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USER FRIENDLY INTERACTION WITH NATURAL OBJECTS IN WEB MAP APPLICATIONS BASED ON OBJECT RECOGNITION

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Abstract

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The maps become a common tool for many users. We can find a wide range of solutions from simple search applications to advanced location intelligence tools. In most cases, aerial or satellite images are used as a background. Above this background, other map layers are presented and used for the actual interaction. Our approach is focused on the mentioned background. Aerial and satellite images comprise a huge amount of objects, but it is virtually impossible to interact with them. This paper proposes a new kind of user interface that allows to interact with these natural objects.

Keywords: map, user interface, user experience, object recognition, remote sensing, web map application

INTRODUCTION

In the last decade, we can see substantial arise of different mobile and web mapping applications. The well known leader in this area is the Google corporation with their Google Maps service. The Google Maps and other similar solutions such as Mapy.cz, Bing Maps etc. share the basic concept. They provide satellite/aerial imagery, topographical or thematic maps that serves as a background for data presentation. These base layers are both from technical and the user point-of-view just raster images. We can see them, but there is no possibility of some advanced interaction.

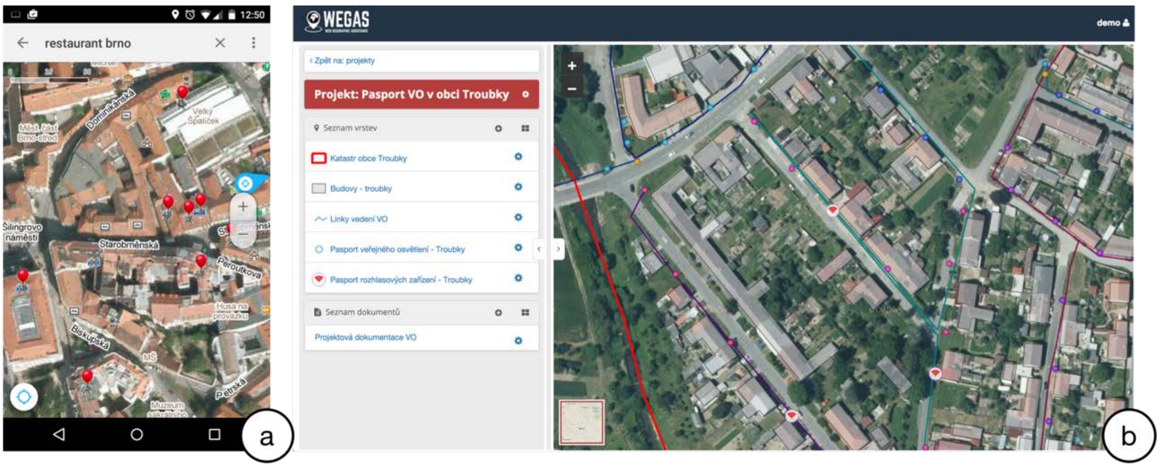
Above this base layer, a set of vector map layers is usually presented. As an example can be taken the road network, selected points-of-interest etc. Particularly, the Google, Seznam.cz and similar companies frequently present the search results as a point layer that allows the user to click on specific points and see related details. On the Fig. 1 (a), we can see the search results for restaurants in Brno. We can say that particularly these vector layers are designed for interaction. There is a wide range of solutions based on the same principle. Many towns, cities and organizations present overview of their properties trough the web map applications. For instance, we can find geospatial information systems that present city infrastructure. The users (usually particular technical department and/or city council) can see electrical lines, pipes, roads conditions, public lights etc. On the Fig. 1 (b), is a web based geospatial information system Wegas developed by Envipartner company. Its purpose is to provide an information about maintained public properties. The users can interact with different layers that contains the description of the related infrastructure.

The last, nonetheless important, category comprises different solutions for business intelligence that incorporate maps and generally work with the spatial information. They are usually called location intelligence (Wolfe, D. & Moon G., 2008). From the technical point-of-view, they have the same architecture as previously mentioned solutions. Analytical layers are presented above some base layer with the satellite imagery, topographical maps, etc. These analytical layers are computed on the basis of complex data and provide information about the company sales and many other details necessary for the decision making process. Different services provided by CleverAnalytics[1] company can be taken as an example.

