

# Improving the Archaeological Sites by Combining 3D Model Artefacts with the Real-life Environment

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**ABSTRACT:** *Augmented Reality is increasingly being used in a variety of ways. One area of application is digitalising cultural heritage. As a result, many tools for developing applications in this field exist. In this paper, we will provide an overview and comparison of the software for mobile AR. Based on our analysis, we have chosen a software tool for augmenting and improving the archaeological sites by combining 3D model artefacts with real environment images. In this case study, we will provide the implementation details of the fountain design in the audience area of the Imperial Palace at the archaeological site Medijana.*

**Keywords:** Augmented Reality (AR), AR Browsers, Mobile AR SDK, Cultural Heritage

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## 1. Introduction

Augmented Reality (AR) is defined as a real-time direct or indirect view of a physical real-world environment that has been enhanced by adding virtual computer-generated information to it [1]. Improvements in computer graphics technology have lead to the world of virtual reality becoming more and more real, while the possibilities of combinations with real (actual) worldly environment opens a new dimension in the understanding of the concept of reality (the real world). In cases where the combination of real space and virtual elements is needed, the practical application indicates that there are no fixed limits.

According to Milgram [2], the possible combination states are shown in Figure 1. Through the implementation of virtual objects into a real environment we create the augmented reality.



Figure 1. Milgram's reality-virtuality continuum [2]

Augmented reality technology (AR) has achieved great progress over the last few years. The ever-increasing implementations of augmented reality are a result of the development of both hardware and software solutions. In this paper we show the implementations of augmented reality in the field of cultural heritage by using mobile devices.

## 2. Comparative Analysis of AR Software

The development of mobile devices over the last few years has contributed to the implementation of the augmented reality technology on these devices. Thus, the mobile augmented reality software has also undergone development, which has facilitated the process during which users', in an interactive manner (using images from the real world), search for information (without the use of a keyboard and mouse). Studying the field of augmented reality from the aspect of development and implementation of AR applications we can identify two groups: AR browsers and AR software development kits.

### 2.1. AR Browsers

This group includes AR browsers (*ARBs*), that are, applications of augmented reality aimed at helping the search of the real environment by using mobile devices cameras. By following the search of the images of the real environment, they are augmented with multimedia contents (html, image, audio, video or 3D models). *AR* browsers index the content through media streams (termed channels, layers, or worlds). *ARBs*, generally, accesses remote resources using web protocols and web services.

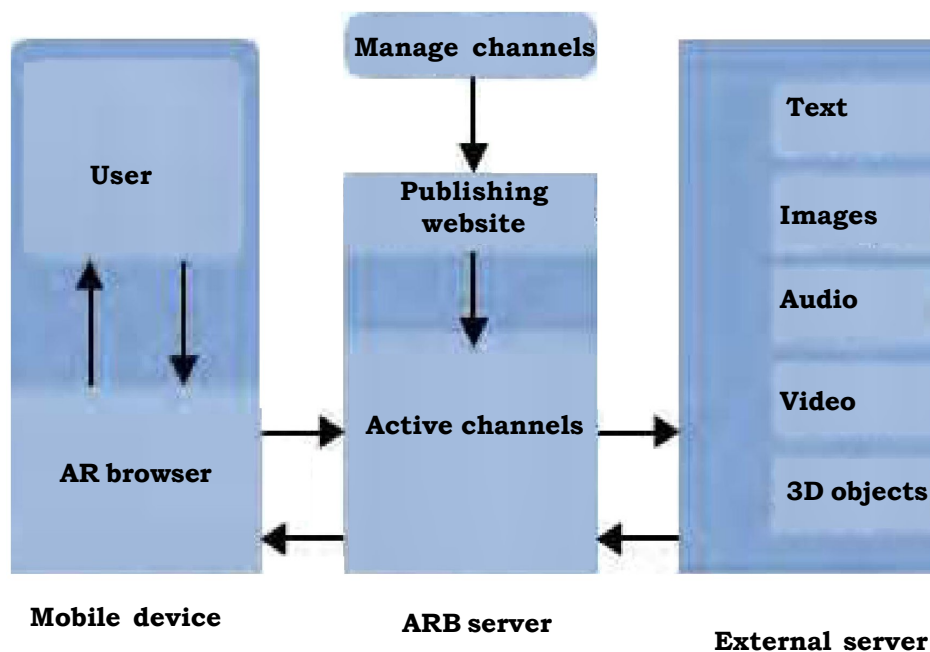


Figure 2. AR browser system overview

All *ARBs* work in a similar way and consist of the following components (Figure 2):

