A Universal Android Tourist Guide Using the GPS Technology

Đorđe Manoilov[1], Dušan B. Gajić[1], Radomir S. Stanković[1]

Abstract – **This paper describes an Android tourist guide for mobile devices, based on the global positioning system (GPS) technology. We present the architecture of the application and its typical use-case scenarios. Employment of the presented application on archaeological sites allows visitors to access additional multimedia content and easily navigate through on-site objects. Other existing systems, aimed at similar purposes, are mostly focused on audio content, while the presented application also features video and 3D material. The use of XML decouples the implementation from the content of the application, thus allowing an almost straightforward adoption of the presented application on different archaeological sites.**

Keywords – **Android, mobile programming, augmented reality, cultural heritage, tourist guide, global positioning system - GPS.**

I. Introduction

The application of information technologies (IT) creates new opportunities for better presentation of cultural and historical objects and museum exhibitions. Multimedia presentations and applications for mobile devices make historical sites and art exhibitions more accessible and more interesting to a wider audience. Through their use, each visitor can find information about an exhibition to the extent that suits their interests. Mobile devices, such as smartphones and tablets, recently became omnipresent in everyday human activities. Tourism industry followed this change.

Development of digital tourist guides based on various information technologies can greatly help in several aspects related to tourism. In addition to helping with the complex preparations before starting a trip, mobile applications can help in solving the problem of lack of information about cultural and historical attractions. Tourists have at their disposal a number of activities, such as visiting attractions or restaurants and shops, but they don’t have enough information to make an informed decision. A similar problem may be encountered during visits to archaeological parks or large museums, due to the large number of offered exhibits and lack of information about the preferred visiting routes. Further, there is often a problem of timing certain activities and having correct information about working hours of institutions. Finding an optimal route to a desired location in an unfamiliar place is another task made easier with mobile devices. This task is especially difficult in large cities, where important attractions are often distant from each other.

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The Android tourist guide for mobile devices presented in this paper is developed by the ARhiMedia group from the Faculty of Electronic Engineering in Niš, Serbia. The proposed application offers one approach to solving problems discussed in the previous paragraph. Solutions to some of these problems were discussed earlier in [1, 2, 3, 4], while this study focuses on solving the problem of choosing the optimal route. The idea for this application emerged during visits to archaeological parks Mediana, close to Niš, Serbia, and Iustinana Prima – Caričin Grad, near Lebane, Serbia.

The paper has the following structure. In Section II, we present the motivation behind the development of the application, as well as its architecture. Section III contains a brief description of the user interface and implementation of the application. Section IV presents the most important conclusions, as well as plans for future work.

II. The Application

The mobile tourist guide presented in this paper, is developed to allow users easier navigation through archeological parks and objects of great cultural and historical importance which very often cover large areas. It also provides information about objects of cultural and historical significance, such as three-dimensional (3D) reconstructions of objects and audio and video content about them. The application also gives users an opportunity to dictate the pace of the tour and to select additional information in accordance with their interests and available time. The presented application is already used in the digital mini-museum of the Faculty of Electronic Engineering Niš, as a demo tourist guide through the Niš medieval fortress and the Roman site of Viminacium, Serbia.

A number of applications designed for similar purposes exist. An example is an Android application *Taj Mahal Official Tour*, intended for visiting the Taj Mahal in India [5]. This application contains an audio guide with a map that shows points on which visitors can stop and hear additional information. Another example is the *Smart Tour Guide* application, created by the Korean Tourism Organization, which contains interesting anecdotes collected from the archives of Korean history [6]. Both applications, as well as most of the other existing applications of similar purpose, are devoted primarily to audio content. The tourist guide presented in this paper puts more emphasize on video and 3D materials. Further, the presented application is developed so that the entire multimedia content is independent of the implementation. Therefore, the application can be applied to any location without additional programming, just by changing the configuration file and adding appropriate multimedia content.

A. The Application Architecture

The application is developed for mobile devices with Android operating systems. Position between points of interest and current position of the user is determined using global positioning system (GPS) and device's orientation sensors - accelerometer and compass. Functions for communication with GPS satellites and for determining orientation of the device are available within the Android application framework [7].

