform with web integration and had all the requirements for his AR system. By providing touch pad opportunity with hand-held computer and its pencil, it displays location information and some information related to the chosen building via wireless internet access over the menus like “Where am I?”, “Depts.?” and “Buildings?” while walking around the campus. The application that works as a browser shows the information about campus and building lists in the field according to the user’s simultaneous location. Information is placed on real world image on head-worn display. Until the user comes in to proximity with campus buildings they are rendered grey. The more it is close, the more the writings become clear in yellow and if you stay in the same position in a highlighted way more than 1 second, it turns into green. This means the user can reach detailed information with the opening of a new menu bar and stay active as long as the user does not change his/her orientation. (Feiner, et al. 1997)

Figure 2-18 Mobile Augmented Reality System

AR technology progressed actively since 1997, with Starner's "Augmented Reality through Wearable Computing" paper. He searches for the concept of wearable computer. "The Remembrance Agent" system used in the application is formed from two parts; user interfaces and search engine. The user interface gives the pictures it takes to the embedded search engine as an input. The search engine, filters old e-mails, note files, and online documents that are suitable and about the location or image that the user provide. (Starner, Mann, Rhodes, Levine, Healey, Kirsch, Picard, Pentland, 1997)

A project named "Tinmith" also takes part in the wearable computer research concept by the usage of mobile outdoor AR. This AR application is supported by terrestrial-based navigation with GPS, electronic accelerometer and wearable computer. It presents information on a HMD. They maintained their study from 1998 to 2006 actively, continuously enlarging their aims. Tinmith is a system designed in order to develop AR applications that has a flexible software structure swiftly. (Thomas, et al. 1998)

Example shown in Figure 2-19(a) shows a user who is able to control interface with a glove interaction. In Figure 2-19(b), visualization of 3D virtual objects rendered over the real world and the ability to be controlled by the user are shown.



a) b)

Figure 2-19 Tinmith Usage Example

ARToolKit, a study of Hirokazu Kato and Mark Billinghurst in 1999, is developed as a tracker library that provides 6 DOF. It kept its popularity under the license of GPL. In their article named “Marker Tracking and HMD Calibration for a Video-based Augmented Reality Conferencing System”, they aim to gather remote users via virtual monitors that can position without depending on the environment they stand. In Figure 2-20(a), AR application interface, in Figure 2-20(b), remote user display and in Figure 2-20(c), virtual white board, and common work area is shown. (Kato, et al, 1999)

(a) (b) (c)

Figure 2-20 AR Conferencing System Usage

In 1999 Höllere, Feiner and Pavlik published “Embedding multimedia presentation in the real world”. They developed a system (Figure 2-21) to allow an augmented tour of university campus. This system also rendered 3D textures onto old buildings and provided extra information about their history. It is the first mobile AR system developed by using tracker that has GPS and magnetics orientation. (Höllere, Feiner, Pavlik, 1999)

Figure 2-21 Virtual flags denoting points of interest, photographed the top of a campus building

2.4 Augmented Reality Today

Improving standards, studies and with the development of new technologies, AR gains a leap in 2000s. Wireless network protocol 802.11a/802.11b, namely, the standard called WIFI can be counted as an example. Similarly, the opportunity to reach maps by using GPS receiver in mobile phones first emerged in the end of 1999.

All of the studies mentioned in AR history lead the studies in AR area in near future. First mobile phone that has a commercial camera is launched by Sharp in 2000. Even its camera resolution was 0.1 megapixels; it becomes the pioneer of the mobile phones of today which has multi megapixel cameras.

In 2001, plenty of academic study and applications emerged in the field of AR. In one of these studies Joseph Newman and his team researched a PDA based wireless AR system hardware. Apart from the previous studies in the field, instead of gaining position and orientation in short and long distance, they studied on a system that presents an independent movement ability which provides indoor location information via ultrasonic sensors. (Newman, Ingram, Hopper, 2001)

