Usage of Geospatial Augmented Reality for the Representation of National Heritage

Dušan Tatić[1][0000-0002-9228-6020], Radomir Stanković[1], Maxim Goynov[2][0009-0007-2244-4314]

[1] Mathematical Institute of the Serbian Academy of Sciences and Arts,
Kneza Mihaila 36, Belgrade, Serbia
[2] Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
8, G. Bonchev Str., Sofia, Bulgaria
dule_tatic@yahoo.com, radomir.stankovic@gmail.com,
goynov@gmail.com

Abstract. The technology of augmented reality can significantly improve the presentation of national heritage. This technology provides quick and more intuitive information search about heritage site landmarks compared to classical technologies that use keywords or scrolling lists. In this paper, we present a mobile application based on geospatial augmented reality technology to present outdoor heritage sites. We provide a detailed description dedicated to the hybrid type of AR tracking that uses ARCore Geospatial API. Also, we present the system's architecture and illustrate its application on the examples of monuments in the city of Niš.

Keywords: Augmented Reality, National Heritage, Mobile Application, ARCore Geospatial API.

1 Introduction

The digitalization of national heritage has multiple benefits in its preservation, protection, presentation, and research that can be applied to the fields of culture, tourism, and education. Therefore, institutions like museums, tourist organizations, and archaeological sites tend to realize the process of digitalization and make digitalized content available to the public. Also, contemporary visitors to heritage sites expect to be quickly informed using information technologies. This can be achieved using interactive solutions implemented directly on site or inform visitors using internet technologies in the form of websites or mobile applications.

The classical solutions require users to search and find the information of their interests using keywords or list of predefined items. Sometimes, searching in this way can take some amount of visitor time when they try to find information about the objects at heritage sites. Moreover, disappointment can be caused when visitors do not find information after searching as the information is unavailable in the database. Also, the visitor can interpret wrong information due to insufficient knowledge of the materials or the similarity of the objects. Therefore, the limitation of searching can be overcome using augmented reality (AR).

Augmented reality technology can be used as a fast information provider directly at heritage sites. By pointing the camera toward a landmark at a heritage site of interest, a visitor can see interactive virtual overlays on the display of a mobile device. These overlays are used to inform the visitor that information is available in the database and, by interaction, explore content dedicated to the object of interest.

In this work, we use augmented reality with ARCore Geospatial API (Google, 2025) to provide information intuitively and quickly on the heritage site and in real-time. First, we review the AR technologies in section two, and in section three, we describe geospatial tracking principles. Section four is dedicated to the architecture of the system and the given use case, after which we provide concluding remarks.

2 AR Tracking

Augmented reality technology is used to provide information about the heritage objects and inform visitors at the location in real-time (Tatić, 2022; Kratchanov and Minev, 2024). The heritage application has been discussed in various fields of research (Boboc et al., 2022). Research in this area is done on creating and testing various hardware solutions such as mobile devices (Paneva-Marinova et al., 2023), smart glasses (Dima, 2022), and using projectors (Cisternino et al., 2021) or other multimedia devices (Lee et al., 2019) for the realisation of augmented reality projects. Realised applications use various AR tracking technologies to recognise heritage sites and provide virtual content. These technologies are image tracking, 3D tracking, and location-based.

Image tracking solutions can be used to recognize flat surfaces like plates, images, paintings, large billboards, and in some cases, structures like facades of buildings (Tatić and Stanković, 2024; Banterle et al., 2015). This kind of solution is very precise and works well as an indoor solution. This technology works best under constant light conditions, such as in indoor environments. Sometimes, using this technology requires the effort of printing and covering heritage sites with this material to achieve the AR effect. Lack of this technology is when it is used outdoors due to variable lighting conditions, when markers are exposed directly to sunlight, tracking may be difficult.

Tracking of the 3D models, spatial maps, or 3D point clouds is the solution when detailed information about some heritage object or area has to be precisely aligned (O'dwyer et al., 2021). This is very precise technology that requires 3D scanning and model generation of this object to create feature points for tracking in 3D. The disadvantage of this solution is that it is a time-consuming 3D scanning process with expensive equipment. The situation becomes more complex when it is necessary to prepare several objects for recognition, especially in an outdoor location. To overcome this limitation in outdoor space, augmented reality based on GPS can be used.

Location-based tracking is based on positioning virtual elements based on GPS coordinates (Kleftodimos et al., 2023). This solution is good for outdoor tracking when precision is not so important. The limitation of this solution is that when the GPS signal is low or unavailable, the virtual content dedicated to the heritage site cannot be aligned or visualized properly.

In this work, we try to overcome outdoor problems using a hybrid augmented reality tracking type. We realised a mobile application based on geospatial tracking to show information on heritage sites with higher precision and without generating additional data that will be used for tracking.

