

The geovisualisation window of the temporal and spatial variability for Volunteered Geographic Information activities

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Abstract: This study presents an attempt to design geographical visualisation tools that allow to tackle the immensity of spatial data provided by Volunteered Geographic Information (VGI), both in terms of temporal and spatial aspects. In accordance with the assumptions made at the conceptual stage, the final action was the implementation of the window entitled 'Geovisualisation of the Panoramio.com Activities in District of Poznań 2011' into the web browser. The concept has been based on a division of the geovisualisation window into three panels, of which the most important - in order to capture spatial variability - have statistical maps at the general level (dot map and choropleth map), while at the detailed level - a dot map on a topographic reference map or tourist map. For two ranges, temporal variability is presented by graphs, while a review of attributes of individual activities of the social website in question is set forward in the table panel. The element that visually interlinks all of the panels is the emphasised individual activity.

Keywords: Geovisualisation window, Volunteered Geographic Information, visualising times-spatial data, open sources, web technology

1. Introduction

Internet services that allow users to create their own content, known as Web 2.0, have pointed out a different approach to methods of collecting spatial data. Of considerable importance are social websites, the members of which use free software and simple tools to effect the implementation of geographical information into the global network. These activities are known as Volunteered Geographic Information (VGI), which according to Goodchild (2007) is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals. The VGI phenomenon has initiated scientific research concerning connections with GIS (Elwood, 2008) and the impact on the Geographic Information Science (Coleman, 2010). Considerable interest has been aroused by the credibility of volunteered geographic information (Flanagin, and Metzger 2008), which is also of importance for identifying the changing balance of the public and private sector (Kuhn, 2007; McDougall, 2009). Spatial data infrastructures within national and European structures have come within the scope of legal standards

and norms (Bielecka, 2003). Internet communities should be treated as an important entity in the obtainment and processing of geographical information. The three basic elements of VGI include the community, spatial data, and the technologies connected by the internet. Examples of VGI service are the „WIKIMAPIA – let’s describe the world!”, www.flickr.com and OpenStreetMap.

This study presents an attempt to design geographical visualisation tools that allow to tackle the immensity of spatial data provided by Volunteered Geographic Information (VGI), both in terms of temporal and spatial aspects. Geographical visualisation (Geovisualisation, GeoVis or Gvis) can be defined as a private activity in which previously unknown spatial information is revealed in a highly interactive computer graphics environment (Slocum et al., 2009). In research concerning geovisualisation, emphasis is placed primarily on the representation of geographical phenomena, on visualisation, and on the interface (Dykes et al., 2005; Baranowski et al., 2009).

The forms of geovisualisation that may be used to handle multi-criteriality and multi-dimensionality of data include the following: statistical maps, diagrams, graphs with two and more variables, multi-series minimaps, and animations of data variability (Slocum et al., 2009). The basic role of the map in the process of geovisualisation is undisputed, while the statistical map and reference map continue to be the primary – because they are most easily understood – carriers of spatial information. A potentially effective method of disseminating and understanding geographical phenomena, which at the same time is a necessary component in the structure of integrated discovery of spatial knowledge, is the geovisualisation window, which allows the user to interact with individual interactive graphical panels (Medyńska-Gulij, 2011). An example of an interactive window for the web user is the atlas of incidence of cancer in Pennsylvania (MacEachren et al., 2008).

2. Methodology

2.1. Procedure for elaborating geovisualisation

The main objective of the present research was to elaborate a method for the interactive geovisualisation of temporal and spatial variability of point phenomena on the example of the Panoramio.com internet community. As it turned out, of primary importance for solving the research problem was the elaboration of procedure for creating an interactive visualisation of temporal and spatial changes that would contain cartographic and other methods of visualisation, the selection of technologies, and design of the geovisualisation window. The geovisualisation window was published in a web browser, and this fact determined the method of processing data and adapting editorial principles to the perceptive capabilities of a web user (Dickmann, 2004).

The utilitarian objective was to create of a tool that would allow each and every internet user to individually and interactively analyse the VGI phenomenon using pre-designed panels: the map panel, the table panel, and the graph panel. The process of

elaborating the geovisualisation of the temporal and spatial variability of the Panoramio.com community comprised three primary stages (Fig. 1): conceptual; acquisition and processing of data; and visualisation and implementation.