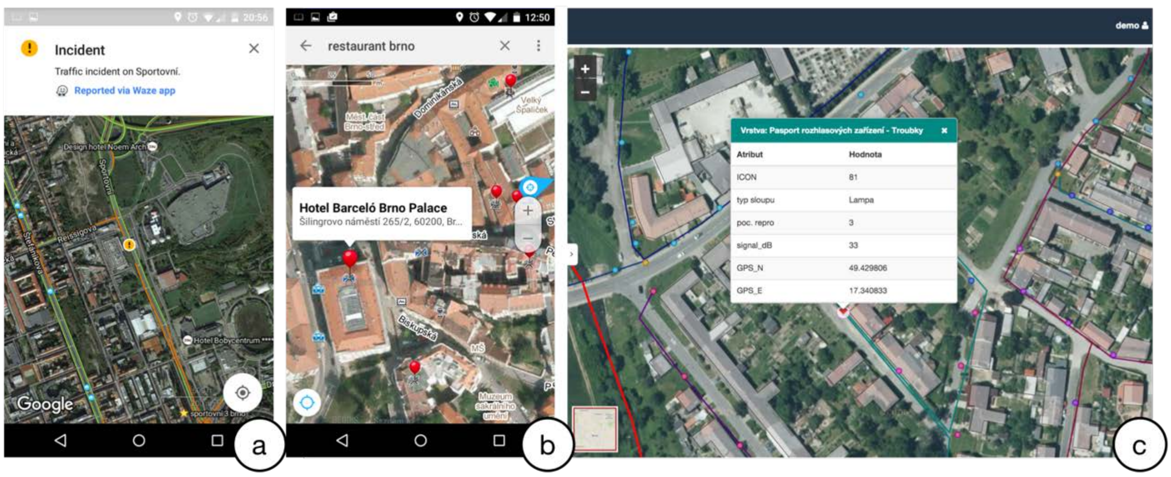
As been presented above, virtually all these applications are based on the same architecture. The users interact with selected (usually vector) map layers. They can see the details of presented object, search within them, even modify them. On the background is frequently a base map layer in a raster form. This layer can be usually changed or disabled, nonetheless, there is practically no possibility of an other interaction. Although there is such need as is described further. Therefore, we focused on this issue and developed a method that allows to decompose this raster layer on the separate objects and allows to present information related to these objects.

Structure of the article

The article is organized as follows: On the beginning, we provide a brief review of user interfaces that are currently used for interaction with different raster map layers. Further, we overview applications of the object recognition in the satellite/aerial imagery. Finally, we propose



1: *Vector map layers above aerial image base map*
(a) Seznam.cz mobile maps application with search results;
(b) Wegas application with inventory of public infrastructure (http://wegas.cz).



2: *Interaction with object on a map*
(a) Google Maps application with details of traffic accident;
(b) Mapy.cz application with restaurant detail;
(c) Wegas application with Wi-Fi hotspot detail.

1 http://www.cleveranalytics.cz/

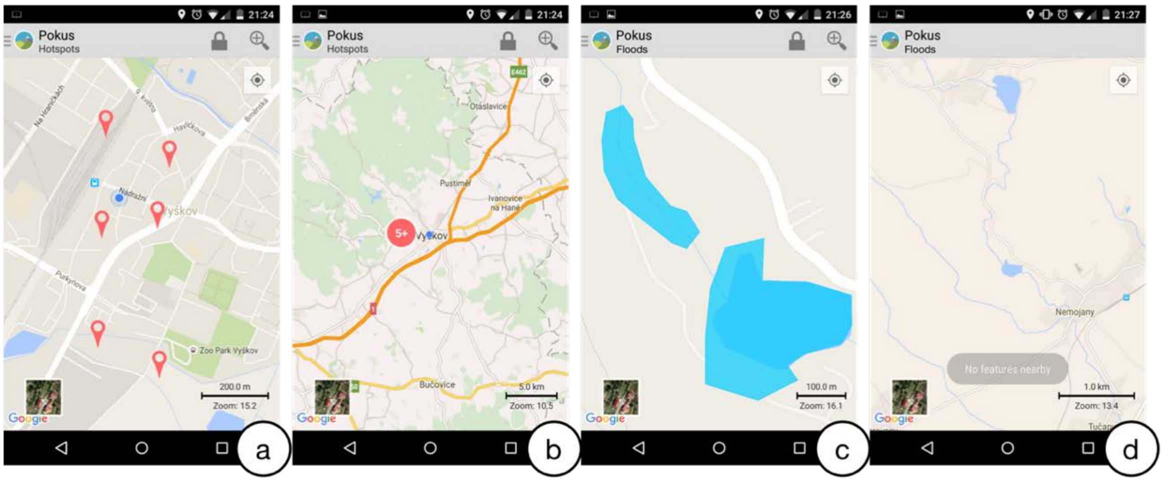
an approach that allows to select target objects in the raster base maps, describe its implementation and present recommended usage for the user interaction enhancement.