The application architecture is shown on Fig 1. The application consists of several forms: *Compass*, *Map*, *List*, *Video* and form for models *3D Preview*. Application logic and multimedia data that are used are completely separated. Each of the mentioned forms will be explained in detail later in the text. Data that are used in the application are packed in an expansion file, which is downloaded along with the application from the *Google Play* market and stored in the external memory of the device.

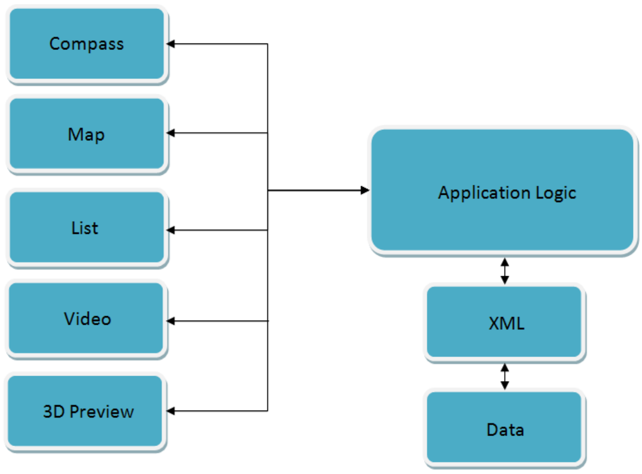

Fig. 1. The application architecture.

The maximum size of application that can be placed on the *Google Play* market is 50 MBs. Typically, there can be a large number of points of interest on archaeological parks. Therefore, there is a possibility that a lot of multimedia content might be necessary, so the application is implemented not to be size-limited. One possible solution are expansion files [8]. An expansion file contains all necessary information and is placed on *Google Play* along with the application. It is possible to add two expansion files, each with size up to 2 GBs. Conceptually each expansion file plays a different role. Main expansion file is the primary expansion file for additional resources that are necessary in application. Patch expansion file is optional, and it is designed for small changes in the primary expansion file. Both expansion file can be in any of the following formats: *ZIP*, *PDF*, *MP4*, etc. Independently of the type, *Google Play* renames them using the following scheme: *[main|patch].<version-of-expansion-file>.<package-name>.obb*.

After the download is complete, data are loaded into the application according to the XML configuration file. For our application, the XML configuration file is also a part of the expansion file. The remaining content is classified into folders whit the tree structure shown in Fig 2.

Fig. 2. Structure of the expansion file.

From the folder names, we can conclude that, for example, the *audio* folder keeps the necessary audio material, *model* folder stores the 3D models of reconstructed objects, etc. Materials to be loaded into the application for a particular object are determined by tags in the XML file. An example of a well-configured XML file is shown in Fig 3.

```
<points>

  <point>
    <name>Rimska palata sa oktogonom</name>
    <latitude>43.328254</latitude>
    <longitude>21.892910</longitude>
    <radius>20</radius>
    <file>palata.mp3</file>
    <img>palata.jpg</img>
    <video>null</video>
    <model>null</model>
  </point>

  <point>
    <name>Istorijski arhiv</name>
    <latitude>43.326537</latitude>
    <longitude>21.894122</longitude>
    <radius>20</radius>
    <file>arhiv.mp3</file>
    <img>arhiv.jpg</img>
    <video>arhiv.mp4</video>
    <model>arhiv</model>
    <model_items>
        <item>arhiv.mtl</item>
        <item>arhiv.obj</item>
        <item>S1.jpg</item>
    </model_items>
  </point>

  <point>
    <name>Rimska ulica</name>
    <latitude>43.325124</latitude>
    <longitude>21.894835</longitude>
    <radius>20</radius>
    <file>ulica.mp3</file>
    <img>ulica.jpg</img>
    <video>null</video>
    <model>null</model>
  </point>

</points>
```

Fig. 3. A well-configured XML configuration file.