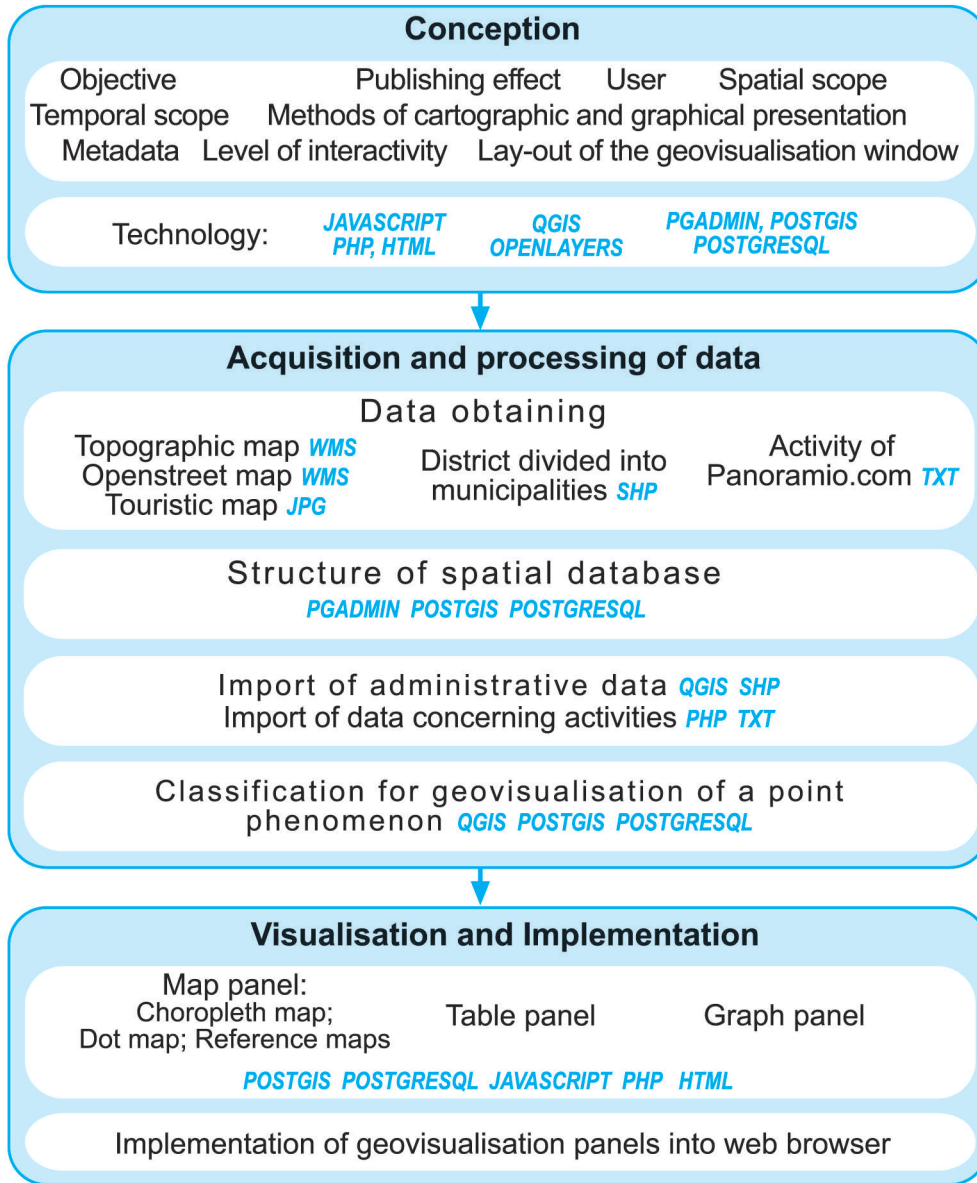


Fig. 1. Procedure for elaborating the geovisualisation window of the temporal and spatial variability for VGI activity

2.2. Concept

Of key importance for elaborating the geovisualisation window were the assumptions made for the first conceptual stage, i.e.

