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TOPOGRAPHIC AND GEODETIC SUPPORT FOR THE DEVELOPMENT OF THE GIS REGISTER OF POLISH BURIALS - CASE STUDY ON BAIKOVE CEMETERY IN KYIV

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Abstract

The purpose of this paper is to elaborate of creating web-GIS of Polish burials at the Baikove Cemetery in Kyiv. Achieving this goal involves the following tasks: to develop the structure of the geographic information system, its framework and to fill the file database. For fulfilment of established tasks, a technological scheme consisting of 12 stages is offered. In the first stage, field surveys were performed to determine the coordinates of each grave of the Polish burials of the Baikove Cemetery using a GIS tablet. The total number of point coordinates was 565, which were concentrated in 7 sections of the cemetery. At the eighth stage of the technological scheme the structure of layouts of each html-page of the created online GIS was developed. In the case of the Baikove Cemetery scheme, plots with Polish burials were marked. At the tenth stage, 5 sheets of topographic plans of burials were generated. The eleventh stage is devoted to the creation and filling of a file database on Polish burials. This database contained the following structure: photo of the burial, coordinates, surname and name, years of life, additional photographs, sex of the buried person, interpreted inscription on the tombstone, as well as, if possible, detailed information and profession of the buried person, its outstanding achievements and accomplishments. At the last stage, the hyperlinks of the transition between the pages were configured and the system was tested. The scientific novelty lies in the development of the concept of joint use of various applications of geoinformation and non-geoinformation purposes. The technological scheme of creation of WEB-GIS of Polish burials of the Baikove Cemetery in Kyiv is offered. The implemented geographic information system is designed for inventory of burials, analysis of the condition of tombstones and their spatial location in the cemetery.

Key words*: WEB-cartography, Polish burials, Baikove Cemetery, historical GIS, file database, burial inventory.*

INTRODUCTION

GIS technologies have found practical application almost everywhere - in forestry, construction, cartography, ecology, seismology, etc. (Openko et al., 2020a, 2020b; Openko et al., 2019; Openko et al., 2017; Openko, 2019a, 2019b).

They are studied in universities and research institutions. GIS technology is a whole industry that affects almost all aspects of human life.

GIS allows mapping of world objects, and their analysis for a large number of parameters, visualization.

Based on this data we can then predict a variety of events and phenomena (Ievsiukov & Openko, 2014; Martyn et al., 2019). This powerful technology allows us to solve a huge number of both global and local problems (Kryvoviaz et al., 2020).

Preservation of cultural heritage is a problem of international importance, as evidenced by the Convention for the Protection of the World Cultural and Natural Heritage, adopted by UNESCO. Solving the problem of cultural heritage preservation is closely related to mapping. The creation of heritage maps is attracting increased attention of researchers and has now developed into a special area of thematic mapping, which needs further development. In addition to the main purpose - inventory of heritage in order to protect it, mapping provides society with new information and knowledge, promotes understanding of the past, present, future. The creation of data banks and heritage maps

allows for a fuller assessment of the importance of cultural monuments, and also to expand programs for their preservation and restoration. Heritage mapping is especially important for historic cities, such as Kyiv.

The current state of collection and storage of materials on monuments of historical and cultural importance is characterized by a variety of documents used to create archives, registers and records. Accounting and information storage services spend large amounts of time on the preparation and issuance of the necessary materials, both to customers and their own departments that are part of the security body.

The materials used by these services are very diverse: textual documentation, historical notes, technical passports, plans of land plots, results of stereo photogrammetric survey (digital models of facades, dimensional drawings), photographic materials, etc. (Pidlisetska, 2015). As the flow of documents increases, it becomes increasingly difficult to record, store, issue and share them with different services and consumers. The development of modern technologies allows us to optimize the overlay of data sources (or datasets), which gave impetus to the idea of creating an information system "Atlas of Polish burials at the Baikove Cemetery in Kyiv" together with our Polish colleagues.