1. The *ARB* represents the client on the mobile device.
2. The publishing website - a website on which developers can register new channels (layers, worlds), and manage their channels and accounts.
3. The *ARB* server is the basis of this system and represents the interface towards other components (*ARB*, the publishing web site, and external servers).
4. The external server – a platform on which are stored all the multimedia contents (images, text, audio, and video) as well as the description of the location (*POI* - point of interest).

On the basis of previous research [4], shown in Figure 3., we carried out an analysis, of the three most frequent *AR* browsers from the first group: Layar, Junaio, and Wikitude.

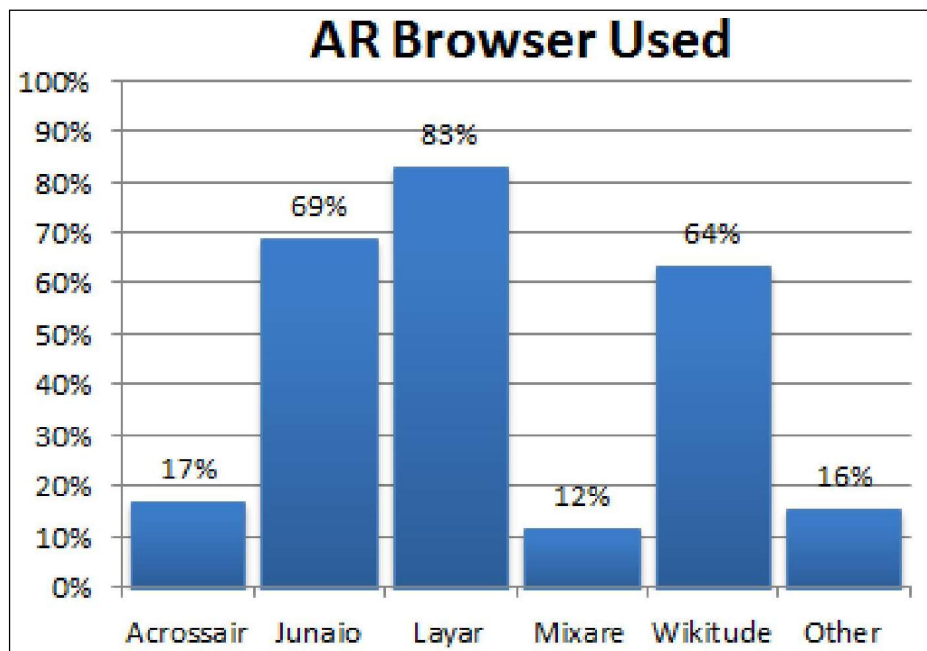


Figure 3. Usage of AR browsers [4]

## 2.2. Layar AR browser

Layar [5] was one of the first *ARB* that appeared on the market, designed for the Android and *IOS* operating systems. It enables both location based and vision based tracking. This browser, the creation of channels also known as layers is enabled. *POIs* are shown, in the form either of an icon or a 3D object, on the display of the mobile device. By clicking on a *POI* it is possible to obtain additional information, to activate some of the multimedia contents or launch another application. The Layar browser gets data on the layer channel with the *JSON* structured data.

## 2.3. Junaio AR browser

Junaio [6] is a powerful *AR* browser which offers the support for location based tracking and both marker and markerless image recognition. For location based tracking, except for the outdoor version, an indoor version was also created, that is, one which supports *AR* even in those locations where *GPS* is not available and where the compass does not work. In order to determine the user's position in these conditions, we use the Latitude Longitude Altitude - Markers (*LLA* Markers).

Location based channels show points of interest. Virtual objects floating at the position of a *POI*. These virtual objects can take the form of: texts, thumbnails, or can be animated and static 3D objects. Each of these *POIs* can be linked to other

images, sounds, videos, and websites. *GLUE* (image based) channels are used for vision tracking and enable one to attach or “glue” virtual 3D models to any real object. The Junaio server transforms markers into tracking xml which then helps the Junaio browser to perform an optical analysis. To describe layers and *POIs* we use a specific *XML* code.

