

The Impact of the Augmented Reality Technique in building the Museum's Signage Systems

Dr. Enass Mahmoud Mohamed Hassan

Associate Professor, Advertising Department, Faculty of Applied arts, Helwan University, Egypt.

Abstract:

Technological experiences have been in continuous motion to productivity and enhancement since decades. Earlier, because of the powerful ideas and projects these experiences produced, museums decided to enhance its signage offerings to visitors by indulging one of the newest and most powerful technologies discovered, Augmented Reality. Augmented reality is a live, direct or indirect view of a physical real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. AR signage proved to add to the visitor's experience in the museum that visitor's wait for further discoveries and developments in this technological field.

The Research's Problem is demonstrated in the following two questions: How does the augmented reality technique affect the museum's signage systems' role in delivering the displays' information to the visitors? And to what extent does the usage of augmented reality technique help improve the visitor's experience and add to his previous view of the displays?

The research aims to highlight the importance of using the augmented reality technique in enhancing the museum's signage systems and urge the museums to use the augmented reality technique for it helps deliver the needed information in an interesting and exciting way.

The research follows an inductive approach, and "Descriptive-Analytical Methodology". It studies the impact of augmented reality and its technological advantages on museum signage.

The research also reached an explanation to the AR technique's ways of enriching the museum displays strengthening the main goal of the museum's signage system, its use in easing indoor museum navigation and its importance in creating enjoyable accessible educational information. In the near future, the researcher expects a massive boom in the AR signage technology that will further create a positive impact on visitors' education and entertaining visits to the museum.

Keywords:

Augmented Reality - AR museum signage - Museum handheld devices - mobile augmented reality

Introduction:

Augmented Reality (AR), a computer science field considered by many as a subfield of the broader concept of Mixed Reality, could alter dramatically the way we interact not only with computers but also with the real environment surrounding us, as well as with other human beings. Augmented Reality has so far been used for applications linked with military training, medicine, maintenance, architecture and urban planning, tourism, and entertainment. This last category embraces museums, considered by many not only as research and exhibition spaces but also as important informal learning environments. ⁽¹⁾

Augmented reality (AR) has received a lot of attentions due to its attractive characteristics including real time immersive interactions displayed in signage systems. ⁽²⁾

In museums specifically, AR signage provides meaningful insights not only for the specialist or

initiated visitor but also for the non specialist or first time visitor who has a difficulty imagining how to navigate in a site he couldn't imagine how it initially looked like in its era. ⁽¹⁾

The right information delivered at the right moment increases engagement and enjoyment; it makes the difference between an ordinary visit and a lasting memory. Although the definition of AR does not specifically address interaction style, the range of AR applications available demonstrate its potential for delivering content in ways that genuinely delight visitors. ⁽³⁾

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- 2- To what extent does the usage of augmented reality technique help improve the visitor's experience and add to his previous view of

the displays?

The research aims to:

- 1- Highlight the importance of using the augmented reality technique in enhancing the museum's signage systems.
- 2- Urge the museums to use the augmented reality technique for it helps deliver the needed information in an interesting and exciting way.

1- Understanding of AR signage:

Over the last years different technologies have provided museum visitors with a new form to see their stored knowledge. One of these technologies is augmented reality (AR).

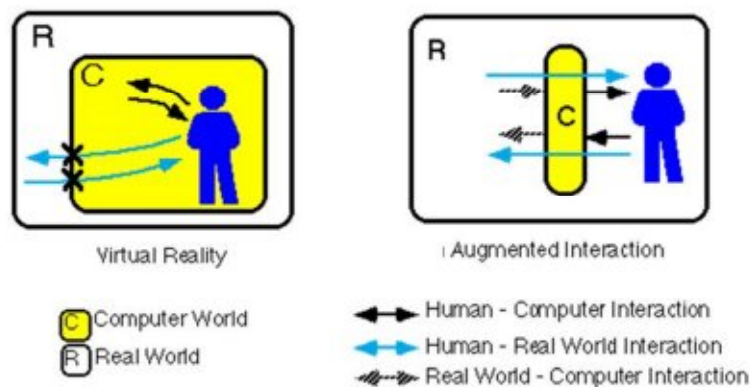


Figure 1⁽⁵⁾

As experts differentiated, Users of AR are still able to sense the real world around them, unlike the users of the Virtual Reality technology, which is a completely computer generated, immersive and three-dimensional environment.⁽⁴⁾ Figure 1 illustrates the different interactions between the user and either virtual reality or augmented reality.