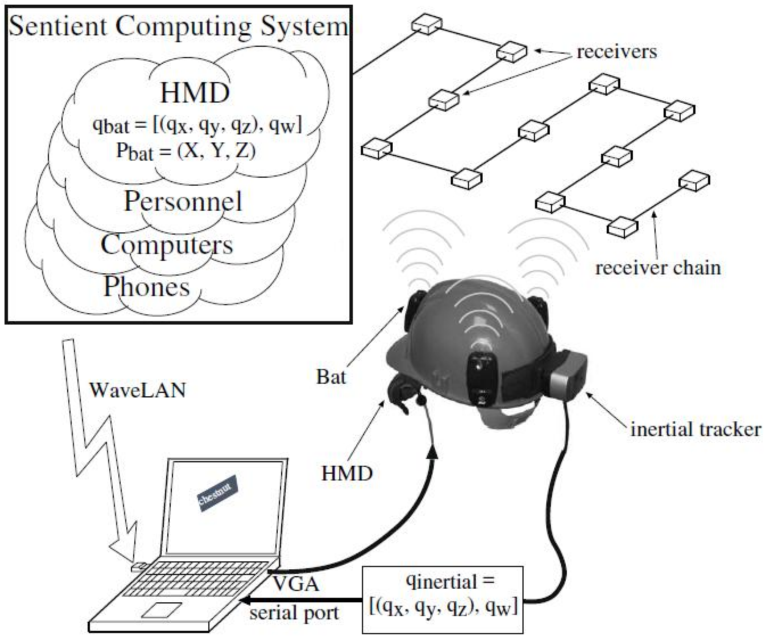


Figure 2-22 Head- mounted display tracking

Jürgen Freud used palm-sized prototype equipment in the project named AR-PDA. It aims to ease the usage of electronically household goods by taking real world images from the camera and adding virtual objects, videos, explanatory notes. (Freund, Geiger, Grafe, Kleinjohann, 2001)

Figure 2-23 AR-PDA

"Mobile Collaborative Augmented Reality: the Augmented Stroll" aimed to gather the users by creating a common space between them. The system was developed by using LAN and wireless LAN infrastructure, enables the movement of mobile and stable users in a common augmented world. This project called Magic is developed to provide an augmented platform which makes it possible for people who work in archeology field to see the notes and pictures of the objects that other people before them have worked with. (Reitmayr, Schmalstieg, 2001)

Kretschmer and his team developed an application that provides interactive story telling in rural and historical areas. PC application called GEIST did have a complex database system which supplied information queues to visualize historical truths and events. To this database Complex inquiries can be formulated and filtered and in this way, stories can be told by fictional avatars or historical people. GEIST motivates the user to go on a sightseeing tour in Heidelberg by telling a story. System keeps the user alive and open to learn and encourages them to learn in a willingly way. (Kretschmer, et al, 2001)

Figure 2-24 Geist System

AR Restaurant application developed by Columbia's Computer Graphics and User Interfaces Lab works on the application named Touring Machine developed by the same group. The application works by putting comments, menus, photographs, and restaurant web sites information on the images coming from the camera. (Bell, Feiner, Höllerer, 2001)

The last study that will be examined related to 2003 is RWWW Browser developed by Kooper and MacIntyre. This browser is a mobile AR application which is recorded as the first study made in this field. (Kooper, et al, 2003)

Human Pacman application created by Adrian David Cheok and his team in 2003 uses GPS, accelerometer, bluetooth, and capacitive sensor as an interactive, ubiquitous, and mobile entertainment system and works with the interface of wearable computer. Pacmen and Ghosts work by presenting 3 dimensional in game graphics with wearable computers which can detect location and perspective in real world as real human players. (Cheok, Fong, Goh, Yang, Liu, Farzbiz, Li, 2003)