- objective: capturing/disclosing the variability features of temporal and spatial activities of the Panoramio.com community broken down into hours and months in the year 2011 for the entire area (district of Poznań) and a randomly selected view (zoom);
- publishing effect: the interactive window in the web browser entitled ‘Geovisualisation of the Panoramio.com Activities in District of Poznań 2011’;
- user: a public internet user with basic internet skills;
- method of cartographic presentation: dot map, choropleth map, reference maps: dot map – lay-out according to geographical coordinates, dot weight – individual activity = 1 dot); choropleth map broken down into municipalities, with a classification based on the Jenks’s method;
- method of graphical presentation: graph presenting changes in the number of activities for individual months; graph presenting changes in the number of activities for individual hours; possibility of comparing changes in the number of activities on the graph for the district of Poznań, for the view, and for Poznań;
- table of activities: a table of attributes for all instances of activities and for activities in the view;
- level of interactivity: spatial navigation (moving the view rectangle on the map of the district); selection of a reference map in the view (topographic/open-street/tourist map); selection of an individual activity (dot) on the map of the district and in the view, and of the record of an individual activity (clicking on the dot results in the dot being backlit in each available location, i.e. on the choropleth map, in the view, in the table and on activity charts);
- technology: an open source software, which in this instance meant using desktop QuantumGIS (QGIS) software (for operations in the .shp format), PostgreSQL and PostGIS database software (for operations in .EXE, SQL and SpatialSQL), and internet technologies: OpenLayers, JavaScript, PHP, HTML i Google Charts (.js, .php); architecture: client (browser) – server with network services (database: PostgreSQL PostGIS, WMS, Google Charts);
metadata: link to a PDF file containing descriptions of data sources, their acquisition, processing and classification according to the procedure for creating the geovisualisation window; data concerning the authors;
- lay-out of the geovisualisation window: the title box and metadata box and the three main interactive panels: the map panel, the table panel, and the graph panel; closed, balanced horizontal composition; visual hierarchy: graphical enhancement of a selected individual activity; interactions in the window: click, scroll, move.

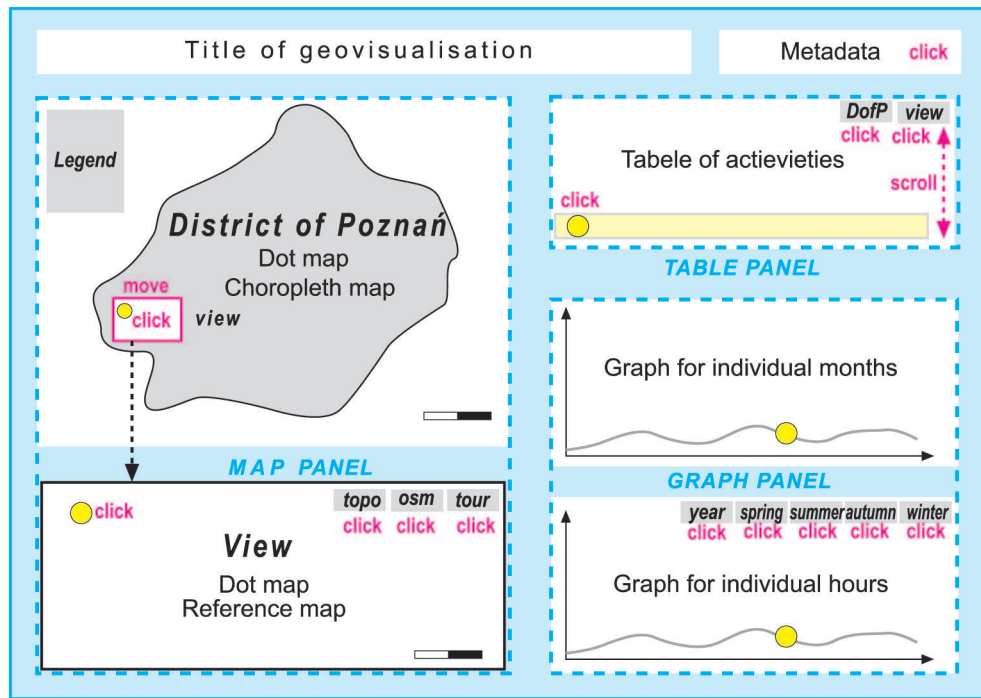


Fig. 2. Lay-out of the geovisualisation window of the temporal and spatial variability for Volunteered Geographic Information activity in the district of Poznań

2.3. Acquisition and processing of data

An administrative map of Poland in .shp format, broken down into districts and municipalities, was used for elaborating the choropleth map and the dot map. In turn, individual point objects constituted activities saved in the Java Script Object Notation (JSON) data exchange format, the strict form of which was as follows: {"count": 17046,

```

"photos": [{
  "upload_date": "19 February 2007",
  "taken_on": "129403987321"
  "owner_name": "Radek Szampa",
  "photo_id": 890788,
  "longitude": 18.222712999999999,
  "height": 880,
  "width": 1480,
  "photo_title": "Kapliczka",
  "latitude": 49.491950000000003,
  "owner_url": "http://www.panoramio.com/user/187280",

