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UNIVERSAL MOBILE CULTURAL HERITAGE GUIDE BASED ON ANDROID TECHNOLOGY

Abstract. This paper presents a universal mobile cultural heritage guide based on Android technology that can help visitors of various exhibitions to browse multimedia information content with mobile devices. The system consists of several independent programming modules that can be combined in different ways to create various mobile applications for presenting cultural heritage. In this way, we ensure universality of the guide and its applicability to different exhibition scenarios. A special module for augmented reality technology is implemented to provide a possibility for presentation of 3D computer generated reconstructions of objects at historical sites using either the location based or vision based techniques. The system is verified on the example of an application for the Archaeological park Mediana in Niš, Serbia.

Keywords. Handheld system, multimedia, augmented reality, tourist guide, cultural heritage

1. Introduction

Rapid growth of information technology and wide usage of mobile devices increase expectations of visitors of museums, archaeological sites, and places organizing and hosting other similar exhibitions. Visitors expect to have due to the advent of technology a possibility to get more information about objects at the exhibition according to their own interest. Printed schemas and textual panels or booklets cannot keep up anymore with the demands of contemporary museum visitors. Therefore, cultural institutions have to advance their exhibitions from a passive viewing of predefined, selected, and necessarily limited amount of information to various dynamic forms by using digital multimedia technologies and mobile platforms.

Therefore, there is a need to create attractive systems and innovative applications in order to attract visitors and enlarge the audiences. Creating a direct interaction between a visitor and the exhibited objects of his particular interest becomes an imperative task to make exhibitions more attractive and appealing to visit. This can be done by using technologies of augmented reality (AR) allowing to combine the picture of the real world captured by a camera, usually the camera of a mobile device, with the virtual computer generated content [1].

Recently, mobile devices like smartphones and tablets become the standard information interface for ordinary customers. These interaction devices are good platforms to create applications for the presentation of cultural heritage. Such applications can help visitors to walk through museums and inform themselves about the selected items of cultural heritage according to their personal interests. Embedded multimedia content in the form of audio and video records, 3D computer generated objects, photos and text can be used to offer interesting and interactive scenarios in order to display their digital collections.

In this paper, we present a cultural heritage mobile system based on the Android technology. The system is created as a universal platform meaning that it can be adapted

to exhibitions of different kind in various cultural institutions. For the direct interaction with the exhibition space, the system provides a special module based on augmented reality technologies.

1.1 Related work. There have been many approaches about virtual heritage projects using mobile augmented reality. In this section, we briefly present three of them to illustrate former, recent, and present approaches to mobile AR implementations primarily intended for representing cultural heritage and enhancement of museum exhibitions.

Archeoguide was among the first mobile systems of this kind [2]. In this system, a rather robust equipment (Head-mounted display (HMD) and a computer in a backpack) was used to communicate with central server and to present multimedia content. This project was tested in Olympia with the purpose to show virtual reconstructions of scenes of life in ancient Greece.

Recently, Ultra Mobile Personal Computer (UMPC) devices became more popular for realizations of AR systems. For example, the *AR-museum guide* presented in [3] uses these devices to guide visitors and inform them about the objects in the Louvre museum. The AR technologies are used to navigate visitors along a specific route. Also, the authors of the project created a Presentation room where visitors can get, by scanning the object, additional information about artwork in their surroundings.

Nowadays, the Natural History Museum in London created the *Augmented reality arena* to explore the complex theory of evolution [4]. They have combined classical film projection technology with custom made handheld augmented reality system to show new interactive experience. Handheld devices are used to track led diodes at the center of the arena so that visitor can see extinct creatures moving at that place.

The system presented in this paper takes into account that exhibition at an archaeological site usually consists of an in-door and an out-door part. Typically, there is an exhibition room to show various size artefacts, ranging from relatively large, such as parts of statues, arms, pottery, etc., to small as for example jewelry, coins, and picks of arrows, and similar objects. Ruins, remaining of buildings, fortifications, temples, etc., make the out-door part of the exhibition to visit. Therefore, the system for applications at archaeological site has to provide a good flexibility to meet different demands for in-door and out-door exhibitions at the same time.