Many foreign and domestic scholars have worked on the creation of various methods for mapping historical and cultural heritage sites. The method of mapping cultural heritage objects using a combination of interpretation of archival aerial photographs and georadar surveying is covered in a scientific article (Chetverikov et al., 2017). The mapping of cultural heritage objects on archival cartographic and aerial representations is described in a number of publications (Chetverikov, 2019, 2020; Arnoud de Boer, 2010; Knowles, 2008). Along with the mapping of historical and cultural heritage sites, the issues of 3D modeling and reconstruction of architectural structures are important (Apollonio et al., 2012; Clini et al., 2017). The use of spatial data and remote sensing data to monitor historical and cultural heritage sites has been previously described (Ehlers & Rhein, 1996; McKeague et al., 2012; Remondino, 2007; Vacca et al., 2018). Methods of creating geoportals with data on cultural heritage sites are covered in previous research (Fiedukowicz et al., 2018; Gregory & Ell, 2007). The design of any atlas is based on the previous achievement of scientists working in the field of integrated atlas mapping for various research objects. For example, Bainozarov A.M. covers the method of designing cartographic products for the the educational complex of Ukraine. Prasul Yu.I. (2004) substantiates the list, structure and content of plans, series of maps and atlases that make up the regional system of cartographic works for tourism. Polyvach K.N. (2007) considers the cultural heritage and its impact on the development of the regions of Ukraine as an object of socio-geographical research, etc.

MATERIALS AND METHODS

To achieve our goal, a technological scheme was proposed, consisting of 12 stages (Figure 1).

The first stage involved the collection of cartographic and descriptive data on the territory of the study area, as well as the search for possible registers of Polish burials. The input graphic materials used were:

- a portion of the topographic plan of Kyiv at a scale of 1: 2000, created in 2009 (since the territory of the cemetery did not change since then, the year of creation for the plan satisfied us) (Figure 2);
- the scheme of the Baikove Cemetery made on the basis of an orthophoto plan (Figure 3);
- maps and satellite images from the online resource Google Maps.

In addition, descriptive materials of figures buried in the cemetery were collected from the Internet and a paper register of Polish burials of the Baikove Cemetery were used as input data.

RESULTS AND DISCUSSIONS

In the second stage, field surveys were conducted to determine the coordinates of each grave of the Polish burials of the Baikove Cemetery using a GNSS controller with RTK antenna LT700H.

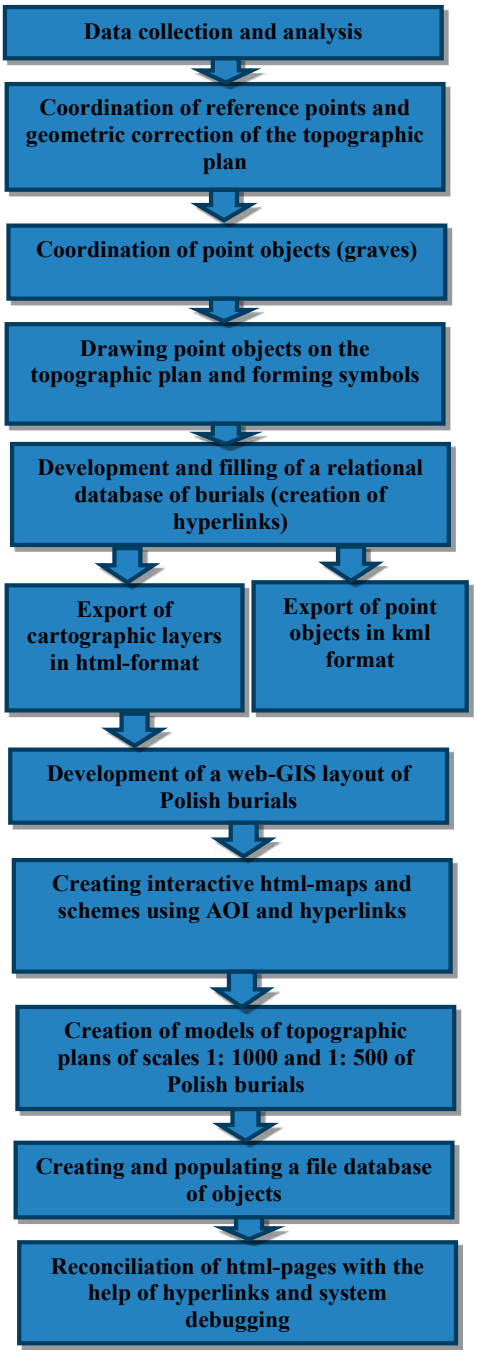

Figure 1. Workflow for web-GIS of Polish burials in Baikove Cemetery

To do this, we evaluated the accuracy of satellite observations. 104 measurements were performed, 77% of which were performed in built-up territory, 23% - in open territory. The research was conducted in the city of Kyiv, the capital of Ukraine, which has a multi-million populations and an oversaturation of built-up territory.