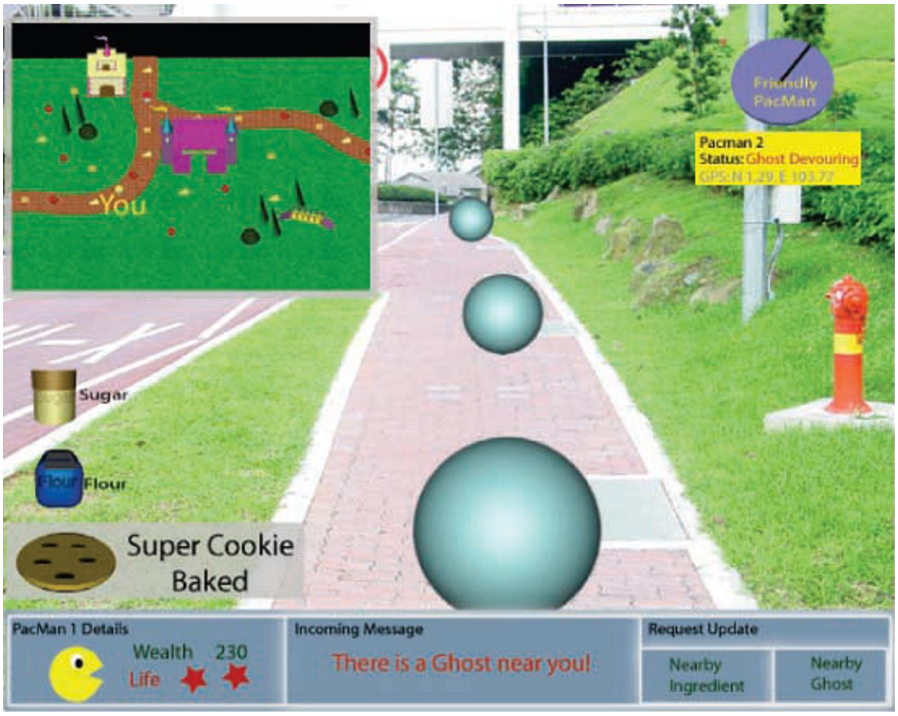


Figure 2-25 Human Pacman

Winning 2003's best mobile game award, Mozzies (Mosquito Hunt) is a commercial application that works with a mobile telephone camera. It is played by targeting mosquito models with aiming point graphic that appears on the application when the camera of the phone is turned.

Figure 2-26 Mosquito Hunt

Möhring and his team presented the first Video see through AR on a consumer cell phone at 2004. It works with the logic of simultaneous image taken from the first camera developed in AR field by reading 3 dimensional labels on mobile phones. The application supports detecting 3 dimensional labels and decomposing different labels. At the same time, it is enabled to visualize 3 dimensional graphics accurately with the live stream coming from the camera. (Möhring, et al., 2004)

Figure 2-27 AR on Consumer Cell Phones

The Invisible Train is the first multi-user application used in hand-held computers. The main purpose of the game is to prevent the users clashing the train while using. (Wagner, et al., 2005)

Figure 2-28 Invisible Train

The application called AR-Tennis developed by Anders Henrysson in 2005 which works with Symbian operating system and ARToolKit library has the characteristic of being the first AR game in mobile phones allowed multiplayer. It won the best game and technical success award of 2005 in The Independent Mobile Gaming contest. (Henrysson, et al., 2005)

The next application studied is Wikitude. This application only uses data of accelerometer and GPS. Wikitude provides the information about the places nearby, position finding and searching services to the users. It was launched in 2008 and have claimed universal acceptance in the field as a very popular application. (Wikitude, 2013)

Figure 2-29 Wikitude

Layar application launched in 2009, shows video and graphic based presentations suitable for the subjects in magazines. It is thought as an improved variant of Wikitude. It supports GPS and accelerometer information similarly; additionally it had an architectural structure of open-source client-server mechanism. Layar’s most important motto is “We want to make the print world clickable.” It includes Yelp, Trulia, finding shops, close bus stops, touristic, natural and cultural places, and AR browsing like Wikipedia, Twitter, and Brightkite. (Layar, 2013)

Figure 2-30 Layar

Arhrrrr! (Designed by Kimberly Spreen and her team), is the first application that provides a high quality content in commercial game category. NVDIA Concorde SDK which provides fast high quality graphics API that is only possible by a dedicated GPU (Tegra) is used. Excluding tracking, all process works on GPU and even though the application has a quite detailed content, mobile phones can work with a high frame rate. (Arhrrr, 2013)

Figure 2-31 ARhrrr!

2.5 Augmented Reality Basic Problems

Constraints and problems observed in AR applications consist of tracking algorithm problems, electronic components sensitivity and precision inadequacies, image processing and image creation processing time needs, and occlusion/collision of virtual and real world objects.