In AR signage, every object you see could be enriched with additional and valuable information. AR is defined as the expansion of physical reality by adding layers of computer-generated information to the real environment. Visitors can visualize, manipulate and browse exhibition information. AR signage allows visitors to deal with these information as if they are part of the real world. These Information could be any kind of virtual object or content, including text, graphics, video, sound, haptic feedback, and GPS data.⁽⁴⁾ Figure 2 shows an applied augmented reality technique in one of the museums' signage systems. This is a Movable Screen in Allard Pierson Museum, that's primary use is to pan through annotated pieces of art and reconstructed landscapes viewing information in the form of text and graphics related to each.⁽⁶⁾

AR is an interaction paradigm that aims to combine computer-generated information with the real world.⁽²²⁾

It is the ability to see (or hear) contextually relevant information superimposed on your view of the world. Usually this is the view you see through the camera lens of your phone or mobile device. But the view might also be a video feed from a webcam on a laptop or large screen. Mediated by the camera, you see virtual content suspended in space as if the device has magically uncovered it.⁽³⁾



Figure 2

2- Importance of AR in the museums' signage systems:

Certain museums can be complicated places to navigate within. They may not have a clear path through the museum and may offer many alternatives. In order to facilitate navigation, we experimented with a variety of techniques and display devices on a mobile museum guide. Museums are known to be rich in interesting exhibits and information.

The problem is complicated even further given the fact that a visitor usually has limited time for a visit. Hence visitors usually need some kind of navigational aid in order to find their way within a museum. The classic navigation aid is the paper map of the museum, which is based on the museum floor plan and enables the visitor to orient themselves and find the way in the museum. However, such paper maps may be inconvenient and not easy to use, especially when a group of visitors is visiting the museum together. Current mobile technology opens new possibilities for supporting indoor navigation. The use of augmented reality technique may ease the indoor navigation:

- Enabling the visitors to visualize the way from the current position towards the destination.
- See the path.
- Identify a landmark.
- See through walls.
- Overlay navigation instruction over the current view.

Devices, such as camera or steerable projectors, installed in the environment provide a variety of technological solutions for supporting indoor navigation. ⁽⁷⁾ Figure 3 shows an augmented reality indoor use. A polished Augmented Reality project done by the Louvre – DNP Museum Lab in Tokyo. The technology used is a Tour Guide that hosted information for the artifacts and also directions helping users to find their way in the exhibition. ⁽⁸⁾



Figure 3

The importance of the AR signage systems used in museums is highlighted in the following

points:

- 1- AR signage system provides an improved experience to the visitors by offering a better interaction with the exhibition contents. In order to do so, the system must immerse visitors into the augmented environment using an interface which allows a natural interaction with these contents.
- 2- It also provides the visitors the educational information of the exhibition in a simple and enjoyable way. ⁽²²⁾
- 3- It further develops the information available to a given person by superimposing extra multimedia such as visuals, sounds or even smells over the actual environment in real time. ⁽⁹⁾
- 4- The co-existence of the real and the virtual could enhance productivity by facilitating comprehension of tasks to be performed in fields demonstrated in the museum. ⁽¹⁾
- 5- The user can find his own way through the site, with the system guiding him and giving additional information wherever needed or wanted. The system will find the tour that matches closely to the visitors interests and enhance user interaction.
- 6- Using the AR technique, not only experienced visitors will benefit from it but also children will be able to get a deeper view into the exhibition's contents further achieving the signage system's goal. ⁽¹⁰⁾
- 7- **Characteristics of AR in signage systems:**
 - Bi-directionality and circularity of communication: The sender and the recipient build, by means of interaction, a consensual domain of meaning.
 - Dynamic Contents: In addition to text, AR signage systems make use of audio or video contents too.
 - High degree of interactivity: An active role of participants exists together with interactivity.
 - Open and contextual Information: The independence of the information and its high and ever changing connection with its sources are reasons why AR is open. Information provided by the AR technology is also connected to the contexts of reference.
 - Low degree of opacity of contents: Information provided by the AR technology can easily be accessed and has multiple connections with its sources.
 - Multi-mediality and cross-mediality: The AR technology can integrate different types of multimedia in one medium. ⁽¹¹⁾
 - Virtual reconstruction: AR has the potential to

show things at scale, such as a building, room or massive objects like ships. Using 3D models, it is possible to reconstruct these large scale contexts around objects which respond to users' movements. As they rotate their device, for example, new elements of the models are exposed and can be explored by zooming or tapping the screen for more information.

- Multiple views on the same gallery space or narrative. Museum interpretation is becoming increasingly sensitive to the needs of different audiences. It is impractical to cater to a variety of needs with printed panels and labels because of space limitations. AR allows invisible content suited to different users to be embedded in galleries and accessed by users on demand.
- Bringing creatures back to life. Using animated 3D models to show what an extinct animal or plant would have looked like is another ideal use of AR. Holding your device over a skeleton or fossil to reveal an animated model answers an age-old interpretive challenge⁽³⁾
- Low risk of technical problems: the user is assisted by supplementing the existing world instead of creating a new one, the limited level of immersion is thought to provoke fewer problems of cyber sickness⁽⁴⁾

3- Augmented Reality Hardware:

Museum affinities with new technologies are not recent. Ever since the World Wide Web boom, museums and other cultural heritage institutions have been progressively investing not only on cutting edge documentation and information systems, but also on multimedia technologies fostering long-lasting relationships with their visitors. Museums around the globe offer their visitors mobile, light weight, multimedia-capable devices that provide interpretation material that promise to accompany the visitor throughout the visit.⁽¹²⁾ Multimedia museum guides that use handheld devices are capable of delivering personalized content depending on user preferences, age or learning abilities with the potential benefit of limitless multimedia delivery through wireless networks. From the side of museum professionals, this way of delivering information presents also advantages, like monitoring visiting patterns, real time communication with the visitors and linking of the museum visit with the pre and post-visit phases⁽¹²⁾

We are currently experiencing a massive boom in AR hardware including:

4-1 Stationary AR systems:

Stationary AR systems are suitable when a larger display or higher resolution is required in a permanent location. These motionless systems can be equipped with more advanced camera systems and can therefore provide more precise recognition of people and scenes. Moreover, the display unit often shows more realistic pictures and is not so much affected by environmental influences such as sunlight or dim lighting.

4-2 Handheld Devices:

Handheld devices accelerate AR adoption. These devices are appearing with ever-better features such as:

- Higher-resolution displays.
- More powerful processors.
- High-quality cameras.
- Sensors providing accelerometer.
- GPS.
- Compass capabilities.

These features help make handheld devices very suitable AR signage systems' platforms.

5- AR signage system's components:

The technology behind augmented reality systems involves numerous fields of research including signal processing and tracking systems, graphics, user interfaces, human factors, wearable and mobile computing, networking or information visualization.

Of course, the requirements for an AR system depend greatly on its intended application, but one can outline a few common basics that even museums share. A visual AR signage system revolves around:

- 1- Museum display.
- 2- A precise tracking system which provides accurate environmental information to keep virtual elements synchronized with the real ones. AR tracking systems must satisfy three conditions in order to function properly:
 - First, a tracker must be accurate to a small fraction of a degree in orientation and a few millimeters in position.
 - Secondly, the combined latency of the tracker and the graphics engine must be very low.
 - Finally, the tracker must work at long ranges.

