

Augmented Reality Software in Presentation of Cultural and Historical Heritage

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Abstract. This paper presents the advent in the presentation of cultural and historical heritage by using augmented reality (AR) technology. The use cases are given on the examples of mobile applications realized as electronic multimedia guides for various cultural institutions in Serbia. Then, a classification of the AR software is proposed based on their usage in the given examples.

Keywords: Augmented Reality, Mobile Guide, Cultural Heritage.

1 Introduction

Augmented reality (AR) technology is used in various fields to improve the presentation of various information contents. A special area of application is the digitalization of cultural and historical heritage. Cultural institutions such as museums, archaeological sites, or tourist organizations use AR technology to improve their exhibitions and provide interactive multimedia information about the current setups. On the other side, contemporary visitors expect to have interactive content that can be used according to their personal interests. By using augmented reality technology, exhibition elements could be recognized in real-time and provide more information. In this way, museum exhibitions become more interactive and visitors from a passive role become active participants who explore content according to their interests.

Various types of research concerning the application of augmented reality technology to cultural heritage have been realized (Bekele et al., 2018; Jingen Liang & Elliot, 2021). Different solutions have been achieved by combining AR software with specialized hardware devices (Not et al., 2019; Durand et al., 2014). A specialized solution concerns spatial augmented reality where interactively physical exhibition elements or museum artifacts are overlaid with virtual content using a video projector (Moumoutzis et al., 2022; Cisternino et al., 2021; Ridel et al., 2014). Wearable augmented reality solutions where devices such as smart glasses and headsets are used and tested to enhance visitor experience at cultural heritage sites (Litvak & Kuflik, 2020; Caggianese et al., 2014). Special attention is paid to mobile augmented reality where software solutions are provided as cultural heritage guides (Xu et al., 2022; Tatić, 2022; Banterle et al., 2015).

In this paper, we discuss the usage of mobile augmented reality technology for the presentation of cultural heritage on the examples of AR mobile applications realized as electronic multimedia guides for several cultural institutions in Serbia. These applications are developed by the ARhiMedia group acting in Nis, Serbia, within the framework of the Mathematical Institute of SASA, Belgrade, Serbia, and are publicly available on Google Play and App Store.

2 Augmented Reality Software

In the following considerations, the term electronic multimedia guide refers to mobile applications custom-designed for the presentation of cultural and historical heritage.

Electronic multimedia guides (e-guides) developed for the needs of various cultural institutions in Serbia are realized by using the Unity engine as a cross-platform game engine. An essential part of e-guides is the Augmented reality (AR) module which is realized by using the EasyAR augmented reality SDK as it is supported by the Unity engine. Implementation of the AR module is based on image tracking, and in different applications, concrete solutions mutually differentiate by the marker type, multimedia content type, location, and some other specific requests possibly issued by the institution for which the application is developed. In what follows, we discuss these differences by referring to concrete examples.

2.1 AR by Marker Type

Augmented reality implementations used in electronic multimedia guides can be distinguished by the image marker type. This differentiation is determined according to the dimensions and type of the objects to be recognized.

AR Marker by Size. The AR markers in electronic multimedia guides could be of various sizes which depend primarily on the dimensions of objects for tracking. These sizes could be categorized as small, medium, large, or extra-large.

The small-size markers are usually used for tracking objects that are printed in small formats, for instance on entrance tickets, or as a part of a booklet, poster, or a small plate. Fig. 1 shows an example of the usage of such markers in an application realized for the National Library of Serbia. This application describes several specialized funds and their collections in the Library. A specially designed pictogram has been assigned to each fund. After pictogram recognition, detailed information about the selected fund is projected on the mobile device of the user as a list of items in the corresponding fund.

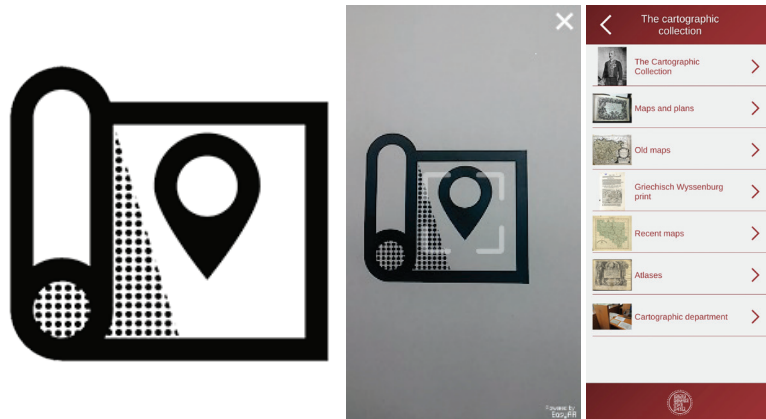


Fig. 1. (a) The pictogram, (b) Screenshot after the AR module is activated and the camera of mobile device directed towards the marker, (c) A scrollable list of items in the fund.