2. Functionality of the proposed system

Functionality of the system is determined by the intended applications and can be split into three parts:

1. Navigation,
2. Information Provider,
3. Storytelling.

In the *Navigation* part, due to the link with Google Maps, the system enables to locate the museum or the archaeological site, and determines the route to it in the standard Google Maps manner. Typically, the system is configured such that the route can be determined from the current position of the visitor, from the bus station, train station, airport, or the harbor.

Information provider is intended to show the basic information about the museum, such as, for example, working hours, exhibitions, prices, souvenir and book shops catalog, other facilities, etc. These two functional units make the system suitable

as the general purpose touristic guide enabling a visitor to navigate across a city, touristic resort, or an exhibition hall of a fair.

The *Storytelling* part, due to the connection with the purposely design repository, is intended to provide detailed information about the objects and various artifacts in the museum or similar other venues. The repository might contain textual, audio, and video records, as well as photos and 3D models of objects and other artifacts. An especially designed module offers the features of the augmented reality systems by allowing inserting computer generated contents into the real scene captured by the video camera of the underlined mobile device. The options of location-based tracking and marker- or image-based tracking are provided. This feature is especially convenient for archaeological sites, since allows augmenting the real scene with missing parts or whole objects. It is also convenient in situations where, due to the conservation reasons, the objects, such as mosaics, reliefs, or paintings, are not directly observable. In this case, the system project the corresponding photos, paintings or drawings, videos, or 3D reconstructions, enriched with underlying sound, speech or music, and textual data and explanations.

3. System description and architecture

The architecture of the proposed system is organized in three subsystems: *Design*, *Logic*, and *Multimedia content*. In this way, we follow the good practice similar to Model View Controller (MVC) concept although this is not a property strongly featured in Android programming environment. This organization into subsystems provides flexibility and adaptability of the application to various scenarios as will be explained below. Figure 1 shows the architecture of the system.

The subsystem *Design* is intended to provide necessary layout for the visitor with an intuitively clear interface and the application determined navigation commands. The layout is determined by the museum (or other customer) and it is a characteristic trademark of a particular customer that can be distinguished from that of other customers. Thus, it can be easily customer tailored, changed or modified without interfering with other subsystems.

Logic is the core part of the system and ensures its functionality through several modules that will be discussed in more details in the next section of the paper. This is the invariant subsystem of the application independent of the customer.

Multimedia content is the subsystem that consists of a custom specific repository with textual, audio and video records, photos, 2D and 3D objects. This content is designed for each application separately according to the interest of the customer. The data are provided in a large set of various contemporary used formats so that the base can be filled in without much troubles whatever the formats provided by the customer are. The system ensures a great flexibility in terms of formats and screen resolutions, orientation (portrait or landscape) and sizes of screens of mobile devices.

Modules in the subsystem Logic. The subsystem *Logic* consists of several modules: *Map, List, Info* and *Augmented Reality.*

Module *Map* is created to show the area of an archeological site or museum. It is implemented with Google maps Application Programming Interface (API) and uses orientation and directions functions from this API. These functions help to locate the current position of the museum or a part of the archeological site on the map. This enables to calculate and show the routes between points of interests and the current position of the visitor, bus, or train station. The point of interest is also interactive and provides more information about the selected place by calling the module *Info*. All

directions and media information are defined with Extensible Markup Language (XML) for a faster content embedding.