3 Principles of Geospatial Augmented Reality

This paper discusses a special tracking type for the augmentation of heritage sites. The augmented reality effect was achieved based on geospatial tracking. Unlike other types of augmented reality tracking solutions, this type of tracking does not need additional markers for recognition. This is a hybrid type of location-based tracking that combines Global Positioning System (GPS), Visual Positioning System (VPS), and data from mobile device sensors. Therefore, high accuracy is achieved in an outdoor environment, allowing virtual content to be anchored in real-world locations based on geospatial coordinates.

GPS uses triangulation methods to create location-based experiences for mobile devices. This is based on the triangulation of signals from at least three satellites. When signals from the satellites are weak or not available, ground network base stations are used to receive data that can determine the geographical position of the mobile device. The better coverage of the signal, the better precision is achieved. Loss of the signal can lead to imprecision, which can influence augmented reality experiences that require stability during tracking.

Therefore, VPS is integrated to overcome the situation of imprecision caused by the limited accuracy of GPS. VPS is based on computer vision algorithms that recognize the parts of the environment. Recognition is established on the matching visual features of the visitors' environment with the images stored in the cloud databases, such as those available in Google Street View. In this way, the VPS approach ensures improved precision in determining the location of a visitor's device in combination with GPS location. This hybrid approach allows AR content to become precisely aligned with real-world locations.

3.1 ARCore Geospatial API

The ARCore Geospatial API is a Google platform tool for developing immersive geospatial augmented reality experiences. It determines the precise location of a visitor's device and enables attaching the anchored virtual content to a specific location in an outdoor space based on GPS and Google's VPS.

Device sensors and GPS data are used to detect the visitor's device location. Then, Google's VPS is used to determine a more precise location of the device by comparing the data captured by the camera with features of the Google Street View images.

Street View images from Google Maps are used to create feature points, creating a 3D model point cloud of the global environment as a VPS localisation model. Neural networks use this localisation model to match feature points captured by the mobile device camera. Then, computer vision algorithms calculate the position and orientation of the device. The position of the device is used to anchor digital content in the real world. In this way, tracking precision is enhanced and gives stability to the virtual overlay than just using GPS.

The Geospatial API can be used at any outdoor place where the location of the device can be determined. The precision of this type of tracking depends on VPS coverage. When outdoor conditions are regular, the GPS signal is satisfactory, and VPS coverage is available, the precision is around 1 meter. Also, in some cases, VPS is enough to do augmentation, when GPS has obstructions and low accuracy, it is better than 5 meters.

4 Implementation

In this work, we introduce an AR system based on a geospatial augmented reality as a mobile application that uniquely integrates real-time virtual content directly at the heritage site. The aim is to develop an outdoor augmented reality experience for heritage sites with the integration of ARCore Geospatial API. This type of augmented reality is used to determine precise mobile device location and orientation at heritage sites and dynamically overlay historical and cultural information.

4.1 System Architecture

The system is designed for mobile devices such as smartphones or tablets. Unity, as a cross-platform tool, is used to realize and deliver applications on various platforms, such as Android and iOS. Also, this tool is one of the best for creating interactive AR and VR experiences.

For the integration of augmented reality, we used the AR Foundation framework. This framework enables the development of augmented reality experiences and has embedded various extensions. In our system, we used the ARCore extensions package that has various embedded features. The ARCore Geospatial API is the feature we used for the development of this AR system.

The system architecture consists of three modules Geolocation, AR Geospatial module, and Info module (Fig. 1).

The Geolocation module is developed to receive content from the database about landmarks that should be anchored in the visitor's surroundings. The data in the database consists of the location for anchoring landmarks of the heritage site and a link to the virtual content for visualisation. This module searches the database for content that should be visualized based on the current GPS location of the visitor's mobile device. Then, this data is sent to the AR Geospatial module for visualisation.

The AR Geospatial module is used to precisely and in real time anchor virtual content using the ARCore Geospatial API. When data are determined by the Geolocation module, this module dynamically creates geospatial anchored content at given locations. When the device is pointed toward the anchored positons, the ARCore Geospatial API using VPS and GPS visualises virtual content to the dedicated location. This virtual content is interactive and, by interaction, provides a link to detailed information about a given heritage site. This information is visualised in the Info module.

The info module is developed to visualise information about points of interest. This information can be shown in various formats such as text, image, video, or 3D module.