Medium-sized markers are used for tracking objects such as wall images, frescoes, posters, or plates in front of the monuments. For example, markers of this type are used in the application of Old Town Bač. In this application, the part of the tourist map at the entrance of the old fortress is used as an AR image marker. After AR recognition of the marker, 3D model of the reconstructed fortress is projected as an overlay on the map. An example of AR recognition of the map is given in Fig. 2.

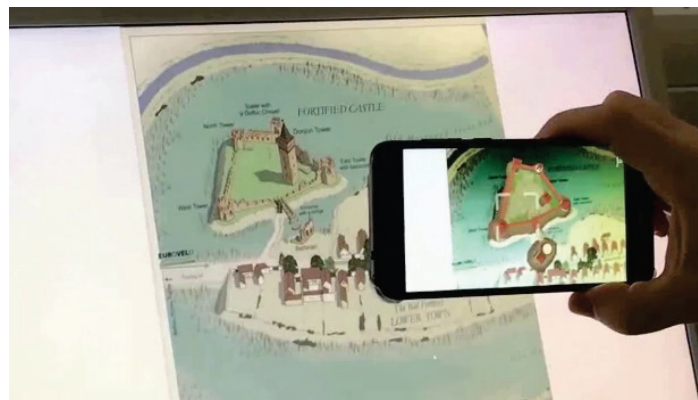


Fig. 2. Recognition of the tourist map as a medium image marker and visualization of a 3D model of the old fortress is realized for the application of Old Town Bač.

Large-size markers are typical for tracking objects such as human-sized billboards or monuments. The application named Windows of Historical Archive Speak is used to recognize billboards that are positioned on the windows of the Historical Archive of Niš, Serbia. Each billboard presents a historical person or event important for Niš city history. After the recognition of the billboard, multimedia information of related historical content is provided. An example of an application that recognizes billboards on the window is given in Fig. 3.



Fig. 3. Windows of the Historical Archive in Niš are covered with billboards of historical persons and events which are used as large markers for AR recognition.

Extra-large size markers are used for tracking huge objects such as part of archaeological sites or historical buildings. An example of recognition of extra-large marker is given in Fig. 4 where a part of the museum building is recognized to project the corresponding AR content. The application is developed for the National Museum of Leskovac in the context of the exhibition devoted to the industrialization of the city of Leskovac, Serbia, in the past times. The application recognizes the facade of the building and provides video animation as an intro to the exhibition. Also, inside the museum recognized are large panels to provide historical multimedia content.

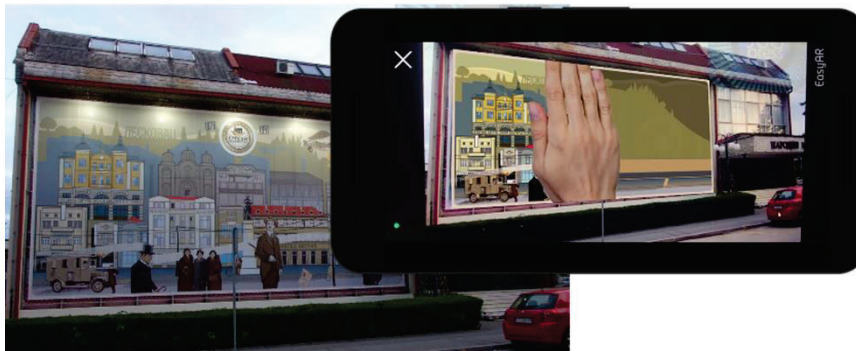


Fig. 4. The extra-large marker for AR recognition is a part of the museum building facade.

AR Marker by Object Type. The markers for AR tracking in electronic multimedia guides can be determined by the object type. These objects are seen as graphics, photographs, paintings, boards, and memorials.

Graphics markers are illustrated images printed on objects such as posters or plates. The illustrated images are in the form of pictograms and symbols. An example of the usage of this type of markers is given in Fig. 5. This marker in the form of a plate with a pictogram was made for the Museum of Aranđelovac for the exhibition of the Open

Air Museum. The Open Air Museum represents the collection of sculptures located in the Bukovički Park. In front of each sculpture, there is a plate. When the plate is recognized, information about the sculpture and its author is provided.



Fig. 5. Recognizing graphic on a plate as an AR maker.

Photography marker type stands for printed photos presented in museums, galleries, or archaeological sites. The usage of this type of markers is illustrated in Fig. 6 on the example of the mobile electronic guide for the Historical site of Brankovina. The printed photos of old house equipment are positioned in front of each room of an old house. Recognizing the photos with AR, provides information about the purpose of the equipment arranged in that room.



Fig. 6. The photo as AR marker.