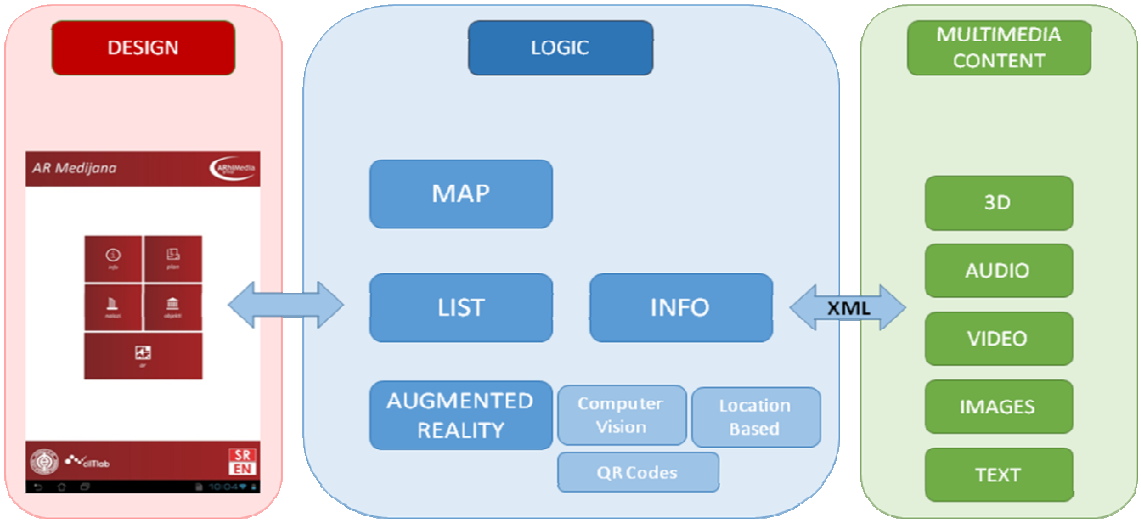

Figure 1. Description of the system

Module *Info* is constructed to show more information about every object defined in other modules. The module consists of five multimedia components:

1) Photo gallery - displays all images about the object,
2) Text area – show textual explanation for the object,
3) Audio player - read written text from text area,
4) Video player - plays video records if provided,
5) 3D model viewer – enable interaction (scale, rotation) with 3D models of objects.

Module *List* is generated to show the list of object and findings selected by following some specific criteria unique for each particular museum or archaeological park. Basic text and relevant photos are shown in the list of items which is defined as an XML file that stores all relevant data. Interaction with this content enables to get more multimedia information.

In the module *Augmented reality*, we use the augmented reality (AR) technology that combine images of the real world and virtual computer generated images and 3D models on the used mobile device display [5]. In this way, the virtual content looks as a part of the real world. The other basic characteristics of augmented reality are that it runs interactively and in real time and precisely aligns real and virtual objects with each other [6]. This should help a visitor to easier imagine and visualize the missing parts or whole objects. We use this technology to widen the visitor's perception of the cultural heritage sites augmented by the additional information. We decided to use Metaio mobile SDK [7] for the implementation of AR, because it supports various types of augmented reality tracking, both vision and location based.

The vision based technology uses the camera of mobile device to recognize parts of the real world. The object of identification could be either marked places or parts of real objects. Using the features of the recognized object, virtual content is registered in the 3D space. We use two types of markers or natural features for tracking. Natural feature tracking (NFT) is good for artifacts or their parts. The demands are that objects need to have characteristic suitable for a reliable tracking. For more details about those characteristics we refer to [8]. If objects do not have characteristics sufficiently good for

tracking, we use artificial markers for the recognition [9]. This kind of tracking is faster and it can recognize more object than NFT. The bottleneck of the usage of artificial markers is that the mystical effect characteristic for augmentation is reduced compared to that usually produced by NFT.

Location based tracking deals with sensors like GPS, gyroscope, and accelerometer. The virtual content is positioned based on data obtained from sensors mixed with picture of visitors surrounding gained from the camera of the mobile device. We use this type of augmented reality, except orientation in space, to project distant objects or these on locations hardly accessible for the visitors. The interaction with points of interest is implemented and connected with the module *Info*. These points of interest could be in the form of 2D or 3D data.

In this module, we also implemented an application for recognition of QR codes. This is useful since allows visitors to get more information about objects in the exhibition. Recognition of QR code transfers us directly to the *Info* module.

Multimedia content. Multimedia content require a special preparation for mobile devices. Because of that, generated 3D models have a low number of polygons (about 1000 to 4000 polygons) in *fbx* or *obj* format. For creation of 3D content, we used specialized software tools for modeling, such as Autodesk 3ds Max, ZBrush, Cinema 4D, etc. Also, low cost 3D scanning was included (123d Catch, Kinect fusion, and David Laserscanner) to make models for our system.