```

```

"owner_id": 187280,
"photo_file_url": "http://mw2.google.com/mw-panoramio/photos/thumbnail/890788.jpg",
"taken_on": "12958762104"
  "camera_type": "Panasonic DMC-FZ35",
  "eksposure": "0.025s (1/40)",
  "focal_length": "20.10mm",
  "f/Stop": "f/3.600",
  "ISO Speed": "ISO200",
  "exposure_bias": "-0.33 EV",
  "flash": "no-flash",
  "photo_url": "http://www.panoramio.com/photo/890788"}, ... ] ... ]

```

The above entry is a JSON entry, which may be considered as a "light" data exchange format based on the object literal successfully replacing XML. This JavaScript subset may be used to create objects, while in the above instance the object is a photography with described features having specific attribute values. To increase interpretation opportunities for users of the VGI phenomenon geovisualisation window, a spatial reference in the following form was adopted: topographic map (WMS), OpenStreetMap (WMS) and a half-tone image of a tourist map (jpg).

Municipalities within the borders of the district of Poznań were selected by means of the functions of the QGIS programme. The administrative units thus selected were saved as an .shp file entitled "powiat-poznan.shp", which was subsequently imported into the PostGIS database using the SPIT tool available in the QGIS suite (Fig. 3).

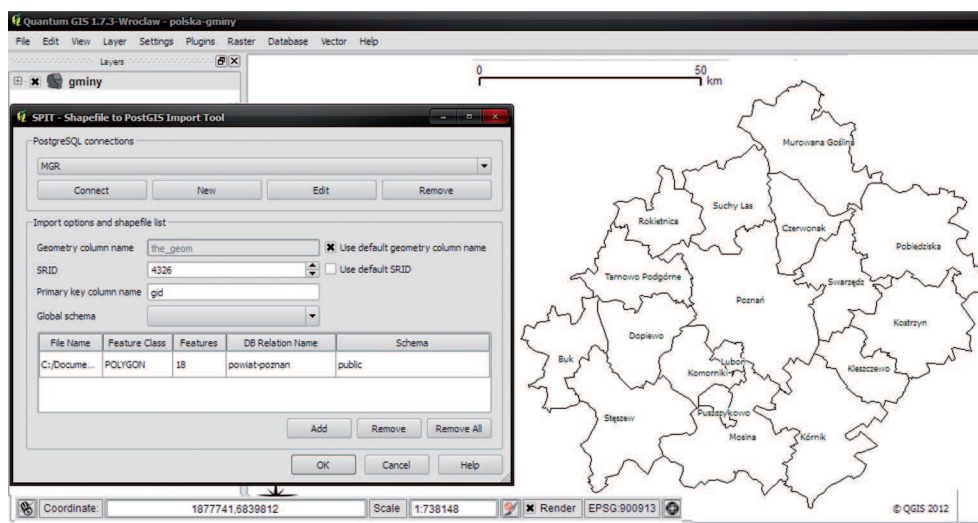


Fig. 3. Import of spatial data from the .shp file into the postGIS database

An initial classification of data concerning activities made it necessary to select attributes for further analyses, which were then saved in a .txt text file as follows:

```
{
  "count": 17046,
  "photos": [
    {
      "upload_date": "19 February 2007",
      "taken_on": "129403987321",
      "owner_name": "Radek Szampa",
      "photo_id": 890788,
      "longitude": 18.222712999999999,
      "height": 880,
      "width": 1480,
      "photo_title": "Kapliczka",
      "latitude": 49.491950000000003,
      "owner_url": "http://www.panoramio.com/user/187280",
      "owner_id": 187280,
      "photo_file_url": "http://mw2.google.com/mw-panoramio/photos/thumbnail/890788.jpg",
      "taken_on": "12958762104",
      "camera_type": "Panasonic DMC-FZ35",
      "ekspozure": "0.025s (1/40)",
      "focal_length": "20.10mm",
      "f/Stop": "f/3.600",
      "ISO Speed": "ISO200",
      "exposure_bias": "-0.33 EV",
      "flash": "no-flash",
      "photo_url": "http://www.panoramio.com/photo/890788",
      ... ]
    }
  ]
}
```

The next step concerned elaborating a spatial database with specifications for tables for ACTIVITIES point objects and for tables for MUNICIPALITIES surface objects. Description of individual columns for the MUNICIPALITIES tables contain the following: gid – a unique identifier of the municipality in the database, primary key; nazwa – municipality name; idgminy – municipality identifier; the_geom – geometry column to which three integrity connectors have been assigned (Table 1). In turn, the spatial reference parameters for MUNICIPALITIES have been presented in Table 2.