All important points in a site are placed within the <point> tag and they are all grouped within the root tag <points>. Every object contains the following tags: the <name> tag, which defines the name of object; <latitude> and <longitude> tags, which are used to define GPS coordinates of object; the

<radius> tag which represents radius around the object in meters, within which users can hear additional information about object. An audio file which will be played for an object is defined with the <file> tag. When a user is found within a defined radius of the object, he also has the possibility to see image of the object, video, or a 3D reconstruction of the object. This is all specified with the <img>, <video> and <model> tags, respectively. If there is a 3D reconstruction of a given object, it is necessary to export the model and its textures from the expansion file. After that, it is possible to successfully load it into the application. Files which need to be exported are defined using the <item> tags. All <item> tags are grouped within the <model_items> tag. For adding new points, its necessary to add the <point> tag, which contains all of the mentioned tags.

III. The User Interface and Implementation

The welcome screen of the application is shown in Fig 4a. In the top of the screen, a user can see the distance to the closest object, radius around, and the current accuracy of the GPS signals received from satellites. All distances are shown in meters, and calculations are based on the user's current GPS coordinates and the coordinates of the closest object in the archeological park.

In the case when GPS signal is not available or it is lost, user's last known location is used for calculations. This last known location is provided by a function called *getLastKnownLocation* [9]. Current GPS position of the user, which includes latitude and longitude coordinates, is stored in the device local memory using two double-precision floating point variables, one for each coordinate. Therefore, memory requirements for storing GPS data are measured in bytes, while the typical available device memory is in GBs.

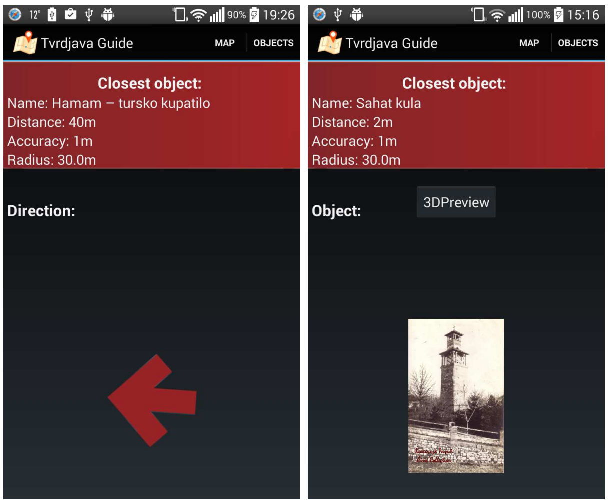

Fig. 4. a) Welcome screen of the application. b) The application screen shown when a user is within the object radius.

Besides these information, there is a compass in form of arrow in the bottom of the screen. Its purpose is to provide users easier positioning within the archaeological park. When a user walks through the park, this arrow is rotated so that its head shows the direction to the closest point.

The method of calculating the rotation angle is shown in Fig 5. In this figure, P1 is the current user location, P2 is the closest location of an object in the archeological park, α is an angle between P1 and P2 in relation to the North Pole, β is an angle of the phone, also in relation to the North Pole, and, finally, γ (γ = α - β) is an angle for which it is necessary to rotate the arrow so that its head shows the direction of the closest point.

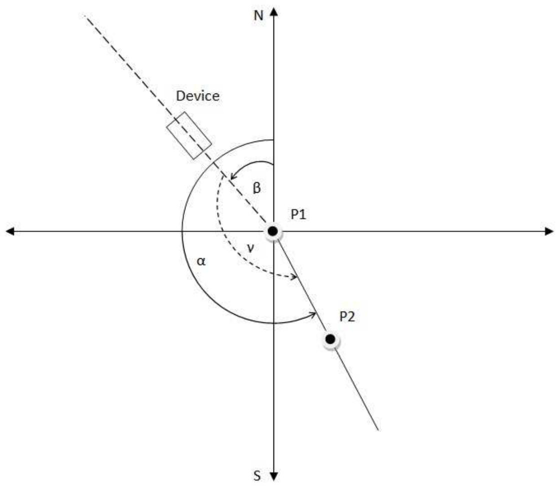

Fig. 5. Method for calculating the rotation angle.