Audio materials are prepared in *mp3* with 44.1 kHz bitrate 64 kbps because only narrative voice was recorded. Video is done in *mp4* with the *h264* codec in the format 720×480 pixels and bitrate 768 kbps. We did the video editing with different software tools like Adobe Aftereffects. All multimedia content is connected with an application using XML. Simple changes of design and content trough XML files make system easy to adjust application to different museums or archaeological sites which ensure its universal applicability.

Design. The application is designed with a large flexibility and extensive possibilities for adaptation to different cultural institutions. Defined trough the Android, the XML layouts are prepared for different screens (Smartphone or tablet PC) resolution. Also, design created in this way enable us to make applications tailored either for the end users (visitors) or experts in the field working in the museums (as a tourist guide, custos, etc.).

4. System implementation

The system is designed so that can be easily adapted to requirements by any museum or archeological site by using the integrated modules. The modules could be enabled or disabled depending on the requests for each concrete museum application. Visual interface is easy to change for every application without affecting the logic of the system. We created several applications for the museums and historical monuments in the city of Niš (Mediana, Ćele-kula, Čegar, Niška tvrđava) by using the proposed system. We will describe the implementation of the system on the example of the application developed for the archaeological site Mediana. In this application all modules and options of the proposed system are integrated.

Application is designed according to the requirements specified by experts for the archeological site Mediana. It offers to a visitor possibilities to choose, depending on his affinities and available time, information about the objects at the places where they once existed and at exact locations. Viewing the information about objects or other

archaeological artifacts is done on the mobile device by using multimedia technologies. In this way, it is possible to upgrade objects at the archaeological site that are protected and cannot be seen or do not presently exist and whose physical reconstruction is complex or impossible.

Main screen shows the links of four main categories *info, map, objects, findings,* and *augmented reality* (Figure 2). The created application is multilingual and visitors can choose one of languages (Serbian or English).

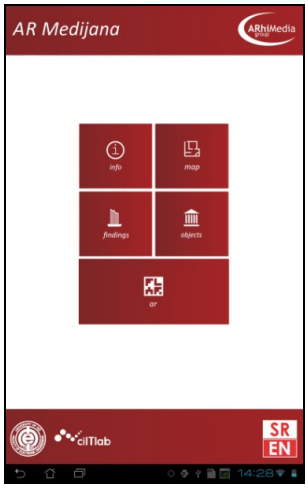

Figure 2. Main screen of the AR Mediana application

Category *map* shows the areal map of Mediana (Figure 3). It is created with the module *Map*. This module has interactive pins (hotspots) which show important points at the archeological site. Each interactive pin gives us ability to get more information about the place. Also, the implemented route option gives to a visitor the opportunity to see the road to the archeological site from the current location, city center, bus or train stations.

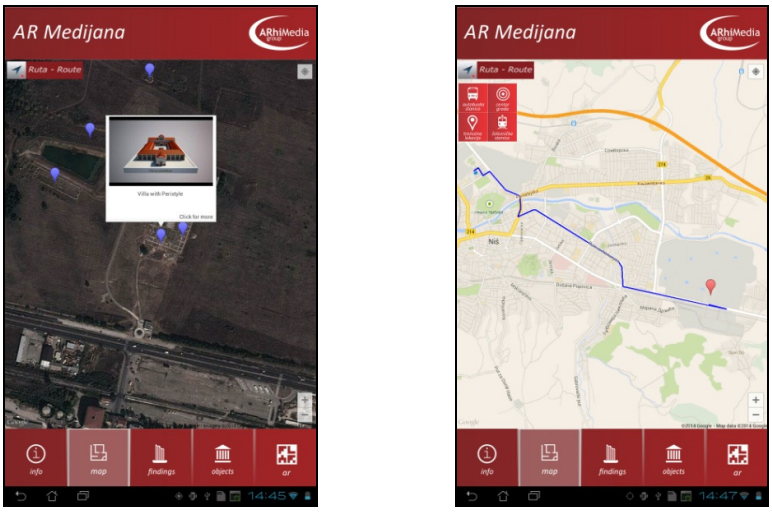

Figure 3. Area of the archeological site Mediana (left) and the road from the current location (right)

All data are defined in the XML where we store the information. More information about hotspots is accessible through the category *more info* in the form of a text and image gallery (Figure 4). Video and audio can be displayed about object of interest. Also, the interaction with 3D models is possible as an option. All this is implemented by using the module *Info*.