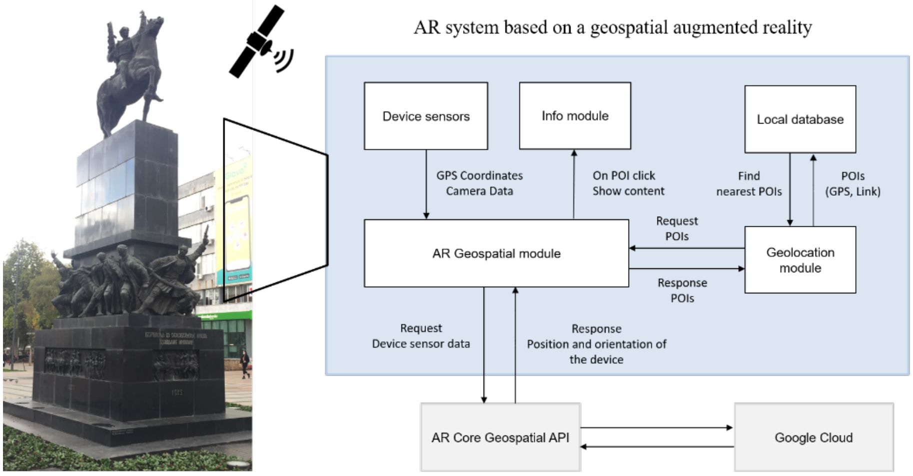

Fig. 1. Architecture of the system.

4.2 Use Case

When the visitor is on a heritage site, the Geolocation application module, based on mobile device location, loads data about nearby monuments from the database. Data consists of the GPS coordinates for anchoring virtual POIs near the monument and links to multimedia information about this place. The AR geospatial module shows virtual POIs on the display of the mobile device and overlays monuments with relevant virtual points of interest (Fig. 2).

Fig. 2. AR virtual overlays over the monuments.

Fig. 3 illustrates an example of a mobile application using geospatial augmented reality technology. The given examples are realized for the monuments located in the city centre of Niš, Serbia. Based on augmented reality technology, each monument is anchored with a virtual button.

Fig. 3. Monuments overlaid with the AR info button.

Interaction with this virtual button in the Geospatial AR module directs visitors to multimedia information. Detailed information about monuments is shown in the Info module. Fig. 4 shows detailed information upon interaction for these monuments.

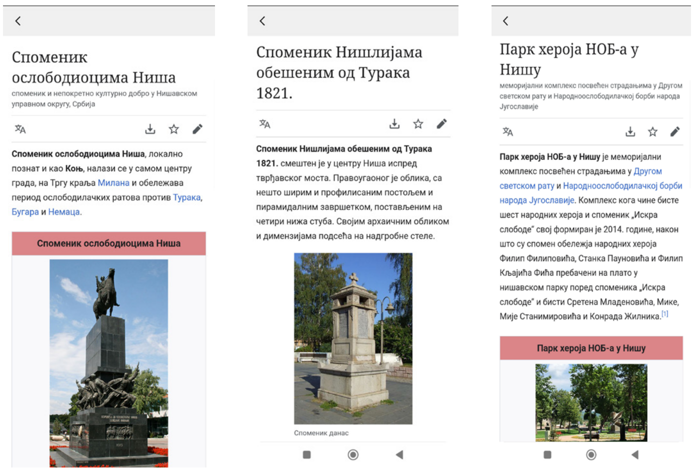

Fig. 4. Information after interaction with the AR info button linked to Wikipedia.

5 Conclusions

Augmented reality technology can help in the presentation of national heritage. This technology can improve searching the content of the heritage site as a provider of interactive overlays in visitors' surroundings.

In this paper, we used geospatial tracking for an outdoor augmented reality application for presentation at national heritage sites. This augmented reality solution is based on a hybrid type of tracking that combines GPS location and VPS. An important advantage of the proposed application is that no installation of the specific object for recognition is required. This is especially important in cases when such installations on the site are impossible or inadequate for certain reasons.

Based on this technology, we created and described the system and its architecture. Also, we provided the use of the realised system for landmarks situated in the city of Niš.

This system provides instant information, compared to classical technologies, instead of using keywords or scrolling content to search websites or mobile applications. The realized system has an enhanced and compelling visual display. Also, the system offers a personalized exploration experience while enabling choice of visit, time of the visit, and duration of visitation tour. Therefore, the visitor using the system switches from being passive to an active participant.

Acknowledgements.

This research work was carried out and is supported by the joint research project “Development of Software Tools and Multimedia Technologies for Digital Presentation, Preservation and Management of Cultural Heritage” between the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences and the Mathematical Institute of the Serbian Academy of Sciences and Arts (2023-2025). This work was also supported by the Serbian Ministry of Science, Technological Development and Innovation through the Mathematical Institute of the Serbian Academy of Sciences and Arts.

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Received: March 25, 2025
Reviewed: May 05, 2025
Finally Accepted: May 15, 2025