Paintings as markers stand for painted objects in galleries or museums that can be recognized. An example of painting as a marker type is given in Fig. 7 for the application created for the Museum of the First Serbian Uprising located in at Orašac which is viewed as the cradle of Serbian statehood. The paintings exposed in the exhibition hall

are dedicated to the leaders and events of the uprising. By recognizing the paintings with AR technology, we bring to life the painted rebels and display their speeches.



Fig. 7. The painting as a type of AR marker.

The panel is a type of marker with the size of a billboard. Fig. 8 presents this type of marker on the large tourist map of the city of Bor. A mobile application created for the Museum of Mining and Metallurgy uses AR technology to recognize this tourist map. Detailed information is provided about cultural and historical sites by recognizing photos on the map.



Fig. 8. The tourist map as a panel type of AR marker.

Memorial is a type of marker that can be a part of archeological sites such as mosaics, statues, or historical buildings. Fig. 9 shows an example of this type of markers on the application dedicated to the Monument to the Liberators. This monument is located at the main square of the City of Niš and has reliefs that symbolize important historical

events for liberation. By AR recognition of the reliefs on the monument, information about the corresponding historical events is provided.

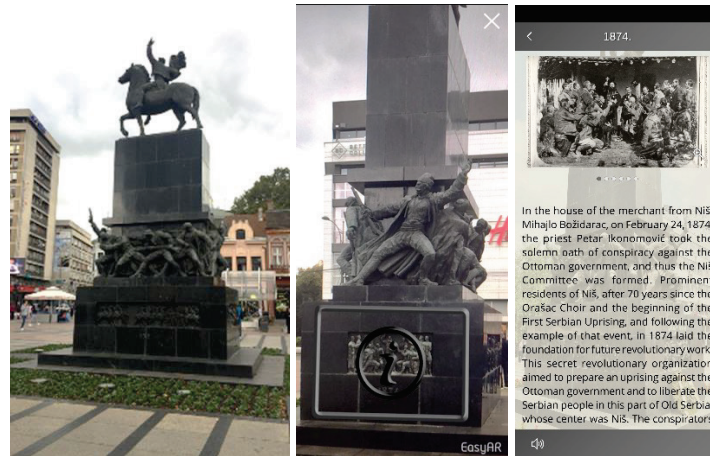


Fig. 9. The part of the monument as a memorial marker type.

2.2 AR Content Type

Augmented reality in electronic multimedia guides can be differentiated according to multimedia content such as interactive links, 2D images, video, or 3D models.

Interactive links stand for direct linking to multimedia content which refers to the historical content after AR recognition. This is implemented as interactive buttons which, after interaction, link to the content. An example of the implementation of these interactive links is given in Fig. 10. The application is realized for the Museum of Ponišavlje in the city of Pirot, and AR is used for poster recognition. The poster consists of photos and each photo refers to one exhibition room inside the museum. When the photo is recognized, the virtual button overlays that photo. After the interaction with the virtual button, multimedia information is opened in a new scene.



Fig. 10. AR recognition overlaying the poster with interactive links.

2D images are plane objects that can overlay recognized content in terms of reconstructions. An example of the usage of reconstructions is in the application of the Homeland Museum of Knjaževac in Fig. 11. This application uses AR technology to recognize the facades of buildings in the city of Knjaževac, Serbia. Recognized facades are overlaid with old photos of buildings that once existed at that location.



Fig. 11. House facade AR recognition overlaying old 2D image.

Video can provide historical content or video animation as an overlay of tracking content. An example of video usage is given for the application of the Homeland Museum of Paraćin in Fig. 12. A special catalog was created dedicated to the industrialization of the city of Paraćin. AR technology was used for the recognition of some pages of the catalog. The recognized page is overlaid with a video dedicated to the historical content on that page.

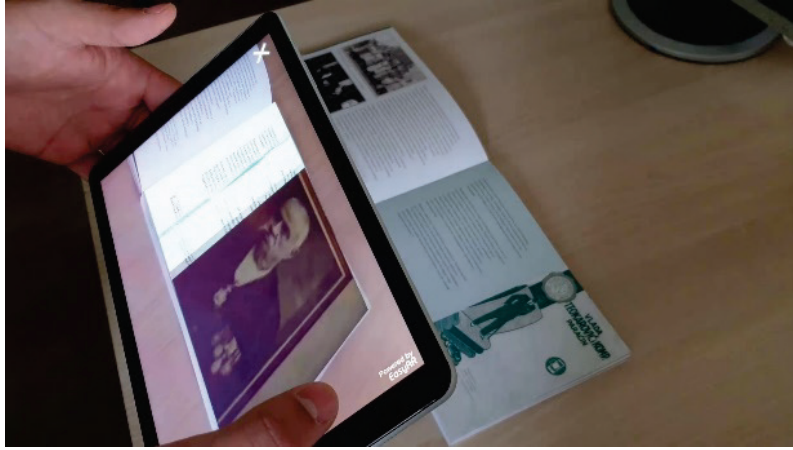


Fig. 12. AR recognition of catalog pages with video overlay.