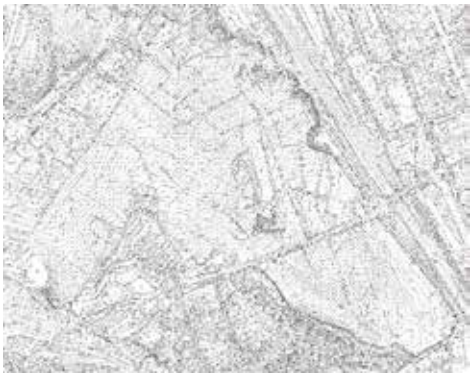

Figure 2. Fragment of the topographic plan of the Baikove Cemetery at a scale of 1: 2000

Figure 3. Scheme of Baikove Cemetery

As the empirical method shows, of the total number of measurement results in 37.50% of errors for GNSS observations are in the 0-2 meters range, 49.04% - 2-5 meters and the other 13.46% - 5-10 meters.

A direct relationship was established between the built-up territory and the accuracy of positioning. With this dependence, not only the height of buildings is important, but also their proximity to the location of the GNSS observation.

According to research, GPS error in large cities and built-up areas can reach more than 5 meters (13.46% of measurement results confirm this). In this case, the height of the adjacent buildings varied from 2 to 20 floors.

According to results, it can be argued that the presence of high-rise buildings significantly affects the accuracy of GPS-positioning when using modern gadgets (in this case, GNSS-tablet - controller). However, in the conditions of "open sky" the maximum accuracy of GPS-positioning can reach 0-5 meters. The magnitude of this error is equivalent to "raw" (raw) satellite observations obtained using specialized geodetic GNSS receivers.

Given that the determined accuracy did not meet the conditions for filming at the Baikove Cemetery, we decided to conduct further filming using RTK corrections with a RTK-antenna LT700H. The application of RTK in satellite observations has improved the predetermined accuracy to 0.30 m.

In the second stage, field surveys were performed to determine the coordinates of each grave of the Polish burials of the Baikove Cemetery using a GIS tablet with an RTK antenna LT700H with accuracy up to 0.30 m.

There were a total of 565 such points in seven sections of the cemetery. The coordinates are obtained in the coordinate system Latitude/Longitude of the WGS84 projection, which are later translated into fractions of a degree for processing point objects in GIS.

Coordinates of reference points were obtained at characteristic points along the perimeter and inside the cemetery by GNSS survey using the ElNav i70 receiver.

The third stage included the coordination of reference points and the binding of this fragment in the GIS MapInfo fragment of the topographic plan of Kyiv at a scale of 1: 2000 on the territory of the Baikove Cemetery. Eleven reference points were used. The transformation was performed according to the polynomial model of the second degree. The maximum binding error is 2 pixels, which corresponds to 0.2 m on the ground (Figure 4).

In the fourth stage, all point objects were spaced according to their coordinates on the map and symbols were chosen (Figure 5).

The standard icon from the MapInfo symbol library - a rectangle with a cross - is selected for the symbol. The symbol was assigned a red colour for contrast display on the background of the topographic plan and size was set to 12 (Figure 6).

