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Analysis and Design of IS for Interactive Mobile and Web Application with Geographic Data and Elements of Augmented Reality

Monika Borkovcová and Jiří Chludil

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Abstract :

The aim of this article is to acquaint readers with the process of analysis and design of an information system that will serve as a provider of necessary data for mobile and web applications working not only with geographic data. Furthermore, for mobile app with augmented reality and last but not least virtual reality. In order to run future applications efficiently, it is necessary to use access to a single central repository in the future cooperating with spatial data and to store 2D objects and 3D building models. The analysis focuses on the development of a web portal and at the same time extensive applications for mobile devices acting as a historical guide to selected cities. The user "at home at the computer" will use the web portal, the user of the mobile application will use it using GPS directly in individual cities. The content will be basically the same, except for the mobile application it will be graphically simplified for easier display ability on weaker HW and due to lower data volume. Next part is development in augmented and virtual reality in 3D environment. The content of the application will include 3D historical reconstruction of selected objects. The user can change the current view of the selected object using 3D glasses or in the case of augmented reality by moving the slider on the display of the mobile device.

Analysis and design of IS for interactive mobile and web application with geographic data and elements of augmented reality

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Abstract

The aim of this article is to acquaint readers with the process of analysis and design of an information system that will serve as a provider of necessary data for mobile and web applications working not only with geographic data. Furthermore, for mobile app with augmented reality and last but not least virtual reality. In order to run future applications efficiently, it is necessary to use access to a single central repository in the future cooperating with spatial data and to store 2D objects and 3D building models. The analysis focuses on the development of a web portal and at the same time extensive applications for mobile devices acting as a historical guide to selected cities. The user "at home at the computer" will use the web portal, the user of the mobile application will use it using GPS directly in individual cities. The content will be basically the same, except for the mobile application it will be graphically simplified for easier display ability on weaker HW and due to lower data volume. Next part is development in augmented and virtual reality in 3D environment. The content of the application will include 3D historical reconstruction of selected objects. The user can change the current view of the selected object using 3D glasses or in the case of augmented reality by moving the slider on the display of the mobile device.

Keywords: analysis information system, GIS data, virtual and augmented

Introduction

The planned applications are virtual historical guides that allow potential visitors to look into the past of selected cities. In addition, the user will be able to view all the information from several different years' perspective, as long as this data is available on the POI. Thanks to the portability of mobile phones, there will be no need to install any special signs and signs in these cities, which will primarily save the cost of any construction work that could be associated with the creation of these educational trails. Another common goal of both applications will be the user's view of cities 150, 300, 600 years ago, all in 360 ° cyberspace around where the user or point of interest will be located. For the available data, the user will be able to choose the year for which they are interested. If this data is available, the application will display it or play it. These resources will be customized to provide the user with as much information as possible about the history of the selected location within the mobile app. Virtual city tours, depending on the type of application, either physically at the point of interest or using other applications from anywhere, include various multimedia content. The applications also work with 3D models of historical objects from different periods, these 3D models will mostly be implemented in the augmented reality mobile application working with GIS or virtual reality. The mobile and web-based history guide displays various 2D multimedia features as well as transformed 3D models in 2D.

Analysis of interactive mobile and web guide using GIS data

The interactive mobile guide will focus only on the Android operating system. Due to the release period of the application is expected to be Android version 8.0 Oreo and later. The necessary minimum hardware requirements for the device will be a GPS module, LTE Internet connection, 2 GB RAM and storage size depending on the size and type of the transformed 3D models delivered into 2D models. The application will allow a "virtual tour" of the processed sites. The user will see a map showing the places and buildings to which information will be stored. These can consist of texts, images, videos, and transformed 3D models for the location. The transformed 3D models will be provided to the user for a detailed view (Vojtiskova, 2016).
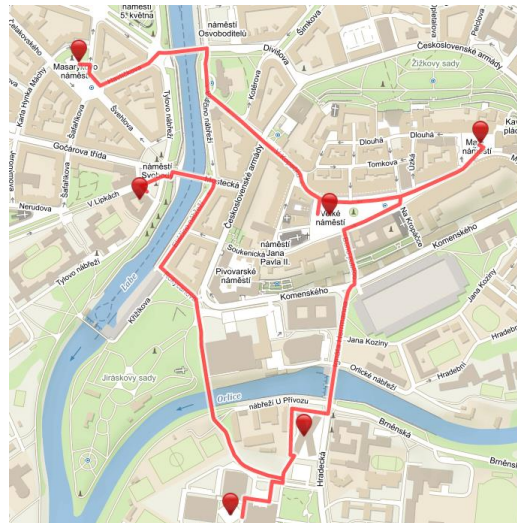
Fig 1. Preview of map with route

After starting the application, the user will be offered a menu of processed locations and switch to the map where he or she is currently located. When you select a location, the map of the selected location is loaded. The interactive map will contain points indicating the processed locations. Clicking on that point will have different responses depending on the type of information it contains. When you save text and image information about a location, an info balloon with the description and image gallery will be displayed.