There are different types of tracking systems that are used according to how augmented reality is implemented. We will thoroughly discuss this point later on.

- 3- Extensive computational power to handle the real-time requirements of augmented reality. (9) A server on which the huge amount of data can be stored.
- 4- Mobile Units, smaller computers carried by every user that process the data for visualization and tracking services, that communicate with the server over a wireless network⁽¹⁰⁾. Ideally, these components should be seamlessly integrated in whatever interface is needed and present little or no limitation to the user's perception of his surroundings and his/her movement in the museum. Several approaches exist, depending on which environment the AR system is used in. ⁽⁹⁾

6-Tracking Systems' Techniques

Augmented Reality can also be illustrated in any application that uses the camera feed as its background. In most cases, though, when Augmented Reality is referred, it is meant that the superimposed graphics and they way they appear depend on the tracking, the localization of the position and orientation of real physical objects. There are several tracking techniques but we will focus on the two most popular approaches the Marker-based and the GPS/Compass tracking.

6-1 Marker-based Tracking:

Marker is usually a square black and white illustration with a thick black border and white background. Some examples are shown in figures 4,5. Figure 4 Using a camera, the software recognizes the position and orientation of the marker and according to that, it creates a 3D virtual world which Origin, i.e. the (0,0,0) point, is the center of the of the marker while the X and Y axes are parallel to the two sides of it and the Z axis is vertical to the plane shaped by the X-Y axes.



Figure 4

One of the most popular regarding marker-based tracking, the coordinate system of the 3D world is as it is shown in figure (5).



Figure 5

The superimposed graphics are designed according to that coordinate system thus every move of the marker affects subsequently the graphics.

6-2 GPS/Compass Tracking:

Another very popular tracking technique used on AR applications is the combination of a GPS and a compass and it is very popular in the latest technology smart phones. The concept here is fairly simple; the software has some places of interest stored as if they were on a map (longitude and latitude values for each one of them) and considering that with the GPS and the compass the software is aware of the direction the user is looking at, if there are any stored places in that area in front of the user, then the information about each one of them is displayed. For the places outside of the field of the user's view, arrows may appear pointing to each one of these places' direction.

6-3 Advantages and disadvantages of the Tracking systems' techniques: ⁽¹³⁾

	Marker-based Tracking	GPS/Compass Tracking
Advantages	<ul style="list-style-type: none"> - the accuracy of detecting the marker's location. - the stability in terms that, as long as the marker is clear in the camera's view, the scene is solid and positioned precisely. - Portability, as there is no need to make any changes on the software for changing the real world environment. 	<ul style="list-style-type: none"> - in terms of accuracy as well as stability because its functionality depends on the GPS-reception of the area it is used.
Disadvantages	<ul style="list-style-type: none"> - the flickering of the superimposed graphics when the marker is "face-on". you should not point at the marker directly. 	<ul style="list-style-type: none"> - marker-less and thus it can be applied without any intervention to the real-world.

7- AR signage system's processing steps:

Augmented reality typically takes a lot of computing power and depending on the execution some applications will be more processor-intensive. No matter which way you execute augmented reality, there will be parallel processes working. ⁽¹⁴⁾

- 1- Scene capture: First, the reality that should be augmented is captured using either a video-capture device such as a camera, or a see-through device such as a head-mounted display.
- 2- Scene identification: Secondly, the captured reality must be scanned to define the exact position where the virtual content should be embedded. This position could be identified

either by markers (visual tags) or by tracking technologies such as GPS, sensors, infrared, or laser.