3D models can serve as a digital reconstruction of parts of historical buildings such as fortresses and similar objects at archaeological sites. An example of the usage of 3D model is provided for the application of the archeological site Timacum Minus near the city of Knjaževac in Fig. 13. The tables placed on the archeological site provide basic information about the archeological site. Using AR technology, the application recognizes the images of Roman ruins illustrated on the tables. After recognition 3D models of the reconstructed buildings overlays images of tables on the screen of mobile device.

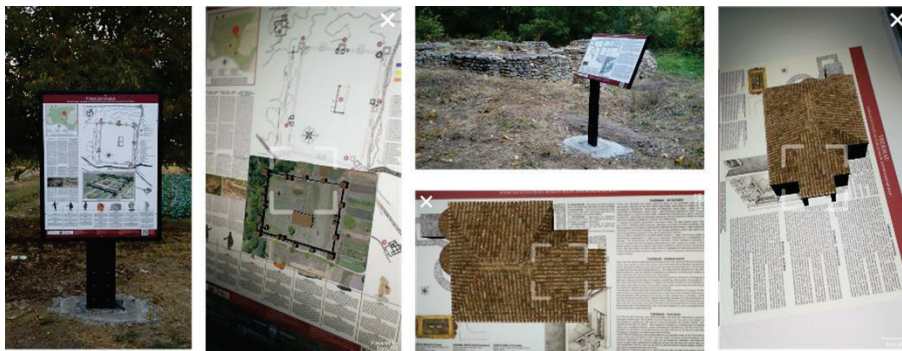


Fig. 13. AR recognition of tables with 3D models as overlay for reconstruction of ruins.

2.3 AR by Location and Institution

The markers could be distinguished by the location of the recognition which stands for indoor and outdoor AR tracking. Indoor AR tracking includes markers exposed in closed spaces in cultural and historical institutions such as museums, galleries, and tourist organizations. Outdoor AR tracking assumes the markers in open spaces such as monuments, parts of archeological sites, and facades of historical buildings. Examples

of indoor and outdoor markers are in Fig. 1, 6, 7, 10, 12, and Fig. 2, 3, 4, 5, 8, 9, 11, 13 respectively. Those AR applications are realized for various cultural institutions such as museums, galleries, tourist organizations, historical archives, and libraries.

3 Classification of AR in Realized Applications

The ARhiMedia group realized over 50 mobile applications that concern the field of cultural and historical heritage. Augmented reality technology is used in 28 applications. The classifications of usage of augmented reality in these applications are given in Table 1 and Table 2. In these tables, the last row shows the number of applications where a particular type of markers is used.

Table 1. Classification of AR by image marker type.

Marker type								
Size				Object type				
Small	Medium	Large	Extra-large	Graphics	Photography	Painting	Boards	Memorials
6	10	11	6	10	5	2	7	6

The most used by size is the large type of AR markers in 11 applications (Table 1). Second, is a medium-sized type of marker used in 10 applications. Next followed by 6 applications are small and extra-large types of markers.

Graphics as object type of AR markers are most used in 10 applications (Table 1). Next by usage is the board type of makers used in 7 applications. Other types are arranged as follows, memorials marker type is used in 6 applications, photography marker type is used in 5 applications, and painting photography marker type is used in 2 applications.

Table 2. Classification of AR by multimedia content, location, and historical institution.

Multimedia content type				Location		Historical institutions				
Links	Images	Video	3D model	Indoor	Outdoor	Museum	Tourist organization	Historical archive	Library	Archaeological site
17	4	3	5	18	12	16	4	2	4	2

The links were the most used AR multimedia content type in 17 applications (Table 2). Other multimedia content types are distributed as follows, 3D models are used in 5 applications, images in 4 applications, and videos in 3 applications.

Indoor augmented reality is most frequently used in 18 applications (Table 2). Outdoor augmented reality application is used in 12 applications.

The largest number of 16 applications was made for museums (Table 2). Next following were 4 applications for the tourist organizations and the same number for the libraries. There were 2 applications developed for each historical archive and archaeological site.

4 Conclusions

Augmented reality significantly improves the presentation of cultural and historical heritage. This paper discusses how mobile augmented reality is used to improve the presentation of cultural and historical heritage. The use cases are given on the examples of mobile applications realized by the ARhiMedia group for cultural institutions in Serbia. This group realized over 50 mobile applications as electronic multimedia guides publicly available on marketplaces such as Google Play and App Store. The usage of augmented reality technology that improves the presentation of cultural and historical heritage in Serbia is available in 28 applications. We determined the usage of AR technology by application of marker type, multimedia content type, location, or institution for which it is applied.

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