Table 1. Structure of the MUNICIPALITIES table

Column	Type	Not Null	Default
gid	integer	NOT NULL	nextval('gmina_gid_seq'::regclass)
nazwa	character varying(47)		
idgminy	integer		
the_geom	geometry		

Table 2. Geometry and spatial reference parameters for MUNICIPALITIES

Name	Definition
Enforce_dims_the_geom	CHECK (ST_ndims(the_geom)=2)
Enforce_geotype_the_geom	CHECK (geometrytype(the_geom) = 'POLYGON'::text OR the_geom IS NULL)
Enforce_srid_the_geom	CHECK (ST_srid(the_geom) = 4326)
gmina_pkey	PRIMARY KEY (gid)

The table for point objects, i.e. activities, has the following attributes (Table 3): id – a unique identifier of an individual activity; medium – single-sign variable corresponding to: f – photography; timestamp – format of time passage, so-called epochs, i.e. the number of seconds that have passed since 1 January 1970 until the time the photograph was taken (the storage of time-related data in this format makes it easier to manipulate the date during addressing queries to the database); point – a geometry column to which three integrity connectors have been assigned; title – a photograph title; date – date stored in the DD-MM-RRRR format.

Table 3. Structure of the ACTIVITIES table

Column	Type	Not Null	Default
id	integer	NOT NULL	nextval('obiekt_gid_seq'::regclass)
medium	character varying(1)		
timestamp	integer		
point	geometry		
title	title		
date	date		

Just as in the case of MUNICIPALITES, Table 4 presents spatial reference parameters for individual activities for ACTIVITY determined by the value of the latitude and longitude coordinate pair.

Table 4. Geometry and spatial reference parameters for ACTIVITIES

Name	Definition
Enforce_dims_the_geom	CHECK (ST_ndims(point)=2)
Enforce_geotype_the_geom	CHECK (geometrytype(point) = 'POINT'::text OR point IS NULL)
Enforce_srid_the_geom	CHECK (ST_srid(point) = 4326)

Table 5 presents the result of administrative data import into the database, with exemplary records for each municipality and attribute columns, stored in the "Well-Known Binary" (WKB) format.

Table 5. Result of the import of administrative data into the database

gid	name	id
1	Kórnik	2890
2	Stęszew	2916
3	Swarzędz	2932
4	Kostrzyn	2889
5	Buk	2855
6	Mosina	2902
7	Murowana Goślina	2904
8	Pobiedziska	2905
9	Czerwonak	2869
10	Dopiewo	2870
11	Kleszczewo	2871
13	Komorniki	2872
14	Tarnowo Podgórne	2946
15	Rokietnica	2915
16	Suchy Las	2931
17	Poznań	2755
18	Luboń	3053
19	Puszczykowo	3054


```

In turn, the PHP script was used to import data concerning individual activities:
For ($i=1; $i=>17046; $i++){
    $d=pg_connect('host=localhost user=postgres dbname=mgr);
    pg_exec($d, "insert into obiekt (title, timestamp, medium, point, date)
    values ('$array[$i][0]', '$array[$i][1]', '$array[$i][2]',
    GeometryFromText('POINT('$array[$i][3] $array[$i][4]'),' $array[$i][5]'", 4326));
    "); }

```

The "\$array" variable is a one-dimensional table in which numbered objects, i.e. photographs, submitted in JSON format have been successively placed. The "\$i" is a freely selected number from the range 1-17046, which is responsible for the execution of iteration and is at the same time a reference to a specific object located in the table. Objects placed in the table have the following values:

\$array[\$i][0] – title of photograph;
\$array[\$i][1] – timestamp 'epoch';
\$array[\$i][2] – medium;
\$array[\$i][3] – longitude;
\$array[\$i][4] – latitude;
\$array[\$i][5] – date: YYYY-MM-DD

The resulting table of activity contained 17046 records of all types, 418 records had the same error, consisting in the entry of the date attribute 01/01/70, which means that photographs added to panoramio.com did not have a correctly entered date in the exif data, or that it was not defined in any way (Tab. 6). This repeatable error was excluded by the removal of specific records from the table following the application of the SQL instruction: DELETE FROM object WHERE timestamp = '0' OR timestamp = 'NULL'

Classification queries were formulated at the data processing stage, and in the course of subsequent operations they allowed to create the geovisualisation panels.

2.4. Visualisation and implementation

The visualisation stage concerned the distribution of panels in the geovisualisation window in accordance with the designed lay-out (Fig. 3) and adapting graphics to visually strengthen the selected activity. The objective of graphical parameters management was to show the user a single selected activity in relations with other activities with reference to spatial entities on topical maps and graphs.

