APPLICATION OF THE LAYERED MODEL MANAGEMENT SYSTEM IN AN INTERACTIVE MAP OF THE UNIVERSITY CAMPUS

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Abstract. The paper presents a web application for navigation through the university campus, which is based on Global Positioning System GPS and OpenStreetMap. The application has a multilayer structure and multi-labelling support. The proposed solution ensures better management of visual data and more efficient image processing comparing to the other known methods. With the new search system, users can place a lot of information on one layer without losing the legibility of displayed data. All the information that was displayed on the map was grouped and assigned to the appropriate categories. Therefore a map contains a lot of related information that needs to be linked to each other. The system has been divided into modules that ensure the integrity of the displayed things. Presenting so much information at the same time is managed by modules. Their main job is to provide results that is then segregated and grouped. The system presented in this paper was applied for Lodz University of Technology.

Key words. Information visualization service, OpenStreetMap, Web service,

1 Introduction

Lodz University of Technology (TUL) is a well-established higher education institution with an extensive structure, over 18,500 students and nearly 3,000 employees. The process of education is conducted in nine faculties and three colleges in 42 different fields of study. The University campus occupies over 32 acres of downtown area with modern edifices and revitalized buildings surrounded by greenery. Factory villas and palaces next to glazed buildings, it distinguishes the Technical University of Lodz against other Polish universities. There are many organizational units on the campus. Besides the faculties and colleges, these are inter-faculty education, sports and leisure activities, entertainment and a variety of organizations supporting student life. A very large area and number of institutes make up a very complicated structure, especially that the campus is divided into a few parts called campuses A, B, C, etc. This is why the authors of this paper decided to develop a web mobile application that
would make it easier to navigate through the campuses. Its aim is to enable students, teachers and visitors to easily find departments and other places of interest on the all campuses of TUL. The idea may be to use GPS and OpenStreetMap as main sources of data. This ensures better management of visual data, more efficient image processing in comparison to the other known methods, and also legible image of the campus map on mobile devices.

2 Interactive maps

There are many examples of using OpenStreetMap or Google Maps [8], which provide a very useful Application Programming Interface (API) to manipulate map's content. Such an approach gives users the possibility to add content to their maps through various services and as a result allows them to prepare a mapping application. Only the purpose of the presented data is changed. In the work [12], the Open Street Map mechanism has been used to present data that directly relates to the university, the campus, the buildings in general and their locations.

There are many examples of areas in which maps are used including mapping cases of earthquakes [11]. In that case it becomes very important to provide timely information. Data after the crash must be updated. These pieces of information have very high resolution and you can read up on current information about the population of buildings, roads and even terrain. However it should be noted that the mechanism of the map engine itself has not been changed. As a result only the single (highest) layer was changed. This service works in most areas of China. Google provides detailed traffic information, high-resolution data (some cities have up to 0.61 m resolution). Important administrative data as well as topographic data is also included on the map. These data are available free of charge. During the cataclysm, such information is useful for people who want to help the victim.

Second example that also concerns safety but is captured in a different context is a case of interactive map that can be used to monitor the location of children [10]. Prior to imposing new data on the map, the authors of such projects must provide the current GPS position of the child to the system. The whole map is for parents who want to take care of children’s safety. One of the first such systems began to operate in the United States. Parents were provided with an administration panel in the form of mobile and desktop applications. Such a system aims to increase the sense of security and reduce crime rate against children.

Third example of using interactive maps is the placement of data that relate to tourists’ travel routes [3]. In Taiwan, tourists on a very large scale plan their own tours (almost 90% of all travelers). In 2015 the government has decided to prepare tourist services that will help users plan their itinerary. This is also a good example where the Google engine is used as the engine that supplies the map source. The tourist offices at the administration panel have to complete the data, including the length of the entire route, the travel time, the photos, the names of the places to visit and the most interesting places. The research has shown great success. A satisfaction of travelers has increased. Tourists were able to plan their holidays in a transparent manner. As can be noted in the enclosed examples, there are many applications that use interactive maps. The principle of operation is similar. All useful data for the end user is placed on the tile layer, which serves as the background for the user data.