INTERACTION WITH MAP OBJECTS

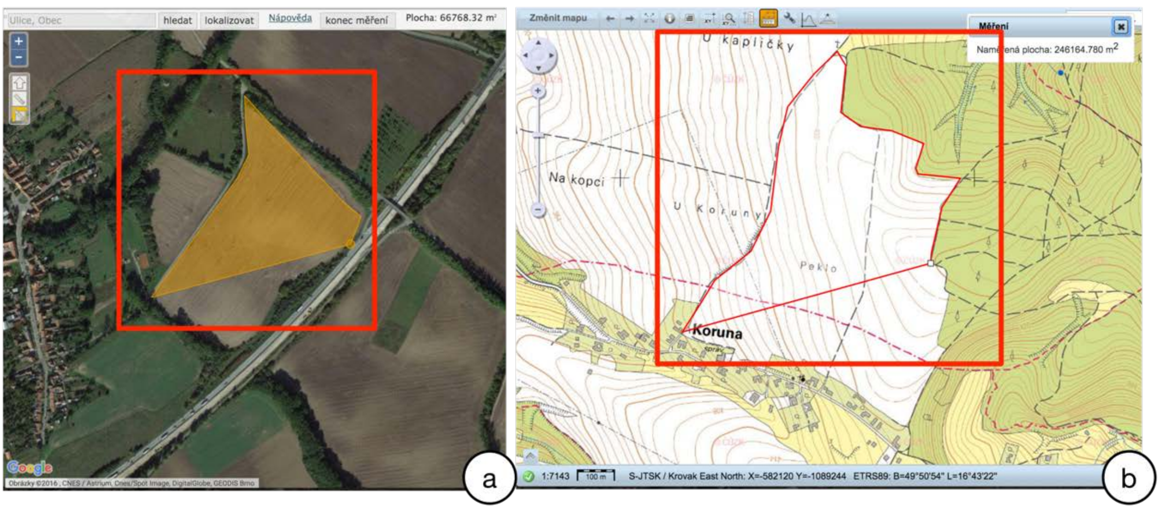
We can split all common interactions with the map object in two groups: interaction with vector layers and interaction with raster layers. The first mentioned case is straightforward. The user simply clicks on appropriate object (i.e. point, line or polygon). If there is only single entity within the interaction area, related action is performed. As an example can be taken interaction with search result on Google Maps application presented in Fig. 2. Similar information window, panel or any other element can be shown even in case of line or polygon.

If there are more entities within the interaction area, the situation is more complex. Appearance of too many entities within a small area can be confusing or difficult for interaction. Therefore, the developers implement two basic approaches for the map content simplification. The first one is the minimal and maximal map scale for each layer. If the map scale is within the given interval, the map layer is drawn, otherwise, it is hidden. The other approach is the simplification of the objects. The points can be grouped, the lines and polygons simplified. Examples of both approaches can be found in Fig. 3.

The interaction with the raster layers is currently limited, nonetheless, required. Especially in



3: *Simplification of layer content*
(a) Envipartner Gisella mobile application with measured Wi-Fi hotspots;
(b) Points clustered to a single symbol;
(c) Polygons with potential flood shown in larger scale;
(d) Polygons completely disappeared from in smaller scale.



