Development of the software application for the building information models in augmented reality mode visualization

A Konyagin, L Shilova *
Moscow State University of Civil Engineering, 129337, 26, Yaroslavskoye Highway, Moscow, 1293337, Russia

E-mail: ShilovaLA@mgsu.ru

Abstract. The paper presents the developing an augmented reality application procedure using the building information models. The augmented reality applications current state is analyzed, the choice of operating system for the application implementation is justified. The application server and mobile parts are presented. The scheme of client interaction with the server at the framework level is described. The proposed application is focused on the end user performing the repair of engineering networks.

Introduction
Currently, the approach to organizing the construction process has changed dramatically, primarily due to the modern technologies, the ever-increasing computing power of computers, and the software development. Thus, mobile devices, which computing power, the abundance of specialized sensors and the development of mobile operating systems, allow to effectively manage the construction object entire life cycle, from the planning stage to its decommissioning. The aim of the presented research work is to develop a mobile application for visualizing building information models using augmented reality on a smartphone running Android OS to reduce the time needed to repair engineering networks of buildings. At the same time, such promising technologies as visualization or, in other words, augmented reality, are actively developing.

To achieve this goal, it is necessary to analyze the existing problems of the introduction and application of augmented reality technology in construction tasks and in the operation of building structures; to identify the features of software development to ensure convenience and functionality during working with augmented reality; to design the architecture and develop a mobile application.

Today, great attention is paid to the issues of information modeling of construction objects, a number of works are devoted to the study of the features of the introduction of information modeling technologies [1-12], as well as the problems of the development of augmented reality technologies in construction [14-22].

The augmented reality (AR) technology allows to provide the contextual information to the end user by superimposing it in the multilayered visual images form on real-world objects in real time. Thus, the considered technology main task is reduced to expanding the information interaction of the user with the environment.
From the interaction with the consumer point of view, there are currently two classes of mobile applications using AR technology. These are the standalone applications that do not involve user interaction and are used to provide reference information about the object. Interactive application is built on the interaction with the user, which can customize the type of an additional layer of data and obtain various data on the object under consideration.

According to the mobility degree, there are stationary systems designed to work in one place (without moving) and mobile able to work in a dynamic mode with different objects of the surrounding real world.

At the same time, according to the realized functional value for the consumer, the augmented reality applications can be divided into the following classes:

Applications providing a visual search and suggest navigation prompts at the user’s request. Context information about an object or person in the field of view can be obtained using the applications that provide recognition [23-24].

Human 2.0 is an augmented reality application for providing step-by-step instructions for accomplishing a specific task.

Applications such as “screen-mirror / lens” suggest the virtual objects imposition on the real world’s environment image for the virtual object spatial characteristics’ better understanding [23-24].

Applications such as product visualization for contextual tasks are usually used in industrial enterprises to solve engineering or design problems [23-24].

Thus, the development of such applications can identify the following problems:

1. If an application depends on location, it needs to be able to determine the user’s location, consider the errors, because augmented reality enriches the real environment and is in close interaction with it, so we need to give accurate information. Also, a very important factor is the user positioning, where the camera focus is directed, because according to the augmented reality definition, it must be able to interact with the three-dimensional space, again, in order to show the reliable information [24].

2. If the application is context sensitive, then the augmented reality should be closely related to the real environment. In this case, the following problems arise: reliability, relevance, redundancy of the context provided.

3. If the applications use the recognition technologies, a wide range of problems arise with the ability to recognize the numbers, letters, images, as well as each element of the environment.

4. The applications require various resources in the form of mapped model files, label data. That fact makes them inflexible and before each application use it is required to conduct preparatory activities in the form of preparation and loading of these resources into the device’s memory.

Methods and Methodology
The operating system choice
During the software application development, the question of choosing an operating system arises. To achieve the goal set in the research work, preference is given to the operating system – Android according to the static data of using this OS (Table 1) [25].

Thus, in case we select the minimum API level of 19, the application will work on any of the Android devices. In addition, there are several platforms for the implementation of augmented reality AR applications on the Android operating system.

The different platforms comparison is presented in Table 2. This information allows to select the most appropriate one.

The architectural pattern
An architectural pattern is a common, reusable solution for common problems in software architecture. Architectural patterns are similar to software design patterns, but have a wider coverage.
After analyzing such indicators as functionality, cost and quality of documentation, we can conclude that AR-Core is the most suitable SDK for developing an application using augmented reality. In one year, AR-Core from Google turned from a beta version, which worked only on a pair of flagship smartphones into a completely stable version, which already supports more than 30 models of devices, among which low-end models are starting to appear.