As long as real objects and virtual images are aligned perfectly, illusion between two different worlds can be held in minds. Mobile image should be aligned with real 3 dimensional grounds so they can move along the real surface in a believable way. By aligning real world surface and modeling the horizontal position and scale of the 3 dimensional grounds, the illusion can be reinforced. (Azuma, 1997)

Another important subject in AR applications is scaling of augmented media. Real and virtual objects should be compatible in scale domain under ideal circumstances. In real world, 3D real objects are in different distances, whereas virtual objects can only be in one depth. Consequently, AR systems need to scale virtual objects to their presentation (real) environment. If the distances of real and virtual objects are not matched, it will not be possible to see either of them clearly at the same time or understand scene clearly. (Human perception always tries to detect every objects distance from the body.) (Azuma, 1997)

Contrast between real and virtual images is another important topic. The ideal is the equivalence of real and virtual objects illumination. If the setting is too bright, virtual image will disappear, on the other hand, if it is too dark, real ground will disappear. (Azuma, 1997)

GPS location errors can be given as an example for the sensitivity problem related to electronic components. Indoor places block the signals like GPS or compass completely, however, indoor places gives us much needed sheltered environment for usage of tracking markers. (Neumann et al, 1999) It should also be stated that, in indoor environments, user movements are easier to predict because of the stability of the place. (Behzadan et al., 2007) Additionally, indoor environments can be prepared priory by using markers, optic signals, or location tracking cameras. In outdoor environments, there is nearly no movement limitation in terms of location and orientation and that is why user's movements cannot be predicted.

The problem of changing ambient light and direct sunlight, which is not seen indoors, is also an important topic for camera tracking methods as any method of computer vision based marker tracking is heavily affected by the bad illumination condition of markers. Another limitation to consider is sunlight coming in reflecting angles or night tracking cameras extra IR sensitivity which causes too bright video problems from sunlight illumination. Problems about tracking confronts by causing inability to match under the circumstances of mismatching or not reacting to changing point of view.

3 A CASE STUDY: ARGUIDE

In this part, ARGuide project and similar applications on museums will be explained.

3.1 Related Works

Archeoguide is a European Union project developed in order to inform the user in the areas where cultural artifacts are exhibited by collation technologies like AR, 3 dimensional visualization and mobile computing in an interesting and user-friendly way. System uses head mounted display, and mobile computing equipment as the hardware. Users' position is located via tracking system and audio visual information is presented so as to make user form more opinion about the site while exploring. The system reaches the media elements installed in database as it is seen in Figure 3-1 by the wireless network exist on mobile computers of users. (Vlahakis, et al., 2001)

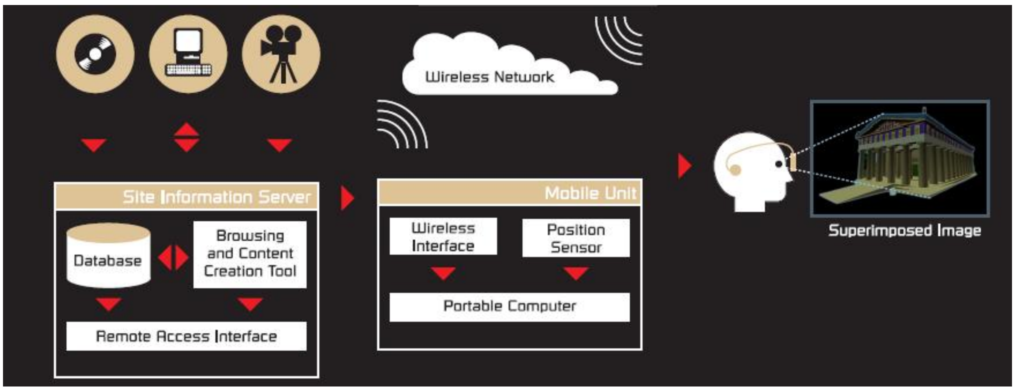


Figure 3-1 Archeoguide Platform Interface

Metaio gives museum guiding service to the user with a mobile AR museum guiding application they developed in 2008 in the stations placed six parts of the Louvre museum.