- 3- Scene processing: As the scene becomes clearly recognized and identified, the corresponding virtual content is requested, typically from the Internet or from any kind of database.
- 4- Scene visualization: Finally, the AR system produces a mixed image of the real space as well as the virtual content⁽⁴⁾. Figure 6 illustrates how augmented reality is used on iPhones. ⁽¹⁵⁾



Figure 6

8- The future of Augmented Reality

Perceived as the technology of the future, Augmented Reality is making its way in the market place by continuing to work with top brands and companies. The numerous applications emerging from the steady development of ground-breaking Augmented Reality is transforming the way people see and

learn from their surroundings, and is revolutionizing companies' business models. ⁽¹⁶⁾ Augmented reality (AR) has been in science fiction for decades. Thanks to smartphones, the technology is finally here to make it happen. New academic research has given us an insight into the exciting future possibilities for AR browsers, but it also highlights the barriers that must be overcome. ⁽¹⁷⁾

Augmented Reality (AR) has been showing lot of promise as an enabling technology in the mobility space. Owing to various reasons like technological limitations, lack of awareness and high costs etc., the technology failed to gain any widespread traction and the resultant adoption. However, the proliferation of powerful smart phones and later tablets has presented AR with the right vehicle to take center stage in enterprise and consumer mobility. As a result, we are witnessing a huge interest in AR technology and its growing adoption in enterprise-level app development and there is much more in the near future. ⁽¹⁸⁾

Presented below is a predicted view done by the Polytechnic University of Turin illustrating the future of AR mobile apps used in the signage system of the Madame palace's museum of ancient art. Figure 7 is A vision of a visitor's AR tour inside the museum.



Figure 7A-7I ⁽¹⁹⁾

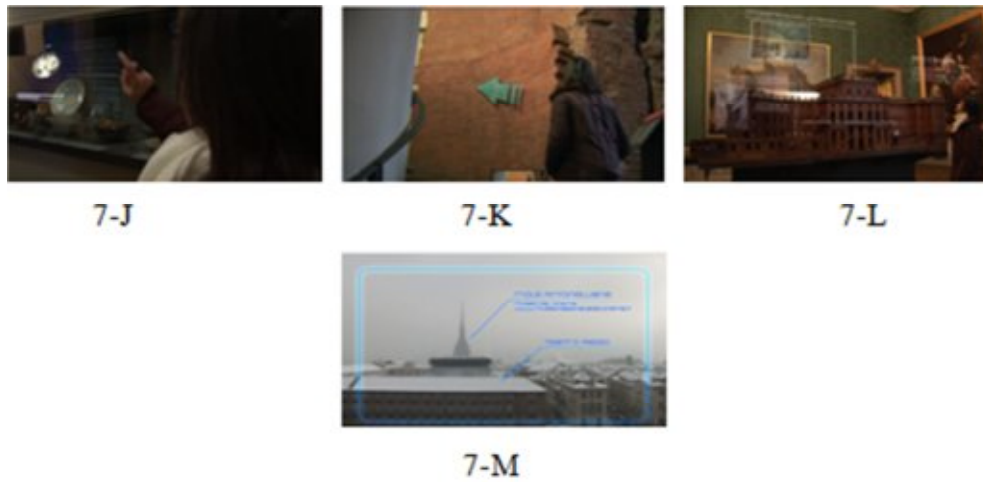


Figure 7J-7M⁽¹⁹⁾

Before entering the museum, the visitor adjusts her mobile by using a future sophisticated mobile app that enhances the guidance inside the museum. The visitor enters the museum and witnesses an augmented light starting to modify as a virtual map for the place. An arrow then appears on the ground leading the visitor to the first floor. Information regarding the displays in the first floor start to float around the visitor introducing her to what is she going to see. The visitor chooses her destination from the museum guide and uses her mobile to save information related to the section’s displays by fixing the mobile in front of the coded area on the guide to transfer the information to the mobile’s storage system. The visitor reaches her destination, chooses some pictures and decides to save them on her mobile. Augmented arrows appear on the museum doors helping the visitor to further move through the museum. The visitor reaches historic displays protected in glass containers. Information related to these displays are augmented automatically on the glass helping the visitor know more about them. The visitor closes the information viewed with a single distant click.