Now, the best choice in terms of the devices functional-number is API 19, which covers more than 96% of all devices, but if we work with augmented reality, it is more expedient to use an API of at least 27, in which case the range of all smartphones which computing power is covered enough for AR-Core to work.

**Table 1. The usage statistics for Android different versions**

| Version of Android | Code name       | Year       | API | Distribution |
|--------------------|-----------------|------------|-----|--------------|
| 2.3.2-2.3.7        | Gingerbread     | 2010       | 10  | 0.2%         |
| 4.0.3-4.0.4        | Ice Cream Sandwich | 2011       | 15  | 0.3%         |
| 4.1.x              | Jelly Bean      | 2012-2013  | 16  | 1.1%         |
| 4.2.x              |                 |            | 17  | 1.5%         |
| 4.3                |                 |            | 18  | 0.4%         |
| 4.4                | KitKat          | 2013       | 19  | 7.6%         |
| 5.0                | Lollipop        | 2014-2015  | 21  | 3.5%         |
| 5.1                |                 |            | 22  | 14.4%        |
| 6.0                | Marshmallow     | 2015       | 23  | 21.3%        |
| 7.0                | Nougat          | 2016       | 24  | 18.1%        |
| 7.1                |                 |            | 25  | 10.1%        |
| 8.0                | Oreo            | 2017       | 26  | 14.0%        |
| 8.1                |                 |            | 27  | 7.5%         |
| 9.0                | Pie             | 2018       | 28  | 10.4%        |
| 10.0               | Q               | 2019       | 29  | -            |

**Table 2. The characteristics of platforms for AR implementation**

| Parameter                        | Wikitude | ARCore | Vuforia | MapST | Kudan | EasyAR | ARToolKit | Xing | NyARToolKit |
|----------------------------------|----------|--------|---------|-------|-------|--------|-----------|------|-------------|
| Maximum Recognition distance (m) | 2.4 / 5  | 1.0 / 3| 1.2 / 3 | 0.5 / 0.9 | 0.7 / 5 | 0.9 / 2.7 | 3 / 3 | 0.5 / 1 | 3 / 3 |
| Recognition of a fixed marker   | 6        | 9      | 10      | 7     | 8     | 7      | 8         | 4    | 8           |
| Moving marker recognition       | 6        | 6      | 6       | 6     | 7     | 3      | 6         | 3    | 6           |
| Minimum Recognition angle (Deg.)| 10       | 50     | 30      | 30    | 35    | 35     | 10        | 45   | 10          |
| Minimum marker visibility for successful recognition | 100% | 75% | 20% | 50% | 10% | 10% | 100% | 25% | 100% |
| 2D Recognition                  | ✓        | ✓      | ✓       | ✓     | ✓     | ✓      | ✓         | ✓    | ✓           |
| 3D Recognition                  | ✓        | ✓      | ✓       | ✓     | ✓     | ✓      | ✓         | ✓    | ✓           |
| Geolocation                     | ✓        | ✓      | -       | -     | -     | -      | -         | -    | -           |
| Cloud recognition               | ✓        | ✓      | -       | -     | -     | -      | -         | -    | -           |
| SLAM                             | ✓        | ✓      | ✓       | ✓     | ✓     | ✓      | ✓         | -    | -           |

**Results**

Designing and developing a client-server mobile application for visualizing a building object in augmented reality mode includes designing a client-server mobile application, the architecture of which is shown in Fig. 1 and server and mobile parts.
Figure 1. The framework for client-server interaction at the framework level

Figure 2 shows the interaction scheme between the client and the server.

The structure of the project using the MVC design pattern (server part) is shown in Fig. 3a, in Fig. 3b the mobile part is presented. MvcConfig is the class that contains the settings for the Spring Controller MVC. WebSecurityConfig is the class that contains Spring security settings. DownloadController is the class that handles GET model requests via REST. MainController is a class that processes the main pages of a web application.
Figure 3. The structure of the project

Summary
The algorithm of the developed application is considered. The application installed on a mobile device: Scan a QR code; get model ID from it; the applications contact the server and request a model with this ID; a model is received; a model in augmented reality with reference to the location of the QR code is displayed.

The developed application can be used in architectural and construction design of various enterprises. So, for example, by unloading information about engineering networks from any CAD product, during the repair period it is possible to accurately determine their location.

In addition, by completely unloading building information model, it is possible to make a presentation (visualization) of a construction object for the consumers.

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