For a video, the video will play in full screen. It will be possible to carry a combination of this data, then it will be displayed in text with a link to the video, which will be clicked again by a full screen overlay. Therefore, the video will be a custom module that will be triggered by the user click through. The last type of data displayed to the user will be transformed 3D models. For the transformed 3D model, a custom module within the application will be created again, allowing the user to freely view the model by rotating and zooming over its own object. On the interactive map, the user will also be able to view through the "street view". This view will be enabled mainly if it is a "virtual tour" and the user will not be physically present at the location, in order not to deny the possibility of comparison.
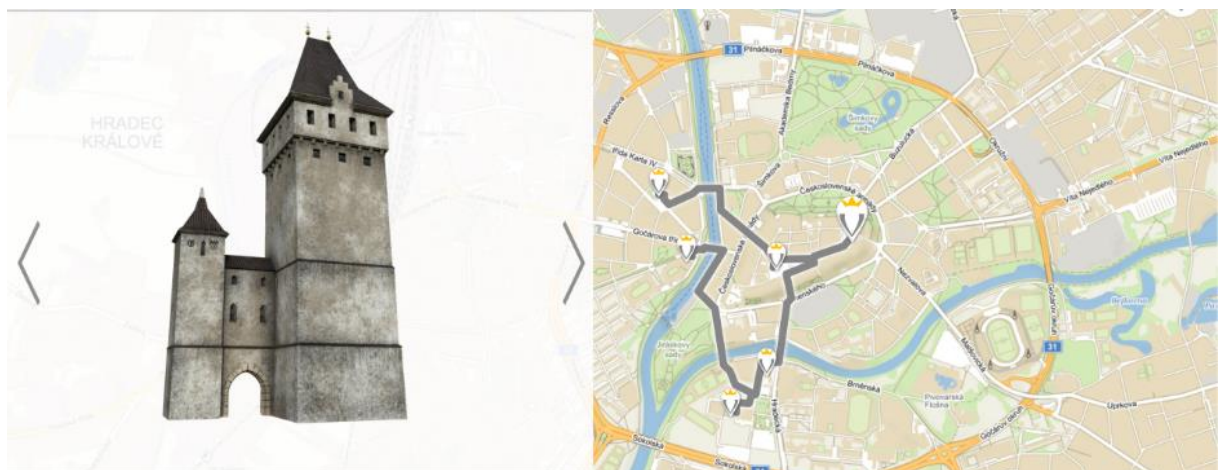

Fig 2. Display transformed 3D model

The main menu will also be available when selecting a location to load a page describing the historical meaning of the place. When the application starts, a request is made to the server for a list of processed

places. The application will be able to dynamically respond to the amount of processed data and print it to the user without the need to interfere with the application. In the same way it will be possible to add information to the interactive map. Depending on the difficulty of data transmission and time delay, any preloading of data according to the estimation of the virtual tour direction or the real direction of user movement will be solved.

Depending on the effectiveness of communication between the web application and the mobile application, cooperation will be possible. The mobile application could then be able to use portions of the web application to, for example, simplify text formatting in paragraphs interlaced with images and other source data. (Olyazadeh, 2017)

The web application will offer the user the same options as a mobile app, as well as a system for getting more detailed information that would be a problem to display in mobile app. This extension will consist of creating a regular information website with its own content management system where interested cities can share their other historical documents, articles and other information. The web portal will be optimized for all the most widely used web browsers.