When the user enters within the radius determined for an object, the application starts the corresponding audio file which is pre-defined in the XML file. This audio file can contain ambient sounds characteristic for an object, or additional information about it. Further, instead of an arrow, the application shows an image of the object. The main function of the image is to show to the user the reconstruction of object, if it is not preserved in its entirety, or to show an image of a mosaic, if it is, for protection, covered with sand. The previously described screen is shown in Fig 4b.

When a user is within the radius of an object, he can view a video clip about the object or a 3D model of its reconstruction. These two features are optional, and if they exist, buttons *3DPreview* and *Video*, respectively, are shown to the user.

By choosing the option *3DPreview*, the screen an example of which is shown in Fig. 7a is presented to the user. This application module is realized using *Metaio Mobile SDK*. *Metaio* is a tool which is primarily intended for developing of augmented reality applications for *Android* and *iOS* mobile devices, but it can be used for the implementation of this module [10].

With simple finger gestures, a user can rotate the model and thus view it from all sides. Zoom options are also implemented. In the top right corner, there is a model which represents *x*, *y*, and *z* axis, in order to provide users easier interaction with an object.

Selecting the *Video* option shows the user a form with a full-screen video about the object. A frame from an example video is shown in Fig 8.

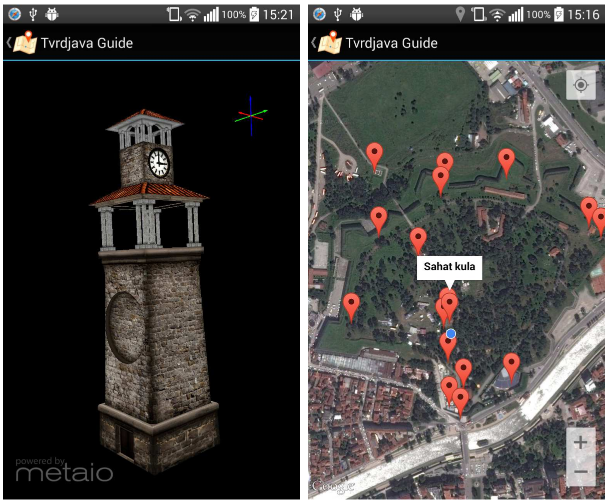

Fig. 6. a) 3D reconstruction of an object. b) Map of an archeological park.

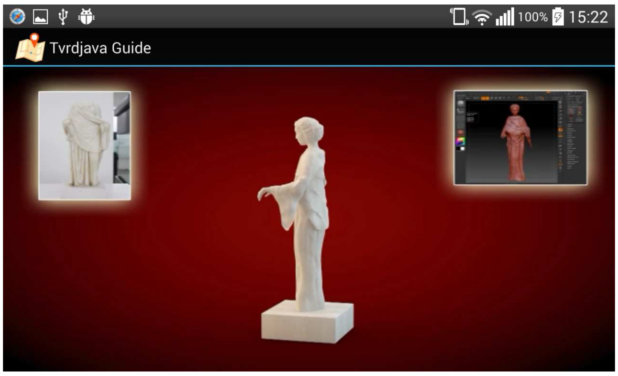

Fig. 7. Frame from a video content about an object.

On the top of the screen within the *Action* bar, there are two more options [11]. The first option is *Map*, which provides an overview of the entire archeological park and objects of interest. Objects are marked on the map as pins, and a pin which is the closest to the user is animated in order to be located easily. This form is realized using *Google Maps*. For our application, we used the *Google Maps API version 2* [12]. An example of using this functionality of the application is shown in Fig 7b. Another option within the *Action* bar shows a list of all objects of interest within the park.

All of the previously described application layouts are designed as responsive, which means that they are not dependent on neither screen resolution nor size.

IV. Conclusions

The application presented in this paper - *A universal tourist guide based on the GPS technology* - is implemented as an Android application for mobile devices. The application provides easier navigation through archeological sites using the GPS, accelerometer, and compass, which are available on almost all current mobile devices. Further, it provides textual information and audio and video contents about objects on the site. The presented application can be applied to any location without the need for additional programming, since its content is completely decoupled from its implementation.

Plans for future work include the implementation of an augmented reality module. The main functionality of this module will be to show the real-world environment augmented by 3D models of reconstructed objects in a common screen.

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