Figure 3-2 Louvre Museum - Visitor with guidance system at station

With the hand-held computer that Schmalstieg and Wagner created for a research, their AR museum guide gets location information provided by a tracking on users and it renders the real world with the interactive 3 dimensional visuals. (Schmalstieg, et al., 2007)

The usage of AR technology in museums and historical places is quite common internationally. Its usage areas can be examined in four titles; outdoor guides and explorers, interpretive mediation, new media art and sculpture and virtual exhibitions. One of the example applications developed about urban area is “Streetmuseum” project supported by Museum of London in 2010. The application queries to a historical picture database the location information taken from GPS of user’s phone. If there are any historical pictures taken at that position system renders picture at where they should be. (Zhang, 2010)

Figure 3-3 Streetmuseum / London

Hugo Barroso studied about wearable AR in Pret-a-Porte at the National Centre for the Arts in Mexico City in 2005. Children sit in front of a digital mirror by wearing simple marked clothes and hats. A different costume appears on each of them that they can see on the mirror according to the markers on the clothes. After 4 years, mask models belonged to museum's collection are shown on user's face with the camera placed to the mirror and by using face recognition algorithm. Since the algorithm is generative, each mask is drawn uniquely to the face of system's user. (Barroso, 2008)

Figure 3-4 Borroso

Intelligent Tourism and Cultural Information through Ubiquitous Services – iTacitus is an European Union research project started in 2006. It aims to make cultural experience more reachable by using AR technology. Project emphasizes the size of the information in cultural heritage and its difficulty to present it trying to provide a better way to present this information. (ITacticus, 2007)

Figure 3-5 iTacitus

3.2 Introduction to ARGuide

Ankara Museum of Anatolian Civilizations and Topkapı Palace, that I visited three years ago, awakened a connotation with Augmented Reality. Museums, the centers of the history, are the first places to visit so as to make cultural trips. What do people do and learn when they visit museums? For instance, in Museum of Anatolian Civilizations, Anatolian Archeology is exhibited starting from the Paleolithic era to structure of Ottoman era and to modern day.

Figure 3-6 Anatolian Museum of Civilizations – Late Hittites Period

The picture in Figure 3-6 is taken out from Malatya, Aslantepe and is one of the artifacts of Late Hittite period and it gives information about life styles of the people who lived during this period. This information is placed near the artifacts with writings and pictures which can be seen in Figure 3-6. (Anatolion Museum of Civilization, 2009)

Assume that these stones standing from prehistoric ages are supported by 3D images, videos, writings, and sounds. Historical artifacts of Hittite period are now available to describe the features of the era with the visuals that allow user to zoom in or out. Thusly, visitors are able to get more information. When the visitor gets close, it is easy to gain particular information and when moving away, general information about the display artifacts can be reached as a whole.

The disappointment occurring while wandering around Topkapı Palace is among the experiences that lead this project to exist. Harem part of the palace was quite weak in spite of being supported by architectural decoration of the era. There is no chance for visitors to feel or see a living harem with janissaries, guards, and personnel. Simple video or complex 3D models of historical figures could have made atmosphere a lot more interesting.

Imagine an excavation site with AR technology, it can become enjoyable in terms of visualization and satisfying with a good quality of graphics to tell a periodical dinner ceremony carved on a stone with an application downloaded to visitor’s mobile devices or with glasses they wear.

Though it started with the idea of virtual guide in the museums, later in time, the application named ARGuide turns into a project that can be used in many different areas with the wideness of usage areas of AR experienced during the preparation of this thesis. ARGuide is an application that mainly gives information in the places located in museums as a virtual guide and supports this information with pictures, videos, 3 dimensional objects, and written expressions.

The ARGuide usage scenarios under the titles of virtualization depending on the chosen hardware and software are examined. Hardware usage options go with glasses and mobile devices. As software, augmentation on field, on section and for and object is made. (Museum room, display case, individual artifacts is another way to imagine this approach). Consequently, while making direct detection for the artifact ARGuide will use frame marker tracking to identify particular artifacts. Markers will be used for room and display case detection/tracking.