For the server part of the portal will be provided server with installed application software - MariaDB in any version and for communication with the database of 2D and 3D objects will be used Oracle Database 12c Release 2, PHP at least 7.1 or later and CURL for PHP. An optional component for the installation will be an FTP server, but its need and functionality should be replaced by web portal administration. The entire portal will be built on the Symfony PHP framework, which is currently one of the most widely used frameworks available. (Kulawiak, 2017)
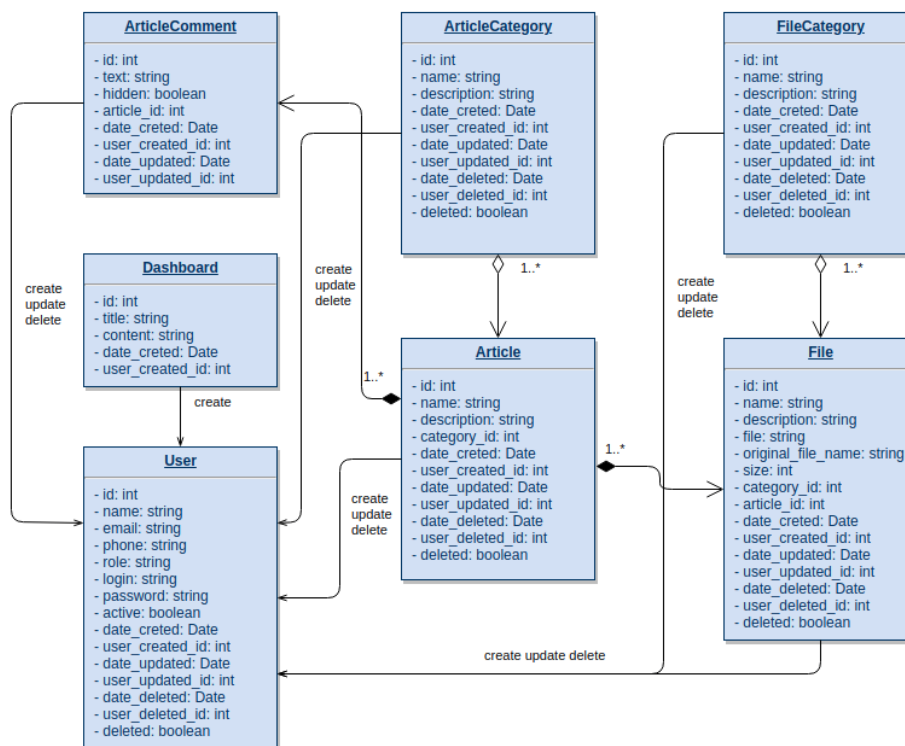

Fig 3. Simplified class diagram

The simplified class diagram represents all the entities in use in the system. For simplicity, multiple links between some objects have been linked. These are mainly associations between objects with the User class. These associations typically represent 3 parallel relationships, namely:

- User->Object:UserCreatedId,
- User->Object:UserUpdatedId,
- User->Object:UserDeletedId.

These associations may or may not always exist at the same time. These classes are mapped to the physical database model using object-relational mapping (ORM). This model directly corresponds to this simplified class diagram.

Another special requirement is the appropriate connectivity that can adequately cover the requirements coming from a larger number of devices. Since it will be necessary to send relatively large amount of information from the repository of graphic objects, it would be advisable to provide at least an asymmetric line with prioritized upload over download and also with a larger bandwidth for sending data than for receiving. The projected capacity can be hundreds of megabits per second after the project has been started. Access to the portal will only be enabled using secure encrypted HTTPS technology with an SSL certificate, this access can cause a slight slowdown of the web application but will make it almost impossible to eavesdrop to the data traffic of the users of the application.

Within the administration part, the content management system will be implemented with complete administration, roles and editing of all available content. The administrator will be able to add all content through the administration section, i.e. create new static pages, manage article categories, create articles, populate the map with data and objects, manage user accounts, upload historical documents, and manage those documents. The administration part will also offer an API that will be used to connect the mobile application. The API will provide all the necessary information for the mobile application. This will mainly be the detail of the planned path at the user's location; information about the POI along the path, available pictorial or textual information about the POIs. This communication API will be secured using the API keys that applications will have to use when querying this API. This API will be created using the hybrid JSON / Rest API.

System analysis using GIS data for virtual and augmented reality

The database server stores all information about the 3D models used in the project. There are stored metadata describing the 3D object (location, age, author of the model, dimensions, etc.) as well as the model itself including textures and their mapping. In terms of data, it is a combination of text-based data and binary data. Based on performance tests and functional requirements, the use of a hybrid structure seems to be the most suitable solution. A relational database will be used to store model meta information, and a key-value database will be used to store 3D object models. (Herrera, 2019)

Formats for preserving 3D objects

For augmented reality in the client application (mobile phone, web browser) it is necessary to preserve and distribute historical buildings in the form of 3D models including their textures. There are several advanced and practical formats for saving 3D objects. By analyzing them, we reduced the selection to three main ones, OBJ, FBX and DAE.