The technology of operation of the geovisualisation window application is based on JavaScript entries using asynchronous queries to the WWW server and the database server (Fig. 4). Such possibilities are provided by AJAX (Asynchronous JavaScript and XML), which enables refreshing individual panels without the need of reloading the entire page.

Table 6. Resulting table in the database following the import of data concerning activities

Id	medium	Title	timestamp	Date
19226	z	Swarzędz - ogródek nad Cybiną	1241191587	2009-05-01
19227	z	Kościół w Sobocie	1220764038	2008-09-07
19228	z	Nature	1187176755	2007-08-15
19229	z	Zachód słońca	1313432801	2011-08-15
19230	z		0	1970-01-01
19231	z	kościół św. Floriana w Wirach	1314113344	2011-08-23
19232	z	GŁĘBOCZEK	0	1970-01-01
19233	z	Wielkopolska, Kopanina	1185701772	2007-07-29
19234	z	Mur	1289738405	2010-11-14
19235	z	Und los geht's....	1149654190	2006-06-07
19236	z	Starynka	1298113468	2011-02-19
19237	z	Nasze polskie bociany	1214554353	2008-06-27
19238	z	Sapowice	0	1970-01-01
19239	z	jezioro(lake) Góreckie	1167480396	2006-12-30
19240	z	Błężewko - Jezioro Bnińskie	1248617728	2009-07-26
...

The usage of interactive geovisualisation elements is connected with the initiation of queries to PHP scripts, and it is this stage that is responsible for the creation of queries, e.g. indicating the season of the year for which data is to be collected from the database, or indicating the location of the view (Fig. 4). The PHP script executes queries to the database with previously specified parameters, in the SQL language and taking into consideration spatialSQL. The response from the database is returned in text form. The transformation of TXT responses consists in the appropriate processing of the returned query from the database through the PHP script. Processing enables straightforward implementation during the next stage. Finally, JavaScript supports implementation into the geovisualisation window, which consists in introducing values processed during the preceding stage into specific geovisualisation panels. This may be considered as "refreshing" of the geovisualisation panel for the view adopted by the user on the dot map – choropleth map.

The key action for initiating the query on the part of the user consists in shifting the rectangle of the view on the general map and clicking the selected temporal scope. Then the appropriate view data are collected from the database on the side of the server. The query comprises the WHERE condition, in the which the temporal range is defined, e.g. spring:

```
WHERE (
  (EXTRACT(MONTH FROM timestamp::abstime::timestamp) BETWEEN 4 AND
  5) OR
  ((EXTRACT(DAY FROM timestamp::abstime::timestamp) BETWEEN 21 AND
  31) AND (EXTRACT(MONTH FROM timestamp::abstime::timestamp)=3)) OR
```

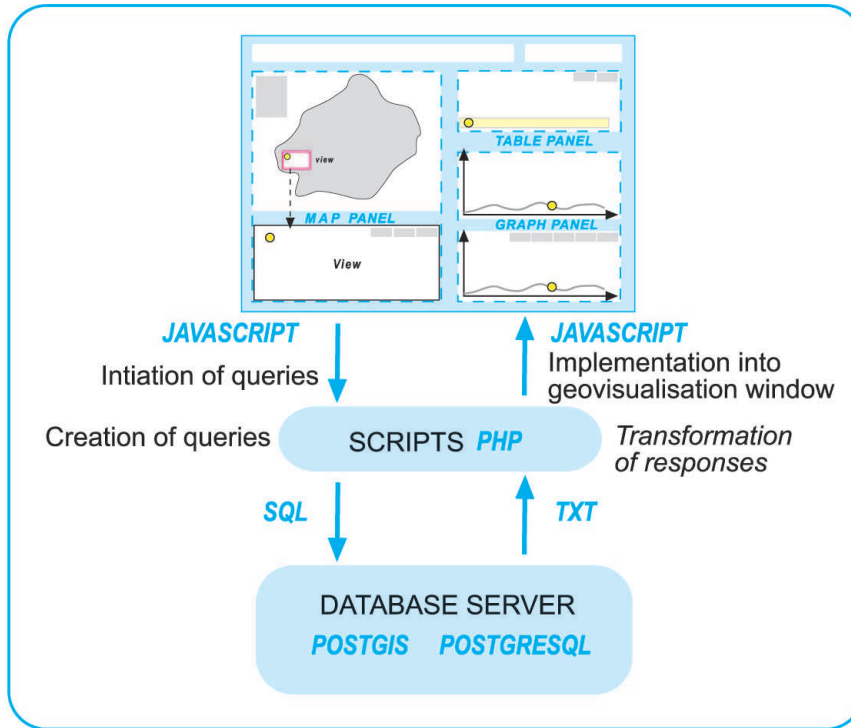


Fig. 4. Technological operation chart of the initiation of queries

```
((EXTRACT(DAY FROM timestamp::abstime::timestamp) BETWEEN 1 AND 22) AND (EXTRACT(MONTH FROM timestamp::abstime::timestamp)=6))
)
```