4: *Interaction with raster map layer*
User is forced to select the required area manually. The working area is in both cases marked with a red square; (a) iKatatr.cz web application; (b) State Administration of Land Surveying and Cadastre web application (http://cuzk.cz)

the professional applications, the user needs to measure the length of some road or rivers, calculates the circumference or area of a forest, parcel or a lake. Currently the only solution is to select the required borders manually. In the Fig. 4 is an example of work with cadastral data in the web applications *iKatastr.cz* and *State Administration of Land Surveying and Cadastre*. Other applications are based on the same principle. It is obvious that such approach is imprecise and lengthy.

Current research in the field of interaction with maps is focused primarily on devices with touch screen and 3D mapping. We can find experiments with new multi-touch gestures suitable for portable devices (Schmid, 2013) or multi-touch tables (Artineger *et al.*, 2010) as well as new methods for navigation (Weissenberg *et al.*, 2014). Expansion of 3D mapping brought many new important issues: production of precise 3D models especially from LiDAR data (Zhou & Neumann, 2008), effective interaction with different indoor environments (Li and Giudice, 2013), interactive 3D mapping (Miksik *et al.*, 2015) or even tactile maps (Taylor *et al.*, 2015). However, none of these domains deals with the problem of object selection in 2D raster image. Partially related is the area of printed map digitalisation (Arteaga, 2013). Nonetheless, the authors usually detect polygons in cadastral maps, not in the complex satellite images.

USAGE OF MAP OBJECT RECOGNITION

Our solution is based on the principle of natural object detection in the satellite or aerial imagery. This area is well known for decades. It has obvious applications especially for agriculture and forestry. In both cases the users must deal with the identification of large areas. Following section briefly outlines several projects that can be taken as an example of the usage.

Czech Terra project is focused on multisource land and it uses evaluation of the Czech Republic. It works with the aerial imagery as well as field measurements. The Czech Republic is divided into 1599 squares of size 7 × 7 km. Each of these squares is further divided into smaller 450 × 450 m large squares, so called "regions". Each region is then classified using the aerial images into land use classes. (Černý, 2009). Further project is focused on an assessment of bark beetle damage in the Trojmezná old-growth forest (Šumava National Park) using the automated classification of the aerial photographs. (Hajek & Svoboda, 2007). The solution was based on the analysis of the aerial images time series. For classification was used blue, green, red and near infra red band. The last mentioned project is focused on the fast grassland vegetation monitoring and evaluation of its management in Krkonoše region (Pomahačová, 2012). The basis is processing of *WorldView-2* satellite data. The goal was to differ meadows covered with particular vegetation, used by cattle etc.

In these few examples, we can see application of different methods. In the case of the *Czech Terra* project, the key method is the complex statistical evaluation where the remote sensing is just one of many inputs. The bark beetle damage assessment is evaluated using object classification which is the first step before split into required classes. The last project focused on vegetation monitoring uses common classification by a teacher. Nonetheless, in all three cases, the classification is used solely as method for the construction of new map layers with required information. In the Fig. 5, we can see an example of common classification of larger area into several classes (water body, forest, field, inhabited area etc.).

OBJECT RECOGNITION AS A MAP USER INTERFACE

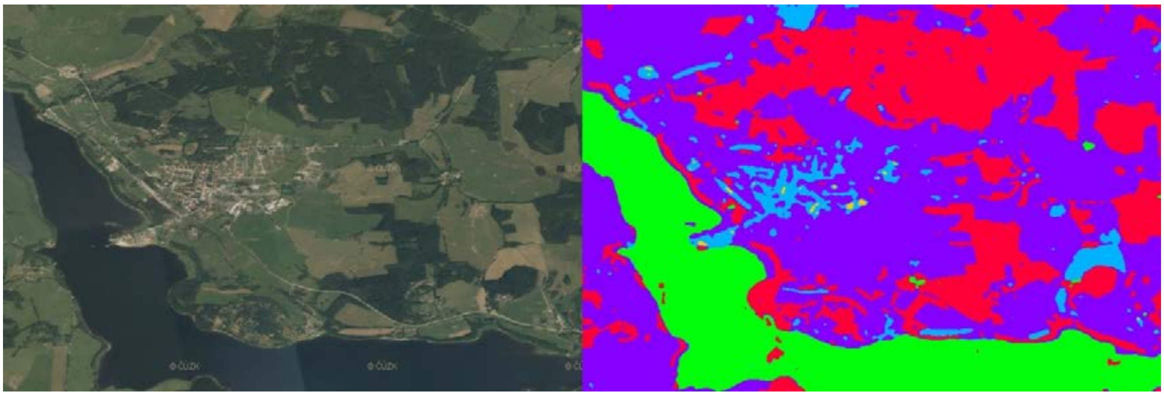
Our experimental web map application implementation comprises two parts: the web-based user interface and server application that makes the object recognition. The graphical user interface is implemented using *HTML* language, *CSS* styling and *JavaScript* language. The user interface widgets are provided by the popular *Bootstrap*[2] and *OpenLayers*[3] libraries. The Fig. 6 presents basic concept of our testing interface. The basic principle is very simple. If user wants to select a region, he/she creates a triangle within required region. The triangle is an input for classification. This designated triangle is send to the server which finds the actual region borders a returns them to the user interface (see the Results section for details). The map layers are loaded into the application using open *Web Map Service* (WMS) standard (Beaujardiere, 2006).