Format OBJ

OBJ is the basic format for preserving the geometry of a 3D model, the file with the OBJ extension only stores the geometry of the static model itself. Textures and their mappings should be saved in a separate MTL file. Nor can store animation scene composition, light, physical parameters. The text version of the OBJ format is open-source, while the binary form is not open.

Format FBX

FBX is a closed format managed by Autodesk and widely used in its software (Maya, 3DS Max, AutoCAD, etc.). This format allows you to preserve the geometry of the model including textures and their mapping, compose the entire scene including lights, cameras, and also an object animation. FBX supports both text and binary form data. It is widely used in game engines such as Unity3D and Unreal Engine, which are used in this project for the output applications. (Yeh, 2018)

Format Collada DAE

DAE is an open format for storing complete scenes, 3D models, animations and even the physical properties of objects. Data is described using XML markup language according to ISO/PAS 17506.

Export 3D objects to database

Automated editing of 3D objects
To increase the credibility of the AR model, it is necessary to adapt the appearance of the 3D object to the actual real scene (weather effects, time of day, time of year). For this reason, the server part supports automatic texture editing (and eventually model geometry). It is assumed that the model will be created only once in the basic version (one set of textures) and the subsequent automated process using additional modules will create a model for use in different weather (rain, snow, sun, floods, etc.) and for different day and night hours. Modules are created for Blender and written in Python. The client application will request an appropriate set of textures depending on the surrounding conditions.

Model approval and scene editor
For professionals, a client will connect to a non-public server API. This client allows the model to be displayed, including textures, metadata editing, and even approval process. Also included is a scene editor supporting virtual reality (VR) or mixed reality (AR, using MS Hololens), where the expert realistically sees what the result will look like. (Cýrus, 2019) The surrounding space of the model is obtained using the GIS API. Another task of this client is to map a 3D object to its true geographical position.

Client applications

Regular users will be able to view the resulting approved models in a web application created using the Three.js library, or in the mixed or virtual reality using the A-Frame JavaScript framework. For Android, a native mixed-reality application is created in the AR-Core framework that can display one or more models embedded in a real-world camera scene. (Overbeck, 2018)

Viewing a model in a scene is more or less a trivial matter, but several difficult tasks have arisen during the preparation of the prototype of the application. This includes mainly determining the exact location of the user (preferably at tens of centimetres) and the exact direction of his view, so that the model can be rendered in the right place. In the current solution, the model is rendered directly into a 2D image from the cell phone camera, i.e. it overlaps the original image.(Hu, 2018)

It is therefore advisable to consider the possible limitation of the visibility of parts of the object so that it fits better into the scene. The possibilities of solving these problems are currently being intensively investigated with respect to the latest technologies (for example 3D scanner in mobile phones using ToF camera (Time of Flight)).

API

Rest-full AP is used for communication of client applications with data storage, which will be divided into several parts:
- *Private APIs* are used to insert and edit 3D models, approve them, and other operations requiring access by a limited number of people (experts).
- *Public APIs* provide access to finished and published models for casual users. It needs to be designed for a large number of users and fast response time.
- *Special APIs for support systems* are used to access GIS or other specialized applications.

Conclusion

The information system and proposed components can be used for similar projects that focus on 3D modeling, virtual and augmented reality, but also for web or mobile application projects that need access to individual graphic objects to be central. Creating new 3D models is done in standard modeling applications, where Blender and 3DS Max create special export plug-ins for the project, which allow direct export and saving to the database on the server. The export module connects to the database server using the REST API and supports user authentication. Each exported model is fully versioned and subject to expert approval before it becomes available to end users. The approval process will be solved using a web or native application. The model geometry, texture and mapping are exported to

the database. Currently, the best choice for use in virtual and augmented reality appears to be the FBX format, which has support for both 3D models used and augmented reality systems for Android with ARCore support. In addition to the listed options, additional functionalities will be required during the project to achieve a satisfactory result. Some of the functionalities may not be known now, as the project is currently in the research phase. These research activities may result in additional requirements and functionalities that will be needed to complete the web portal and mobile application. The last development phase will be testing, partial testing will be performed continuously by means of Unit testing, in the application layers of individual applications a prerequisite of faultless functionality is necessary. These Unit Tests will be carried out using a testing framework, and scenarios for system and acceptance testing will be developed. These scenarios will then either be automated using test frameworks or guidelines for their complete manual execution, so that anyone can perform these test tasks.

Acknowledgment

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