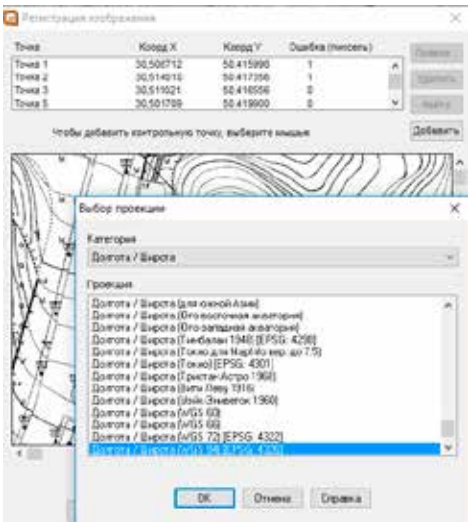

Figure 4. Topographic plan binding window

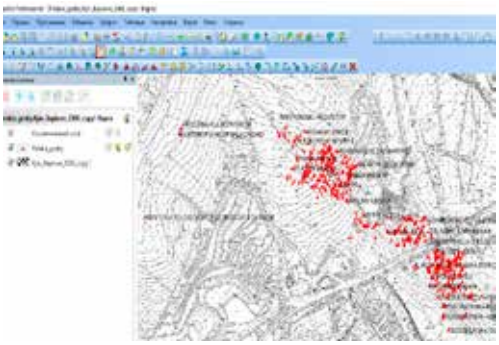

Figure 5. Visualization of the applied point objects of burials on the topographic plan of the Baikove Cemetery

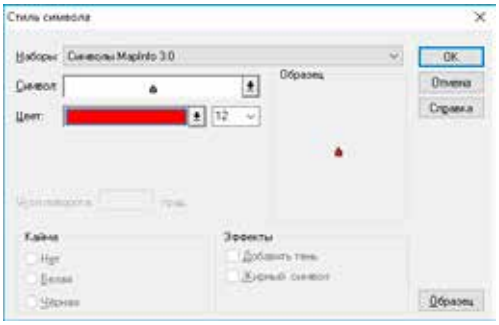

Figure 6. Symbol settings window

The next step was to develop and populate a relational database (Figure 7) for point objects, which included the following columns:

- grave number;
- surname and name of the buried person;
- coordinates of the grave;
- hyperlinks to burial information in the file database.

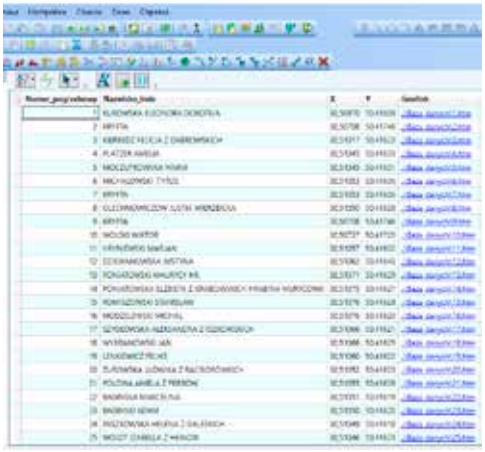

Figure 7. Filled tabular database to the vector layer of point objects

Next, all map layers were exported to html format, and the point object layer was exported to kml format using an universal translator, which allowed viewing of burial data in GoogleEarth (Figure 8).

To export data to html-format we used the application MapInfo HTML-map, written in the programming language MapBasic. This appendix specifies the layer and column that will be used to define the hyperlink. The title of the map and its size in the browser window were also set (Figure 9).

Figure 8. Exported burial dots layer in kml format, opened in Google Earth

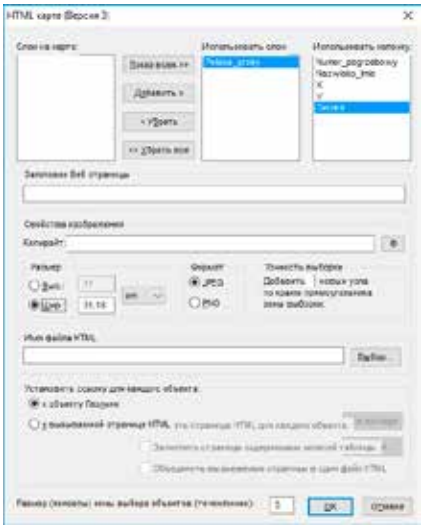

Figure 9. HTML map creation window

At the eighth stage of the workflow the structure of layouts of each html-page of the online GIS was developed (Figure 10).

Figure 10. The main page of the developed GIS

The satellite image on the main page of the system served as a hyperlink to GoogleMaps to view the location of the object and the surrounding infrastructure (Figure 11).

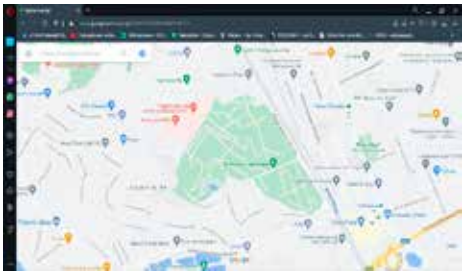

Figure 11. GoogleMaps transition window

All map data had hyperlinks to the selected AOI objects. In the case of the scheme of the Baikove Cemetery, if the areas where there are Polish burials were selected and when clicked on, a topographic plan with marked point burials opens (Figures 12 and 13).