As been mentioned, the server side of proposed application contains classification engine which detects the actual borders of the region. The application is implemented in the Python language and *Flask*[4] framework. Currently used method is based on clustering principle. The goal is the usage of described interface in a common map applications; therefore, as the cluster analysis input are taken primarily publicly available aerial RGB data from a WMS service. Nonetheless, classification based solely on the RGB can be in some case imprecise; hence, we recommend calculation of indices that can be derived from RGB data. The *Green Leaf Index* and *Visible Atmospherically Resistant Index*

2 http://getbootstrap.com
3 http://openlayers.org
4 http://flask.pocoo.org

(Hunt *et al.*, 2013) are well known examples. We used the first one, the latter does not provide significant precision improvement in our test scenario. The result of the clustering is a region of pixels that is potential target region. This potential region is vectorised. Above such vector representation can be made further analysis.

An important part of the implementation is from our point-of-view the post-processing phase. A situation presented on Fig. 7 (left) can be seen very frequently. We call this situation a "bridge". A part of the field with adjoined road is presented in the left part of the image. Because they are composed of same or very similar material, they are taken as a single object from the classification point-of-



5: *Example of larger area classification. The area contains water body, forests, fields etc.*

6: *Testing user interface with selected area*

7: *Results of a classification. The left part of the image presents a "bridge" that connects adjoined road.*

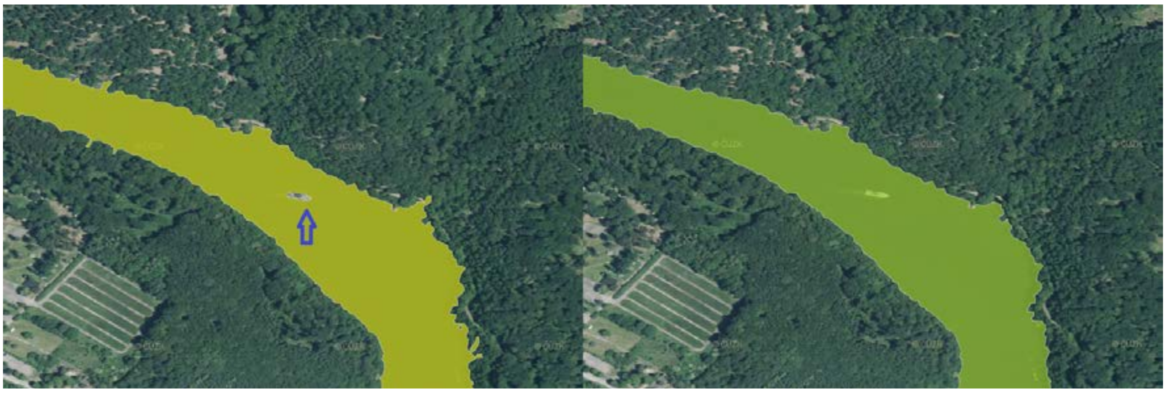
view. Nonetheless, from the user interface point-of-view, we understand that they are separate objects. Therefore, we recommend to detect such situations. We implemented an algorithm that is based on the definition of a buffer of the selected size. This buffer is moved along the polygon borders. In case, within the buffer is located just a single polygon boundary, we have common polygon border. In case there is more than single boundary, we have potential "bridge". Even such a simple method can substantially improve the recognition process. The right part of the Fig. 7 presents results of this algorithm. The road is no longer taken as a part of the field.