#### 2.4. Wikitude AR browser

The Wikitude World browser [7] is used for location based tracking. *POIs* are grouped into worlds, just like layers are formed in the case of the Layar browser. It supports 2D multimedia contents. This browser uses its own *ARML* language (Augmented Reality Markup Language) which is based on *KML* (Google) and enables the addition of more data onto the *POI* including addresses, telephone-numbers, links, different icons and images. Using the *ARML* database we can exchange data between the client (the mobile device), the Wikitude server, and external servers. This *ARB* can be used on *IOS* and Android platforms.

#### 2.5. AR Software Development Kits

The second group of software includes software development kits (*SDKs*) used to create mobile applications running on *IOS* and Android devices, providing mobile *AR* functionality. This software is by its structure and functionality significantly more complex than the software from the first group. Unlike the *AR* browser, the *AR* software development kit enables greater freedom in the development of applications.

From this group we will present two types of *AR SDK* software: metaio Mobile *SDK* and Vuforia *SDK*.

#### 2.6. Metaio Mobile SDK

Using this tool we can develop applications both for the Android and the *IOS* platforms. This software uses fast and modular libraries and algorithms since it was designed to be used on mobile devices. It offers location based, markerbased, and markerless 2D and 3D object tracking. In addition, the metaio Mobile *SDK* [8] enables both *QR* Code and Barcode scanning. With the help of this software, the *AR* browser Junaio was also developed. Figure 4. shows the metaio Mobile *SDK* architecture.

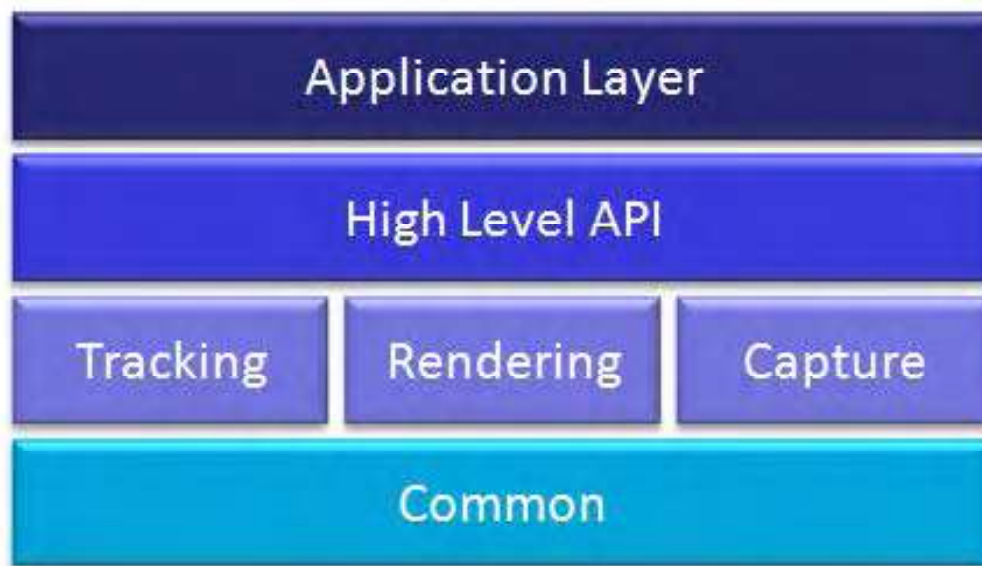


Figure 4. Metaio Mobile SDK architecture [8]

The metaio Mobile *SDK* can be used in different ways depending on the type of application. For simpler applications we use the Application Layer. Applications can be configured based on an *XML* configuration file. The high level *API* development enables the realization of complex applications. At this level, knowledge of programming is required. This *SDK* platform also allows access to low level components. This approach is used in the case of special demands, when some other 3D graphics engine is required, as well as in connection with capturing and tracking modules.

## 2.7. Vuforia SDK

Qualcomm [9] has developed a platform for augmented reality known as Vuforia. Vuforia *SDK* supports the Android and *IOS* platforms. It uses natural-feature tracking and frame markers. In addition to these characteristics, Vuforia also supports the option of virtual buttons, which registers the contact between the user and the marked parts of the marker. The tracking of objects which are rectangular in shape or something with a similar shape is also made possible. For the purpose of tracking the Vuforia *SDK* via one's Target management system, a dataset configuration *XML* file is created. The Vuforia uses *OpenGL ES* for rendering 3D objects. The Vuforia has an *AR* extension for Unity that enables vision detection and tracking functionality.