Augmented arrows reappear helping the visitor navigate through the following stage of the visit. The visitor reaches a model of the museum in early centuries. Augmented Information related to the historic record of the museum start to appear all around the model. The visitor then moves to the museum’s roof and starts pointing out important buildings surrounding the museum and augmented information start appearing informing her of the names of these buildings. The visitor’s augmented visit to the museum now ends.

9- Analytical Study:

The researcher chose several models to illustrate the impact of the augmented reality technique in building museum’s signage systems and to highlight its importance in increasing the thrill and excitement of the visitor while visiting educational institutions.

Model (1):⁽²⁰⁾

The AR system presented in this model is demonstrated in the exhibition of “Valencia, land of counties : Dialogues with heritage ” in Valencia, Spain.

AR Hardware	Stationary AR System
Tracking System Technique	Marker-Based Tracking
System Components	<ul style="list-style-type: none"> - A Region of Valencia’s map with dimensions 3×5 meters. - 70 different hot points on the map grouped by colors. Each color refers to a different subject of the Region of Valencia heritage. -7 pointers, one associated to each subject of the heritage. Each pointer has a marker printed - Markers printed on the pointers which is used to calculate its position and markers printed on the map which are used to compute the spatial reference of the system. - Several hosts, each is formed of a PC, two visualization screens and one Kinect camera.
Importance of the AR system	<ul style="list-style-type: none"> - The visitors walk on the map and feel as if they were traveling through the real region of Valencia. - The AR system was able to provide an improved experience to the visitors, supporting the learning process with the multimedia resources and virtual 3D elements associated to the hot points of the exhibition.

The way in which the system works:**- The system can be split into 4 subsystems:**

- 1- The communications subsystem communicates all hosts using a Client-Server model. It performs the synchronization between them over the same exhibition environment.
- 2- The logic subsystem manages the system operation. It selects the subject associated to the active pointer in the system and identifies

- the hot point when the pointer is placed on it.
- 3- The tracking subsystem obtains the position and orientation of the elements of the system: map, pointers and Kinect camera.
- 4- The visualization subsystem shows augmented information over the real exhibition environment content. (Figure 8) shows the system's components of Augmented reality system components..

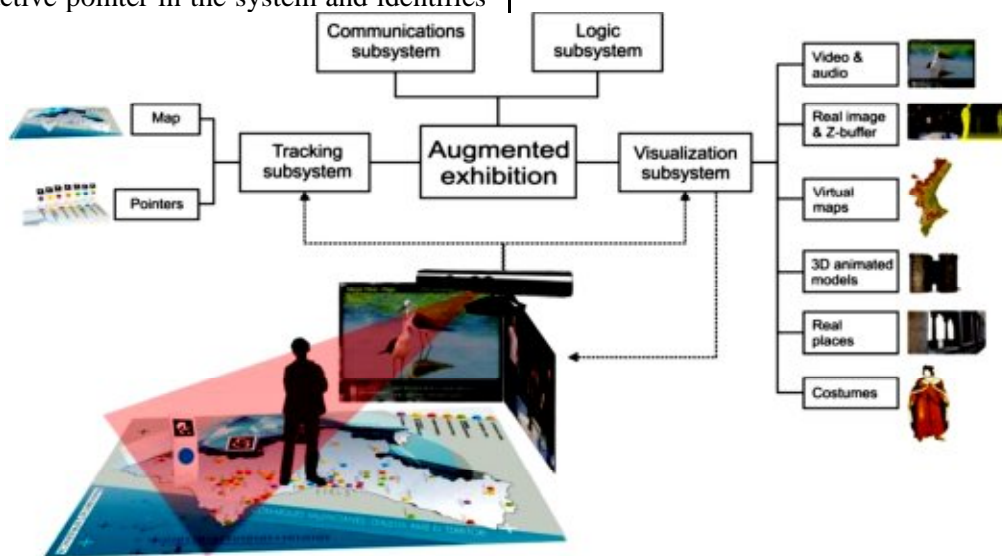


Figure 8



Figure 9

- Mixing the real and virtual worlds:

In order to mix real exhibition content and augmented reality information, initially the Kinect camera's captured information is painted. This image is a reflection of the real exhibition environment. Using the depth map information given by the Kinect camera, the values of the z-buffer for each image pixel are calculated. In this way, the elements of the image, visitors included, can be placed correctly in the virtual scene. Finally, the virtual elements are painted taking into account the z-buffer information, performing a correct occlusion between real (visitors and exhibition room) and virtual (3D models,

maps, etc.) worlds. This process can be observed in (Figure 9) which is Augmented reality scene composition using depth information.

When a visitor catches a pointer the system shows a multimedia resource of the subject selected on one screen. At the same time, on the other screen, an augmented visualization of a subject map replaces the real one. Thereafter, visitors can select a hot point of the selected subject on the map just "travelling" to the desired location and placing the pointer on it. Once the point is selected, a multimedia resource associated to

it is showed on one screen, while on the other screen, a virtual 3D object is showed in the augmented visualization. In the same way, visitors can choose another hot point or change the subject selected by leaving the actual pointer and caching a new one. There are 3 different kinds of virtual 3D objects that can be displayed in the augmented visualization: 3D animated models which represent buildings or objects related to the hot point, virtual scenes created using images of real places and costumes to “dress up” the visitor.



Figure 10 Visitors using the system

Model (2): ⁽²¹⁾

This model discusses a Technical insight into the signage system of the 2014 DLD Museum Tour: An Augmented Reality exhibit for the Bavarian National Museum.

AR Hardware	Handheld devices AR System
Tracking System Technique	GPS/Compass Tracking
System Components	<ul style="list-style-type: none"> -Museum displays that included statues and 3D models. - Handheld units such as tablets and mobiles. -Tracking system that varies from one handheld device to another. -A server on which the huge amount of data can be stored.
Importance of the AR system	<ul style="list-style-type: none"> - The AR museum experience provided a great sense of depth and space to the user viewing each display without distracting him from the physical object. - This experience also helped immerse visitors in the historical era they couldn't live in.

-The way in which the system works:

Figure 11 is in the Tilman Riemenschneider: Mary Magdalene scenario we introduced to the user an audio explanation of the piece, some general background information and a photographic overlay that showed the sculpture's past place of residence. While Figure 12 In the Conrad Meit's “Judith with the head of

Holofernes.” scenario the museum connected pieces of explanatory text to the model with 3-D white lines.



Figure 11



Figure 12

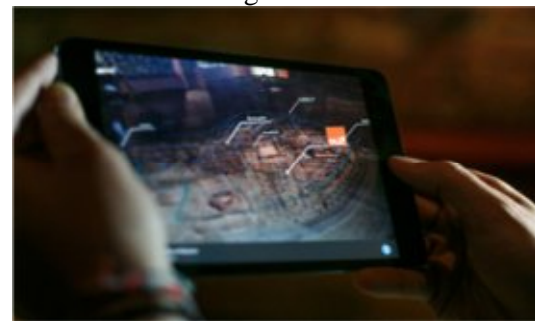


Figure 13

Figure 13 illustrates the Jakob Sandtner: The Munich City Model allowed visitors to compare between the past and today's Munich by overlaying a map of today's Munich on the model showing what buildings replaced old ones.