ARGuide‘s starting point is the visual inability of the museums to communicate with the information as it mentioned in the beginning of 3rd section. The extra information provided by electronic audio guide is triggered by entering numbers attached to the sectioned parts and played by headphones bought before entering the museum. The first problem with this traditional augmentation is the inability to receive detailed information from the same unit that reflects more than one era. For instance, in the section where Hittites artifacts are exhibited in Anatolian Museum of Civilizations, hairclips of the era are shown, however, there is no information to differentiate the hairclips in voiced guide feature. If the same situation is realized with ARGuide, it would be possible to give information about each hair clip by zooming in camera and detecting hairpin with natural feature tracking against our database of known artifacts. In this way, a person who wants to gain detailed information about a specific artifact will be able to get information thanks to the application which directs them to related web sites or information sources.

If a different example is examined, the information about the room pictured in Figure 3-7 under the name of “Valide Sultan Dairesi” in “Topkapı Palace” is situated on a stand on the right. The room presents the architecture of the era, however, fails to reflect the spirit of it. When the visitors look at the room with an ARGuide glasses, it will be rendered with the 3D visuals of the era on sultans’ desks. With the information saved to database previously, users can reach detailed information about whichever title they want or maybe discover other important historical figures which used the room throughout history. (Topkapı Palace Museum, 2013)

Figure 3-7 Topkapı Palace

ARGuide prototype application is improved on the work of Mr. Osman Hamdi: “The Tortoise Trainer”. The creation exhibited in Pera museum is considered as one of the important artwork of Turkish History.

In order to use ARGuide, a visitor that comes to the Pera Museum is able to download ArGuide mobile application to the mobile devices in the enterance. The marker placed on the lower-left corner of The Tortoise Trainer table is read by the camera of the mobile device. In Figure 3-8, the user sees the main monitor that belongs to the application interface on the screen of the mobile device.

Figure 3-8 ARGuide – The Tortoise Trainer: Main Screen

In Figure 3-8, different information is presented on the interface screen of the application. The icon placed lower-right is an information about The Tortoise Trainer. In Figure 3-9, an explanation for a general information about the table can be seen. Information such as the owner of the table and in which year it was is mentioned.

Figure 3-9 ARGuide – The Tortoise Trainer: Legend

The 'question mark' buttons in Figure 3-9 provides extra information with different comment by positioning on the object and person on the table. The first comment seen in Figure 3-10 involves information about the meaning of the tortoises.

Figure 3-10 ARGuide – The Tortoise Trainer: Tortoises

The button placed on the hand of the Tortoise Trainer presents information about the reed in Figure 3-11.