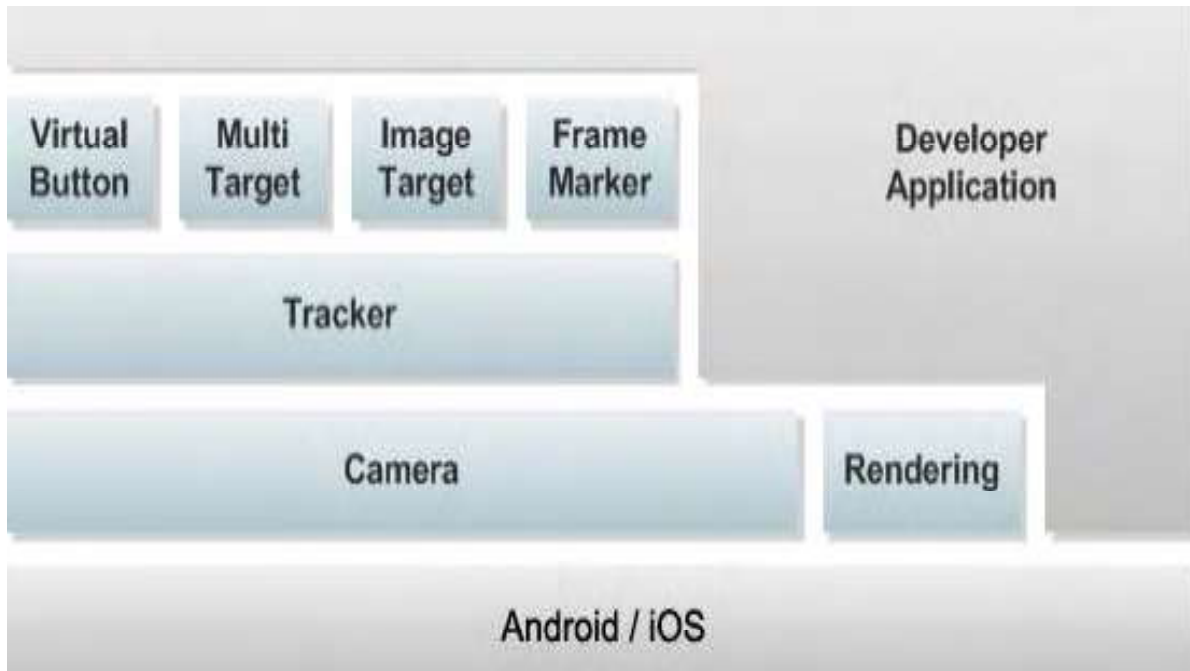


Figure 5. System overview of Vuforia SDK [9]

## 3. Evaluation and Implementation

### 3.1. Evaluation

After experimenting in practice with the software briefly discussed above, a comparative analysis of *AR* browsers and *AR* software development kits can be summarized as in Table 1. The most important elements of the software are shown: Platform – the system platform on which the described software is implemented. Tracking – The type of tracking which can be supported by the given software. Vision based – tracking which is based on the natural features (*NFT*) or classical (fiducial) markers [10]. Location based – this type of tracking is realized with the help of the *GPS* sensor and compass which are the constituent parts of a mobile device.

*AR* view content – the type of multi-media contents used to augment reality. *2D* means classic multimedia contents (html, image, audio, video) while the *3D* refers to the possibility of displaying 3D objects. *3Dani* marks the possibility of displaying 3D animations.

We can conclude that the Layar and Junaio, judging by the given elements, are very similar. They can be implemented on the same platforms and support the same type of tracking except that Junaio supports location based tracking in the closed space where *GPS* is not available. From Table 1 we can note that Wikitude supports only location based tracking and only has the possibility of *2D* contents.

In the case of *AR* software development kits Metaio and Vuforia, they support the same platforms. We can note a difference can only be found in the case of the location based tracking which, for now, is not supported by Vuforia *AR SDK*.