The WHERE condition also serves to collect only those activities from the database that are contained in polygons defined by the geometry column for MUNICIPALITY tables:

```
WHERE ST_Contains(a.the_geom, b.point)
```

During the transformation of responses there are created the appropriate view lines (in two graphs) and a table of attributes, which corresponds to the contents of the view panel.

The second key action that may be performed by the user is clicking a randomly selected dot (activity) on the view, which then changes its colour from red to yellow – both on the general map and on the enlarged view. In addition, the record corresponding to a given activity in the table of attributes is highlighted. Furthermore, the marked activity is placed on municipality activity graphs, broken down into both years and hours of activity. This effect was achieved by using JavaScript and manipulating on objects defined in the html language.

The graphs were elaborated dynamically using the Google Charts Api tool. This tool allows it possible to generate and personalise graphs by means of the appropriate

url link, which connects to Google sites where the graph is prepared as a png image with parameters corresponding to those placed in the url link. The "refreshing" of new graph values for the interactive view window consists in effecting the transformation of responses from the database into a url link with specific parameters. The table of attributes has been executed using the html language and the css styles sheet. The "refreshing" of the table consists in effecting the transformation of responses from the database into a html code, which is subsequently implemented into the panel.

3. Results

In accordance with the assumptions made at the conceptual stage, the final action was the implementation of the window entitled 'Geovisualisation of the Panoramio.com Activities in District of Poznań 2011' into the web browser (Fig. 5). The map presents the spatial lay-out of activities on the social website: uploading photographs with locational information and other attributes connected with data of this type.

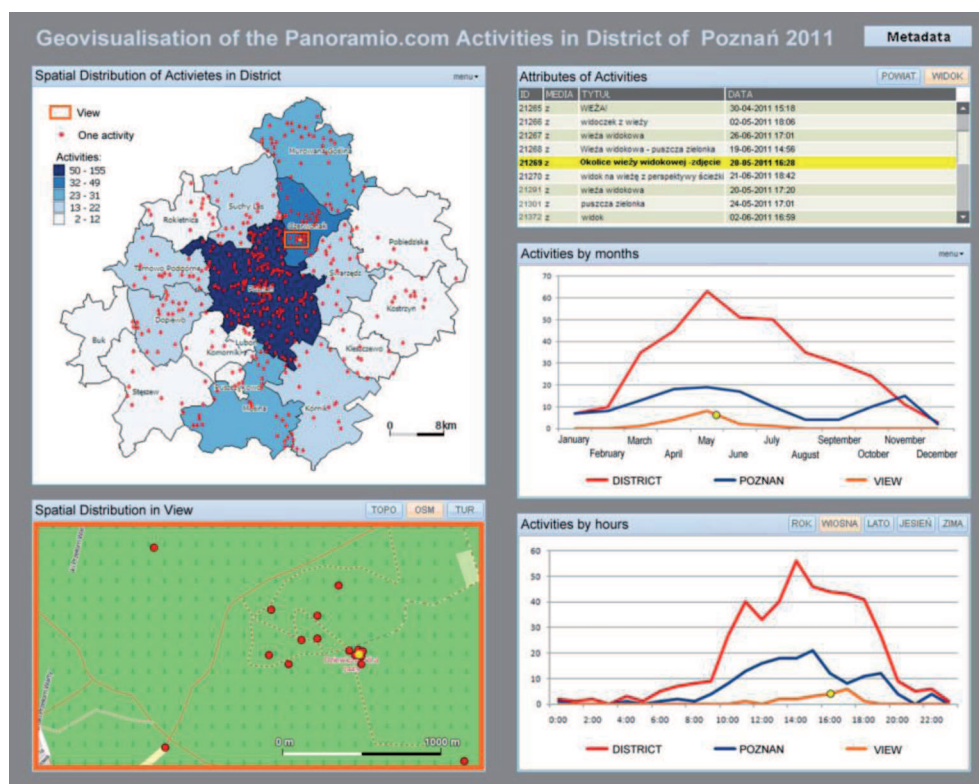


Fig. 5. Geovisualisation window in the web browser

In accordance with the principle of learning about space progressing from the general to the specific, the choropleth map identifies municipalities with maximal and

minimal activities, and assigning sets of points within these entities. Using the view rectangle, the user selects the area in which he intends to investigate the detailed location of dots on the map on a larger scale and, by clicking the appropriate reference map, may interpret the distribution of activities. The example presented in Figure 5 shows a set of activities at a touristically attractive object – Dziewicza Gora mountain. Each dot on the general and detailed map may be clicked, which also results in the backlighting of the attributes of this activity in the table, thus making it possible among others to read the comment to the photograph, e.g. "Vicinity of the viewing tower".