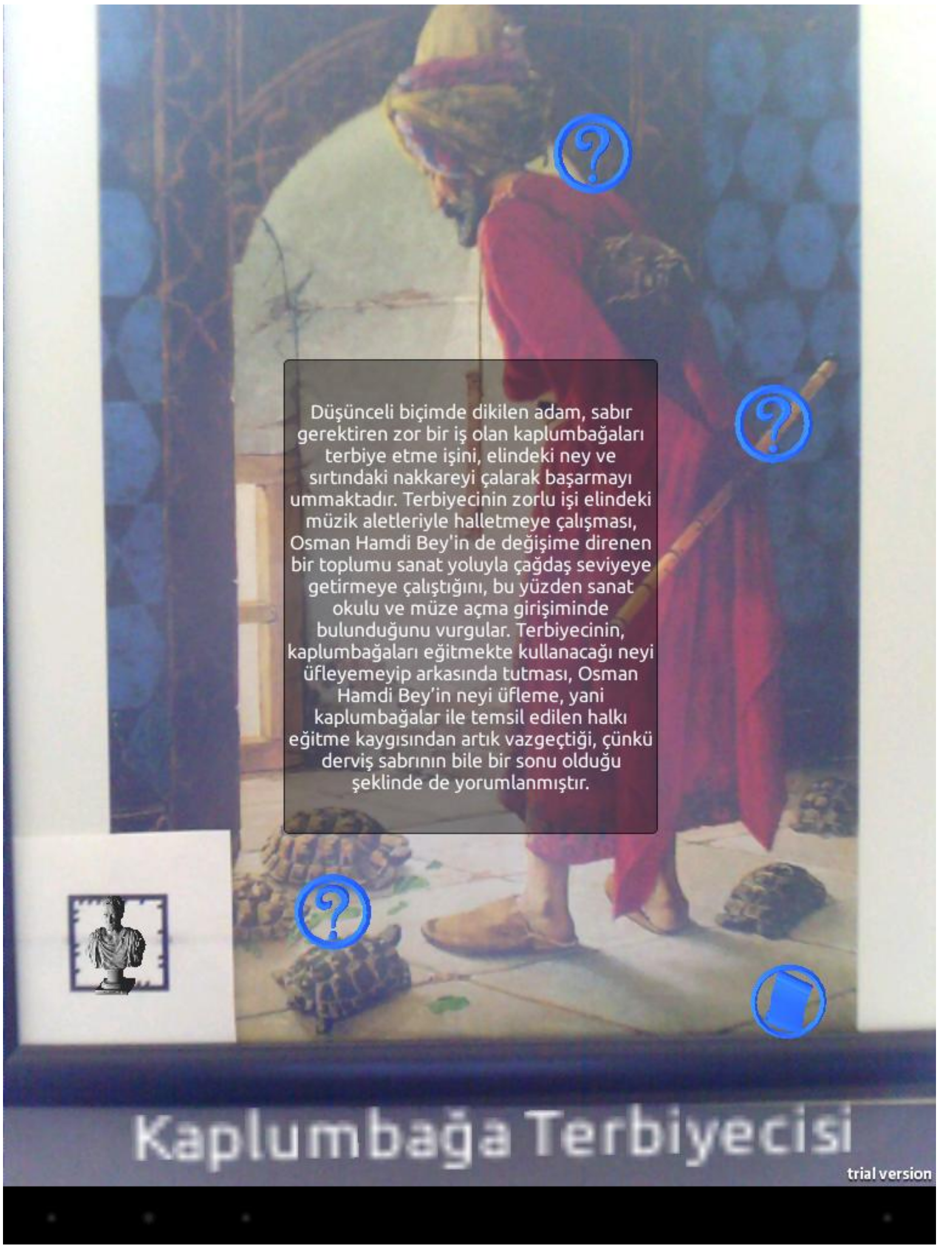


Figure 3-11 ARGuide – The Tortoise Trainer: Reed Flute

The button placed on the Tortoise Trainer provides information about the person on the table in Figure 3-12.

Figure 3-12 ARGuide – The Tortoise Trainer: Person

In this way, users get information easily via AR technology without searching on the internet.

3.2.1 Presentation Hardware Selection

Any successful application of augmented reality is highly dependent on the presentation of augmentations as these are the main way for an AR application to manifest itself. (Milgram, et al., 1994) MR environments defined in the field often describe virtual environments and real environments as two different ends of a virtual continuum (Figure 2-14). A rational way is provided for choosing the right presentation technology or hardware for related applications based on the view of virtual continuum and requirements of the application.

First point to decide is to choose between a see through or screen based displaying system. ARGuide is going to be used in improving the level of information a museum and its artifacts provide. Users should be able to both interact with sections of museum, display cases, and individual artifacts while still experiencing museum as a whole. This wide angle view and natural presentation requirement effectively disqualifies screen based systems as better choice even though they are more widespread and easily available. For a total immersive museum experience users should be able to look around and get augmented information imposed on artifacts and rooms. This marks my applications needs as an optical see-through, despite their experimental status and technical complexity.

3.2.2 AR Tracking Algorithm Selection

There are many options provided for tracking of real world environments. As our applications main interest is on museums many of the physical tracking options are not suitable for implementation (Such as ultrasound, etc.). Considering our applications need for tracking at two different level, ambient (Room/Display case) augmentations and artifact augmentations. For ambient augmentations such as a janissary in the throne room of Topkapı palace, the required information is to detect location to put the janissary which can be easily provided by framed marker recognition. This marker does not have to be directly at the position of exhibition. It may be on a different corner just to mark room area and to detect the ground more easily. Framed/Imaged marker recognition is widely available in many libraries such as ARToolkit, Qualcomm Vuforia, which is mentioned previously.