### 3.2. Implementation

Taking into consideration the characteristics of the described software systems, we have opted for the Junaio *AR* browser. Using this *AR* browser we have designed an application for the archaeological site Medijana. The application was designed so that when the visitor, while touring the archaeological site, using the camera on the mobile device, detects a mosaic, the screen of the device shows a 3D model of the Roman fountain in the exact location where it was once located (Figure 6).

In order to realize the application, we used tracking: *NFT* (natural feature tracking), that is, vision based markerless tracking. In our case the tracking object is the image of the mosaic.

The *AR* view content represents a 3D model of the fountain. The model of the fountain is given in the \*.obj which is encrypted with the help of the online Junaio Model Encrypter. These *AR* content is stored on the external server.

The structure of the application follows the one given in Figure 2. On the external server we generated a program code (*php*) which is used to connect with the Junaio server. This code enables the execution of other processes: the authentication process, the selection of multi-media contents as well as the transfer of the necessary parameters (*XML*).

The creation of channels is provided through the user interface on the Junaio server. We selected the Junaio *GLUE* channel. When forming the channel, we defined the other necessary data: the *URL* of the external server, the link for the homepage, and refresh time to search the request to the external server. It is possible to define the channel for it to be either of the type public or private. For additional searches of the channel the necessary tags are defined.

This application is experimentally verified on the tablet Asus transformer with the Android Honeycomb platform.



Figure 6. Application example

Augmented Reality is one of the upcoming technologies the usage of which becomes simpler thanks to the development of mobile devices. The described application realizes a new quality of the presentation of museum exhibitions. By using augmented reality technology it is possible to perform the restructuring of the archaeological sites and objects which do not exist and whose reconstruction is complex.



AR browsers									
name	platform		tracking				AR view content		
	 iOS		vision based		location based		2D	3D	3D ani
			marker based	marker less	outdoor	indoor			
Layar	✓	✓	✗	✓	✓	✗	✓	✓	✗
Junaio	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wikitude	✓	✓	✗	✗	✓	✗	✓	✗	✗
AR software development kits									
Metaio Mobile SDK	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vuforia AR SDK	✓	✓	✓	✓	✗	✗	✓	✓	✓

Table 1. A comparative analysis of mobile augmented reality software

#### 4. Conclusion

In this paper we carried out an analysis and a comparison of mobile augmented reality software. An application was designed for the virtual projection of the fountain in the auditorium of the emperor's palace at the archaeological site of Medijana. We have shown one of the possible ways for displaying cultural and historical heritage at the archaeological sites.

By using these applications, the desire and interest for the acquisition of new knowledge regarding cultural heritage or history can be increased. Learning is made more complete and extensive at the very location, enhancing the learning process. In order to use this technology it is necessary to perform the digitalization of cultural heritage, which contributes to its preservation.

This type of systems offers the visitor the possibility of selecting his own choice of additional contents regarding the object being viewed, in accordance with the available time and his personal interests.

Further research on this topic should be focused on the use of more inclusive software from the AR software development kit group for the realization of multi-media guides based on AR technology which could replace standard audio guides.

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#### References

- [1] Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. *Multimedia Tools and Applications*, 341-377.
- [2] Milgram, P., Takemura, H., Utsumi, A., Kishino, F. (1994). Augmented reality: A class of displays on the reality-virtuality continuum. *Telematcher and Telepresence Technologies*, 2351, 282-292.
- [3] Azuma, R. (1997). A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*, 6, 355-385.
- [4] Grubert, J., Langlotz, T., Grasset, R. (2011). Augmented Reality Browser Survey. *Institute for Computer Graphics and Vision, Graz University of Technology, Austria*.

- [5] Layar. (2012). Retrieved from <http://www.layar.com/browser/>
- [6] Junaio. (2012). Retrieved from <http://www.junaio.com/develop>
- [7] Wikitude. (2012). Retrieved from <http://www.wikitude.com/developer/wikitude-augmented-reality-for-developers>
- [8] Metaio Mobile SDK. (2012). Retrieved from <http://www.metaio.com/software/>
- [9] Vuforia AR SDK. (2012). Retrieved from <https://ar.qualcomm.at/qdevnet/>
- [10] Gervautz, M., Schmalstieg, D. (2012). Anywhere Interfaces Using Handheld Augmented Reality. *Computer*.