Figure 12. The location scheme of the Baikove Cemetery with configured hyperlinks territories to topographic plans

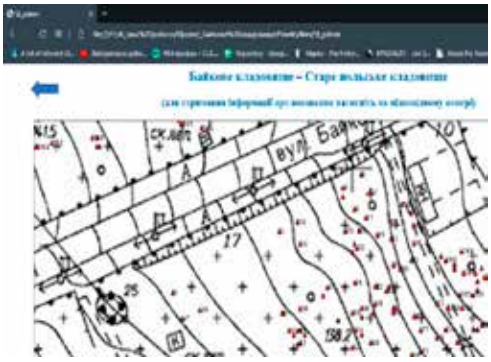

Figure 13. Example of one of the territories of the cemetery in the form of a topographic plan with point objects with programmed hyperlinks to the file database

In turn, when clicking on them, information about the burial appears from the file database (Figure 14).

At the tenth stage, 5 sheets of topographic plans with burials were generated. One sheet at scale 1: 2000 and four sheets at scale 1: 500, for better "spreading" and initialization of burials (Figure 15).

During the eleventh stage, a file database on Polish burials was created and filled. It included the following data: photo of the burial, coordinates, surname and name, years of life, additional photographs (if possible), sex of the buried person, interpreted inscription on the tombstone, as well as, if possible, supporting information and profession of the buried person (Figures 16 and 17).

Figure 14. Example of a database file with burial information

Figure 15. Example of displaying one of the topographic plans with spot objects of Polish burials

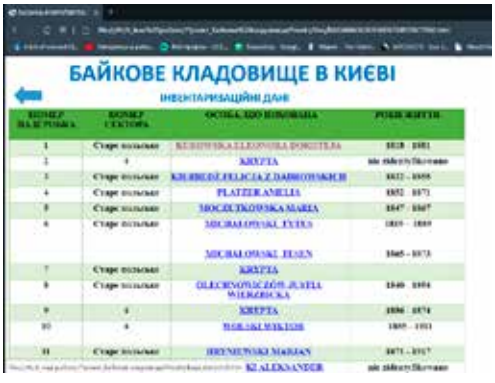

Figure 16. Page with inventory data on Polish burials

Figure 17. Example of a database files with burial information

Finally, the hyperlinks of the transition between the pages were configured and the system was tested.

The technological scheme of creation of WEB-GIS of Polish burials of the Baikove Cemetery in Kyiv is thus offered. The implemented geographic information system is designed for inventory of burials, analysis of the condition of tombstones and their spatial location in the cemetery. In addition, the created GIS can be used for tourism purposes and in the study of historical figures of Polish origin.

CONCLUSIONS

During the study, the maximum accuracy of GNSS - observations for the development of the GIS register in the city of Kyiv was calculated. Using the LT700H controller, we evaluated the accuracy of satellite positioning. In particular, we found that in 37.50% of cases the total positioning error of the measurement results is in the range of 0-2 meters, in 49.04% - 2-5 meters and in 13.46 of cases - 5-10 meters. Based on these results, we decided to use an RTK antenna for the LT700H controller, which allowed for an increase of the positioning accuracy to 0.3 m, for further field work.

As a result of realization of the set purpose the online geoinformation system of the Polish burials on the Baikove Cemetery which includes the following sections is created:

- areas of the cemetery with Polish burials, which are reflected in the topographic plan M 1: 2000, linked in the coordinate system WGS84;
- point objects of each tomb of Polish burials were identified using a GIS tablet with an accuracy of 0.30 m. The objects were plotted on a topographic support and geo-links were created to the corresponding file from the system database;
- models of plans with Polish burials in scales 1: 2000 and 1: 5000;
- inventory table of Polish tombs in the cemetery with the sector of burials, number of the tomb, the person buried and years of life. The person's last name and first name are linked by a geolink to a file database that includes 565 objects;
- generated file with kml extension for viewing burial spot data using GoogleEarth software.
- the system is connected to GoogleMaps.

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