Second tracking algorithm needed is called natural feature tracking. Natural feature tracking or 3D object recognition is positioned in the computer vision field. It is a very computational intense process and has a high degree of complexity. It works as recognizing contrasts and edges on a designated object and compares this information with its database of known objects which is prepared before actual recognition and tracking. With natural feature tracking ARGuide can identify small, detailed objects and provide augmentation. Please imagine a hairpin collection from ancient Greek to Ottoman era. If you use current headphone based information technology even tough system talks about hairpins extensively you will not be able to recognize which one it is talking about. ARGuide with natural feature tracking will allow users to zoom (or physically get closer so that only artifact that is interested is present in view) and get selected information for that specific artifact. As a side note, natural feature tracking is a risk in ARGuide project as it has high complexity, harder to find in libraries or implement and has considerable arguments against its performance. (Neumann and You, 1999)

For prototype implementation of ARGuide, Vuforia's frame marker recognition library is used. This library was choosing as it has marker recognition with marker identification. Vuforia's frame markers are designed in such a way that when they are image processed they provide a marker pose matrix and a barcode ID.

ARGuide uses provided ID number to decide which content to present. As an example "The Tortoise Trainer" content is linked with marker ID 2 in prototype implementation.

As explained before, experiments with different illumination conditions showed that it has significant importance for the success of marker tracking. While bright direct lights on marker provided good results most of the time, reflection and too much brightness was sometimes occluding markers borders causing tracking to be halted. Under low light conditions contrast between white and black areas were not enough for marker to be recognized.

4 FUTURE WORK

After the prototype version ARGuide application, planning will be started off in detail. The project will be interdisciplinary and the team will consist of people who studied graphic design, archeology, history, and engineering.

The project's first pilot scheme is thought for museums, however, it can also turns into a wider project with its virtual guide implementation. It can be refactored to many applications like banks' information offices, info desks situated in concert or other activity areas, providing augmented visuals at zoos etc.

ARGuide first prototype studies start with The Tortoise Trainer table. Concordantly, related studies about the table exhibited in Pera Museum will proceed. It is planned to improve the application according to user feedbacks after the meetings with Pera Museum. Starting its first journey with this flow, ARGuide's major aim is to become widespread in museums and exhibitions in Turkey.

Augmented Reality is far behind Virtual Environments in maturity. Several commercial vendors sell complete, turnkey Virtual Environment systems. However, no commercial vendor currently sells an HMD-based Augmented Reality system. A few monitor-based "virtual set" systems are available, but today AR systems are primarily found in academic and industrial research laboratories.

Within another 25 years, people will be able to wear a pair of AR glasses outdoors to see and interact with photorealistic dinosaurs eating a tree in our backyard this is could be very possible considering the fast advancement of the AR subjects and technology.

5 DISCUSSION

Extra information and augmentations provided by AR applications like ARGuide, will also impact ambiance of museums and their presentation texture. How this change will be perceived by masses can only be effectively discussed by presenting a software prototype.

The need of change on how museums present cultural and historical exhibits in the age of information technologies is and important thing that should be discussed. Possibilities that AR applications provide for cultural exhibits is beyond just extra information, it can, and it should change how exhibition composition is done. If a museum desires to use AR application, the museology concept has to be changed, as well. As an example, 3 dimensional live historical figures that id touring in Topkapı Palace will make the information management of the museum change to accommodate such opportunity.

Accepting The Tortoise Trainer as ARGuide’s first prototype, users are provided extra information about the artworks with the help of the application downloaded to mobile devices. In areas decorated according to the historical ambience, using electronic devices may have a negative feeling on some users. In addition, for user who does not own a mobile device, HMD glasses should be provided.

Finally, it is believed AR applications on museums are just a beginning of a new method of presenting information for museums and cultural exhibitions. This technology and scientific literature already shows that AR applications provide more than just presentation, they also provide immersion and interaction for public with their own cultural heritage. Museums are already in need of AR applications to make them more attractive to common public and fulfill their duty of enlightening masses.

6 CONCLUSION

AR enters the period of crawling from the state of new born with today's applications and the possibilities of magnificent projects in the future. The more AR applications become robust, the more its social acceptability and technical possibilities will increase.

AR is also a very interesting subject as it is only an infrastructure to provide augmentations to real environment. This implies that it has the capability to be very helpful or be very wasteful or maybe both at the same time depending on the application completely.

In our digitalizing world, the innovations AR brings will carry us forward culturally because of the importance of reaching to the correct information. AR was born and came to the crawling stage and seeing the days AR walks and improves and following its developments will be in my future targets from now on.

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