3 Our Solution

All interactive applications presented in the previous section have two layers structure and do not have any support for multi-labeling which have significant impact on user experience. However they inspired the authors of this paper to develop a multilayer structure and new algorithms for more efficient visual data management. It’s worth
to notice that authors implemented search algorithm with multi-labeling support. As a result one place can be represented in multiple ways in example by its formal name, common name or the connections with other departments.

To facilitate the process of finding other information besides buildings, it is also possible to browse the events that take place at our university. As a result, an interactive map have been developed, which makes it possible to navigate around the university by quickly displaying shortest route to the destination place. The web application is available at this web address https://nav.p.lodz.pl. The most important features of the application are as follows:

- Very large base of university facilities. Buildings were depicted on 4 layers (stroke layer, entrance layer, layer of events and campus layer)

- Schedule of events (a panel that manages events at the university. In the current version it is a panel that allows add animated points on the map. )

- Information Panel (a panel that regularly downloads information from the websites, such as p.lodz.pl and zu.p.lodz.pl. Application can also promote other services operating at the university)

- Intelligent search engine (This is a field where the user can type any item related to the university.) The search engine is designed to look for words that have been included in the title as well as aliases, for example a student who has a timetable may use a building ID or a full name of the building.

- Find your current position (GPS). The HyperText Markup Language (HTML) Geolocation API is used to get the geographic position of a user. Such information will be useful for students who do not know the city, but also for users who want to easily find a route to a specific place at the university from their current location.

3.1 Model of the search system and displaying of layers

The Graphical User Interface of the application is shown in Fig. 1. The search panel was divided into 4 sections...
The first section is the switch between normal and satellite maps. Authors of the system used OpenStreetMap and also have found free tile vendors for this navigation system. The second part of the menu is the selection of the campus (A or B, or C, etc.), by default both A and B are selected. These campuses are represented as a group of buildings and each one has its own color. The third section is the selection of a specific faculty, Lodz University of Technology has 9 faculties. Such filtering helps to order elements on the map.

The last section provides information on a group of buildings called "the others". Here we find buildings such as; academic housing, administration, colleges or interfaculty buildings. The information that is placed on the map is stored in the NoSQL database collection where the engine is MongoDB. The database was launched on one host. The mechanism in this place is not distributed. This is a collection of coordinates, aliases, building information (for example address, building number, website address and additional notes. A layered model of the described system (see Fig. 2) was built by the use of the Leaflet framework.

The Leaflet is the leading open-source JavaScript library for mobile interactive maps that is designed with simplicity and increased performance. This framework can work efficiently across all major desktop and mobile platforms, it can also be extended with lots of plugins and it is easy to use and has readable source code [5]. Leaflet can supports Web Map Service (WMS) layers Vector layers, Tile layers and GeoJSON layers natively. Other types can be used via additional plugins [4]. The major Leaflet object types are Raster types, Vector types (Path, Polygon or Circle), Grouped types (FeatureGroup and GeoJSON) and Controls (Zoom, Layers) [7].

The first layer that has the highest priority is the layer of events. Such a layer will be managed by the university promotion department. The Layer of Events consist of points on the map that are described by the coordinates. The person who manages the contents of the webpage in this layer clicks and describes events, which are saved in the system. The latitude and longitude of such a click are captured as the object’s properties. These parameters are the coordinates for the event point. Layers 2 and 3 refer to the building itself for a particular category, for example faculty, college. Here the application uses labeling by identifiers. Thanks to our program it became possible to
group buildings and assign them entry points. This data set can then be grouped as a whole campus.

Worth noting is that this is very useful information because many students who are looking for something on a specific campus, search for a building or a division that they do not even know, if such exists and how they can get there. Layer 4 is the last one. This serves as the background for our application. OpenStreetMap provides many different kinds of maps. Here, we have set up our own version of the mapping server as a source, giving the ability to fully generate user own maps. The layer of the management system is the server that provides the Representational State Transfer (REST) API. Using the GET query, the system can return the appropriate combination of layers. The system allows users to standardize the way in which all data is displayed. This is primarily about ordering and grouping objects into one and giving effective results.