Figure 4. Information about an object, gallery, text, audio (left) and 3D model (right)

In categories *findings* and *objects* we used the module list (Figure 5). The category Objects shows the list of all buildings and civil engineering constructions on the archeological site (summer palace, horreum, military barracks, etc.). Movable materials are shown in the category *Findings* (bronze gait, coins, statues, etc.). This is organized as items that have small pictures and text information. If desired, more information about items can be obtained through a further interaction with the device. More detailed description of items in findings and objects can be obtained from the category *more info*.

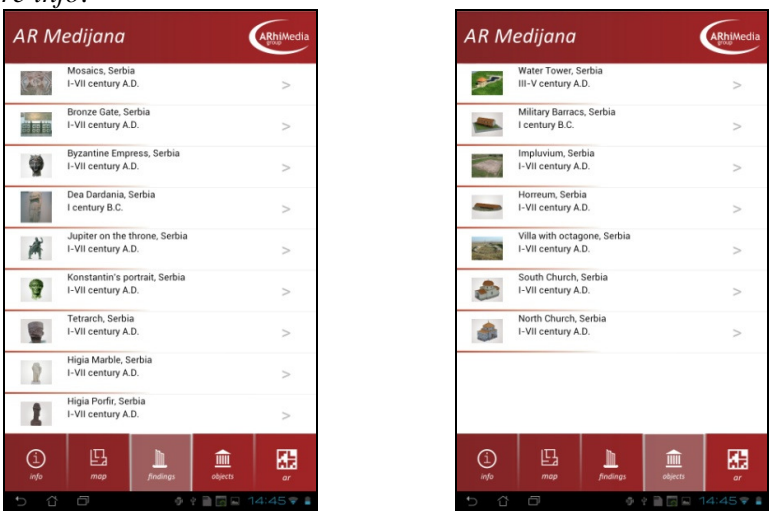

Figure 5. Lists of findings (left) and objects (right)

Category *augmented reality*, divided in subcategories (*Reconstruction*, *Orientation*, and *QR Scan*), is created with the AR module. Subcategory *Reconstruction* is used to recognize the parts of the archeological site and perform their reconstruction with AR technologies. First problem we had to solve was to show mosaics which are protected and hidden under the sand for the conservation reasons. We place the markers at the corresponding places located across the archeological site. When a visitor directs the camera of the mobile device towards a marker, he gets the real world image augmented with the virtual image of the mosaics (Figure 6). The second problem was to do the reconstruction of missing objects. Along the accessible paths of the archeological site, there are archaeological ruins of few buildings. Placing the markers near the ruins,

the visitors can see through their devices the reconstruction of the buildings inserted in the image of the current surrounding. The interaction with the computer generated content is enabled and provides more information. The information we get through the links with the Info category, in the form of audio, video, text, images etc.

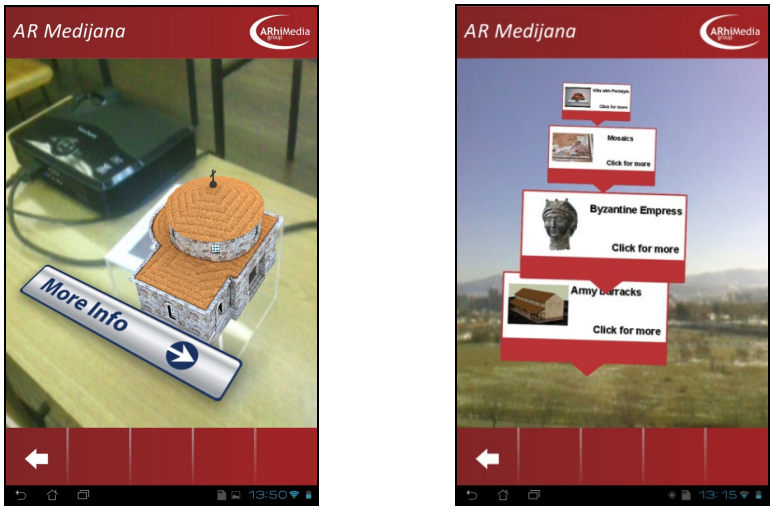

Figure 6. Augmented Reality marker (left) and location based (right) tracking

The *Orientation* subcategory is used to show objects in the visitors surrounding with location based augmented reality methods (Figure 6). Because Mediana is a large site (40ha) we are able to show to visitors far away points of interest in the form of floating balloons which show the image, name, and direction of the object based on GPS data. These points of interest provide more information when visitor interact with them. Information is linked with the category *Info* and provides all options for the selected object.