The presentation of activities on two graphs for the district, for Poznań, and in the view window facilitates a comparison and interpretation of the number of activities in these three spatial ranges, broken down into both months and hours for the year 2011. The distribution of activities over the course of months indicates that the internet community of the researched area most readily takes pictures in spring. The hourly distribution attains a maximum in the afternoon hours. An interesting dependence is that the decrease in activity between 16:00 and 18:00 in Poznań is accompanied by an increase in the number of activities in the view area, in which in this particular case is a recreational zone.

4. Conclusions

Until now, research related to the geographical visualisation for web users has focused on the search for new data management methods by users with at least a general knowledge of GIS (Andrienko and Andrienko 2006). In contrast, our study is also addressed to members of social media, as spatial data also relates to VGI. The authors of this study believe that it is imperative to guide the direction of analysis by appropriately placing panels in the geovisualisation window and by adapting interactive functions.

The fundamental advantage of the elaborated method of interactively geovisualising the temporal and spatial variability of point phenomena retrieved from a Web 2.0 application using VGI is its versatility, for it may be used to analyse each and every internet community. The procedure presented in Figure 2 contains successive stages of elaborating an interactive visualisation, which is viewed by the user of the web browser. The concept has been based on a division of the geovisualisation window into three panels, of which the most important – in order to capture spatial variability – contain statistical maps at the general level (dot map and choropleth map), while at the detailed level – a dot map on a topographic reference map or tourist map. For two ranges, temporal variability is presented by graphs, while a review of attributes of individual activities of the social website in question is set forward in the table panel. The element that visually links all of the panels is the selected individual activity. Such graphical highlighting may be considered as a deliberate focusing of the observer's attention used in topical maps (Dent, 1999), as well as the utilisation of the principles of creating point signs on maps (Medyńska-Gulij, 2008).

The processing of data took place in an open source software thanks to the utilisation of free desktop software, database software, and internet technologies. The

technology of operation of the geovisualisation window application is based on AJAX, that is the utilisation of asynchronous queries to the WWW server and the database server, which ensures the efficient "refreshing" of individual panels. The user of the web browser has received a tool that may be easily used to analyse the VGI phenomenon for Panoramio.com. Research may be continued with the objective of testing the functionality of the geovisualisation window with respect to data features or descriptions of members of each social media, which are becoming an ever more important source of spatial data.

Acknowledgments

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Okno geowizualizacji czasowo-przestrzennej zmienności dla działalności Volunteered Geography Information

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Streszczenie

Problemem podjętym w tych badaniach stało się wykorzystanie metod z nurtu geograficznej wizualizacji do wskazania cech fenomenu VGI w zakresie zmienności czasowo-przestrzennej.

Zgodnie z założeniami poczynionymi w etapie koncepcyjnym finalnym działaniem stało się zaimplementowanie do przeglądarki internetowej okna pod tytułem: "Geowizualizacja aktywności społeczności Panoramio.com w powiecie poznańskim w 2011 roku". Koncepcja została oparta na podziale okna geowizualizacji na trzy panele, z których najważniejsze znaczenie dla uchwycenia zmienności przestrzennej na poziomie ogólnym ma kartogram, natomiast na poziomie szczegółowym mapa kropkowa wyświetlana na podkładzie mapy topograficznej lub turystycznej. Zmienność czasową w dwóch zakresach prezentują wykresy, a przegląd atrybutów poszczególnych aktywności prezentowanego portalu społecznościowego zapewnia tabela. Elementem spajającym wizualnie wszystkie panele jest wyeksponowana graficznie pojedyncza aktywność.

Przetwarzanie danych odbyło się w środowisku open source, a technologia funkcjonowania aplikacji okna geowizualizacji bazowała na zastosowaniu asynchronicznych zapytań do serwera WWW oraz serwera baz danych co zapewnia sprawne „odświeżanie” poszczególnych paneli.