MongoDB is an open source database that uses a document-oriented data model. This database uses format similar to JavaScript Object Notation (JSON) documents with schemas. The data source for this database was the coordinates that were generated using Quantum Geographic Information System (QGIS). The search engine is an authoritative application designed to monitor the results of MongoDB database shredding. This is where the assigned labels are returned for the results and the crawl collections are located in the MongoDB reference database. [2]

4 Use QGIS software to edit geojson data

Before the geolocation data was placed in the database it was edited and modified with QGIS software. This is a cross-platform software. Based on the free geoinformation software (GIS) license. The project is part of the Open Source Geospatial Foundation (OSGeo). QGIS allows to manage geographic data, create user’s own data, including GPS coordinates, perform spatial analysis, and create maps [1]. The functionality of the program can be extended by using additional plugins such as Georeferencer, OpenLayers, Geographic Resources Analysis Support System (GRASS). The program provides the opportunity to integrate with other OSGeo projects, including With PostGIS, MapServer, Geospatial Data Abstraction Library (GDAL) / OGR. The system is being developed by a group of volunteer programmers. QGIS allows, among others, collection, processing (creation, selection, identification, editing, viewing, management), displaying, analyzing, interpreting and sharing spatial data including publication of map compositions in the Internet [6]. The system is available under the GNU GPL (General Public License) license in 39 languages. The application uses over 1000 different coordinates, which will outline the buildings and their inputs. The application occurred to be very useful in preparing initial datasets. Manually writing down building coordinates and entering them could take a lot of time. With an application that provides a graphical user interface, data generation has proven to be much faster.

5 Monitoring of the application popularity

A popularity of the website was monitored by the use of the Google analytics tool, which is a statistics system that collects data about users who visit a website. This is possible by placing a special JavaScript code on the page, which takes the relevant data from the page when a user visits the page and sends it to Google Analytics [9]. A summary of such data can be viewed later on in a form of various extended reports - either ready or created by the user. The sample data that Google Analytics users collect when analyzing website traffic are:

- How did they get to website (whether through the
search engine, by referring from another site, or by
directly typing the page address in the browser)

• What is their physical location (state, city)

• What software they use (operating system, browser,
device type)

• How they behaved on the site (how long they stayed
on a particular page, how many pages they visited)

![Fig. 3: Visitors in general statement. Blue color represents returning users and green the new ones](image)

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All of this information appropriately analyzed and interpreted can help to improve the system and better align it with its audience. Google analytics reported that over the past 3 months the site had visited over 800 students. The collected data shows that the application enjoys popularity and already has a group of people who regularly use it. At the moment of writing 61.6% are so called returning users and 38.4% are new users who never visited the website (Fig. 3).

Over 70% of returning users that want to come back to the application are 18-24 years old and these are, where as more than (25%) are in the age 25-34 rest 5.85% are 45 or more years old (see Fig. 4). The results seem to be rational, with the affiliate program ultimately intended to use the group where the end user is the student. We can assume that a big part of returning users of age 25 or more are PhD students or professors working at TUL which is good indication that application is useful also for people who are already familiar with the topography of the university.

![Fig. 4: Representation of returning users by age](image)

Fig. 4: Representation of returning users by age

### 6 Summary and conclusions

The proposed system can be used on different platforms and devices. It’s even possible that the same user will start application on a personal computer and after a moment continue on a mobile device. Such functionality was applied with responsive technology. The application has become very user-friendly tool that can be used on devices with different kinds user input as well as screen sizes. The layered structure of the application provided the separation of the individual information which resulted in more convenient their management. As a result task like assigning labels to specific locations, grouping, etc. are now much easier to do. With such a large number of buildings and campuses, it became crucial to manage very large amounts of data. Here, by using layer hierarchies, it was possible to obtain a readable map with many different data that are interrelated. Good indicator of the of the application popularity and usefulness is a number of users and the related statistics. According to them, it turned out that many users returned to the system.
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