Category *QR Scan* is used for the objects marked with the QR code inside museums. Recognized QR code is liked with the *more info* category where visitors can find more information.

5. Conclusion

Contemporary information technologies offer a lot of opportunities for various applications in digitalization and presentation of different forms of national heritage. This however imposes many challenges in determining how these opportunities can be used in the most appropriate way with respect to the rigorous demands on preserving and proper presenting items of national heritage, and at the same time to provide the most informative and attractive exhibitions. The related applications have to be inexpensive and it this way accessible for many visitors of exhibitions. Taking these observations as a motivation, in this paper, we present a universal mobile guide based on Android technology.

The term universal refers to two features of this system. First, it can be run on different mobile platforms such as tablets and smart phones, which make it easily affordable for many ordinary visitors of exhibitions of national heritage. Second, after certain modifications, that are simple and easy to make, the same device can be adapted to different kind of exhibitions, ranging from touristic guides across cities, through out-door exhibitions at archaeological parks, to closed space museum exhibitions and fairs.

The architecture of the guide is organized into functional subsystems which makes it adaptable to different application scenarios. In all applications, the core part of the guide, the logic of the system, remain unchanged. The required modifications are

done on the layout and data repository as specified by the customer. All functionalities usually provided by the Android technology based devices are implemented. Due to this the visitor can display various types of multimedia files.

The application is further enriched with an especially designed module that enables the augmented reality option, which allows displaying virtual reconstruction of different objects embedded in the real environment. The proposed solution was tested and verified by a concrete application developed for the Archeological park Mediana in the City of Niš, Serbia.

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References

[1] Sparacino, Flavia, *The Museum Wearable: Real-Time Sensor-Driven Understanding of Visitors' Interests for Personalized Visually-Augmented Museum Experiences*, Proceedings of Museums and the Web**,** 2002.

[2] Vlahakis, Vassilios, M. Ioannidis, John Karigiannis, Manolis Tsotros, Michael Gounaris, Didier Stricker, Tim Gleue, Patrick Daehne, and Luís Almeida, *Archeoguide: An augmented reality guide for archaeological sites*, Computer Graphics and Applications, IEEE 22, 5 (2002), 52–60.

[3] Miyashita, Tsutomu, P. Meier, Tomoya Tachikawa, Stephanie Orlic, Tobias Eble, Volker Scholz, Andreas Gapel, Oliver Gerl, Stanimir Arnaudov, and Sebastian Lieberknecht, *An augmented reality museum guide*, Proc. 7th IEEE/ACM Int. Symp. on Mixed and Augmented Reality, IEEE Computer Society, 2008, 103–106

[4] Barry, Ailsa, Graham Thomas, Paul Debenham, and Jonathan Trout, *Augmented reality in a public space: The Natural History Museum, London*, Computer 45: 7(2012), 42–47.

[5] Carmigniani, Julie, Borko Furht, Marco Anisetti, Paolo Ceravolo, Ernesto Damiani, and Misa Ivkovic, *Augmented reality technologies, systems and applications*, Multimedia Tools and Applications, 51:1(2011), 341–377.

[6] Azuma, Ronald T., *A survey of augmented reality*, Presence Teleoperators and Virtual Environments, 6:4(1997), 355–385.

[7] Metaio Mobile SDK, http://www.metaio.com/products/sdk/, January 2014.

[8] Herling, Jan, and Wolfgang Broll, *Markerless Tracking for Augmented Reality*, Handbook of Augmented Reality, Springer New York, 2011, 255–272

[9] Kato, Hirokazu, and Mark Billinghurst, *Marker tracking and hmd calibration for a video-based augmented reality conferencing system*, Proc.2nd IEEE and ACM International Workshop on Augmented Reality (IWAR'99*),* 1999, 85–94.

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