RESULTS

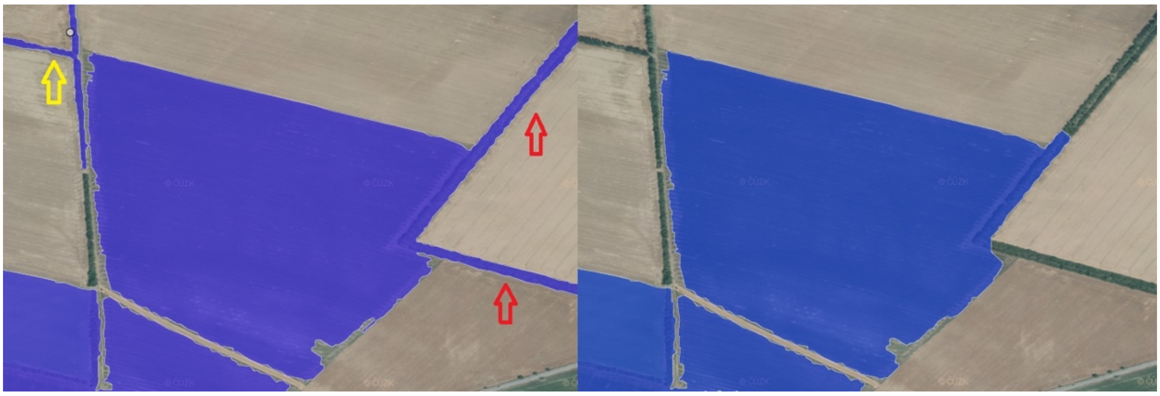
Both examples that will be presented deal with the problem of common natural object selection. In the first case, a water body is selected, in the other case, a part of a field is chosen. We always illustrate results obtained by application of a common soft computing method (clustering) and results improved by our post-processing algorithm.

The first example presents a problem of a small object within target area. The object covers the target area, therefore, it should be taken as a part of the area. On the Fig. 8 (left), we ca see a result of a common recognition that avoided the object (ship) area. In the right part of the figure, proposed enhanced detection was used. The borders of the water body are more precise and the object in the middle of the water is taken as a part of the water body.

The other example presents second common problem. The target area is accidentally extended by some other object in its vicinity. In this particular case presented on Fig. 9, some roads are detected as a part of the field. Technically, it is not a mistake. The composition of the road is virtually same as the composition of the field. Nonetheless, the user understands that the road and the field are separate entities. Proposed enhanced detection algorithm avoided most of the roads.



8: *Example of larger area classification. The area contains water body, forests, fields etc.*



9: *Example of larger area classification. The area contains water body, forests, fields etc.*

CONCLUSION

The key contribution of this article is the concept of completely new kind of map user interface. Although there is an obvious need for selection of natural object in the raster base maps, contemporary interfaces lack such capability. Our method allows the user select required area by three simple click into target location. Therefore, it substantially simplifies the selection process. Even in case the boundaries of detected area are not precise, their manual adjustment is still much faster and more precise than purely manual selection.

We dare to claim that the currently used detection method is not substantially important. Our results as well as results of many other projects focused on object detection in aerial or satellite imagery prove that the objects can be detected with suitable precision for described cause.

Moreover, on the basis of our experiments, we proposed post-processing enhancement of a common soft computing method that allows to select target region more naturally. Especially, we are able to avoid artificial holes in selected area and/or attachment of similar objects in the region vicinity.

In the future research, we will focus on testing of different soft computing methods that will allow to apply our method on even wider range of cases. We recommend well known books (Theodoridis & Koutroumbas, 2008) as well as recent research articles focused on machine learning applications in the remote sensing area (Lary *et al.*, 2016). There is also a live research in the area of remote sensing index definition. Implementation of other indices than currently used GLI can provide more precise results. Among many recent works, we can mention recently published (Dörnhöfer & Oppelt, 2016) or (Asadzadeh & de Souza Filho, 2016).

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