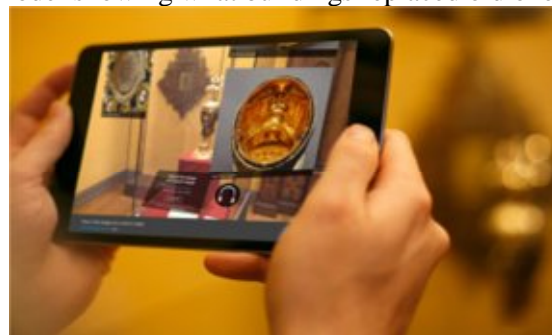


Figure 14

Figure 14 shows the Christoph Jamnitzer: The Moor's Head contained three nice reference images of the interior and base of the cup which were not viewable to the visitor. In order to

display them and not take away from the physical model, the museum created a thumbnail effect that shrank and grew the images when the user tapped on them.



Figure 15

Figure 15 depicts the case of Hubert Gerhard: Flying Mercury the museum displayed large images of other artworks created by the artist. They are “floating” around the sculpture.

Model (3): ⁽²²⁾

This model discusses the Augmented reality technique used in the Auckland museum’s Marine Exhibition, Moana to magnify Alien-like

fish specimens from the deep, life-size shark replicas and microscopic phytoplankton and make it look like works of art.

AR Hardware	Handheld devices AR System
Tracking System Technique	GPS/Compass Tracking
System Components	<ul style="list-style-type: none"> - Handheld AR devices such as tablets or mobiles - AR mobile apps - Blocks that demonstrate different marine environments
Importance of the AR system	<ul style="list-style-type: none"> - The system helps visitors view Living organisms seen only a handful of times in human history. It is joined by experiential technology that brings current marine research to life. - AR allows visitors to explore the inside of a root-like seaweed structure and see the marine animals living within it.



Figure 16

Figure 16 The visitor got to select a block with any seaweed structure he likes and starts rotating it under the handheld device to view the different animals living in it. ⁽²³⁾

Results:

By studying the various themes of the research, the researcher found the following results:

1- Augmented Reality is the expansion of the real world by adding layers of virtual information on the originally existing objects. This helps enrich the museum displays strengthening the main goal of the museum’s signage system.

- 2- Augmented reality is different from the virtual reality in that users of the augmented reality still sense the real world around them, but users of the virtual reality are completely immersed in a computer-generated world.
- 3- The use of augmented reality eases indoor museum navigation with its remarkable characteristics such as the abilities to identify landmarks, see through walls or overlay navigation instruction over current views.
- 4- The importance of AR museum signage lies in that:
 - Augmented reality help visitors experience

and learn the educational information in simple exciting ways by using virtual visuals, sounds and even smells.

- It also adapts to the interest of the different categories of visitors whether experienced, inexperienced, adults, or even children.
- 5- The flexibility of the AR technique gives it to ability to maintain its effectiveness even though it may be a stationary AR system.
- 6- AR museum guides that use handheld devices are capable of delivering personalized content depending on user preferences, age or learning abilities with the potential benefit of limitless multimedia delivery through wireless networks.
- 7- The technology behind augmented reality signage systems involves several fields to be put into consideration including signal processing and tracking systems, graphics, user interfaces, human factors, wearable and mobile computing, networking or information visualization.

Discussion:

The researcher sees that museums all around the world have to engage in the technology of augmented reality in designing its signage systems. This engagement would result in a huge influx of visitors from the same country and would increase the interest of tourists from all around the world. It would work as an attraction force that would attract financial and spiritual gains. People from the same country would feel proud for having such a public wonder existing and would feel the huge importance and value of such a place. Financial gains too would give a chance for the countries and the programmers of the augmented reality technology to further develop the AR signage systems into more powerful and efficient futures.

Conclusion:

The researcher, after the theoretical and analytical study presented in the research, concluded that the augmented reality technique is one of the most important and effective techniques used in museum signage systems due to its flexibility that allows it to be applied in any museum regardless of its environment or its visitors'.

The researcher believes that the future will witness a massive development in this technological field that may surpass any other traditional technology used in signage. Augmented reality is another step further into the digital age as we will soon see museum signage change dynamically in the near future to display

enhanced content and media right in front of us even without a use of an enabling technology. This has amazing applications that can very well allow us to experience museum visits more productively, more safely, and more informatively.

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