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Web-GIS "Drawings of the Russian State of the 16th-17th centuries"

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Summary: The paper describes an experience of online-publication of the collection of the earliest Russian cartographic drawings (2nd half of the 17th century mostly), which cover a significant part of Russian territory, mainly the European part. Most of them have never been published and were not easily accessible for scholars and users due to poor physical condition. The web-GIS combines opportunities of geocoding of picture with capacity to use an authentic image. It contains tools for navigation on the map, filtering drawings by date and text, referencing with historical administrative division and modern topography, studying of drawing as a picture, transcription of 17th century handwritings.

Introduction

The mapping of historical data related to the pre-Modern period has its own specifics. First, as a rule spatial coordinates of objects may be specified only with great approximation. Second, when comparing the objects of one chronological layer, it is necessary to have an idea about historical context in which these objects existed. When comparing the sets of diachronic data, we should know what kind of deformation of the historical context happened within the timeline.

We want to share an experience of online-publication of Russian archival materials by means of web-GIS project. The project is based on the 17th century Russian cartographic drawings, preserved in Russian State Archive of Ancient Documents mostly. Also we managed to publish several drawings from other Russian collections (Archive of Saint-Petersburg Institute of History (Russian Academy of Sciences), Russian State Library, State Historical Museum). The project had been carried out by the Laboratory of Historical Geoinformatics at the Institute of World History (Russian Academy of Sciences) in collaboration with Russian State Archive of Ancient Documents. The frontend of the project was built by NextGIS company. The financial support was granted by Russian Scientific Foundation.

This project should be treated as a part of a future Russian national historical GIS. The solutions it approves, aim to practice in user-friendly presentation of historical data: 1) to publish unique archival materials about Russian history; 2) to elaborate a technique of online publication on the basis of GIS-technology; 3) to study the published materials as sources on historical geography.
Web-GIS project "Drawings of the Russian State of the 16th-17th centuries"\textsuperscript{1}

This project is devoted to publication of the collection of the earliest Russian cartographic drawings (mainly the 2nd half of the 17\textsuperscript{th} century). The online publication is a significant step in ensuring safety of archival documents. It is especially important for the earliest Russian cartographic materials. Providing online availability of archival information is a courageous experiment for which only few archives in the world feel ready. The whole collection comprises about 1000 documents. Most of them have never been published, and they are not easily accessible for scholars and users. The Catalogue of these artifacts was prepared by Vladimir Kusov. It formed the basis of our work but nearly one hundred new documents was uncovered extra Catalogue (Golubinskij, Frolov 2019). The drawings of the collection are most valuable for public viewing for the "geographic information" they hold, i.e. symbolic representation of settlements, forests, lakes, roads etc. For this reason, integration of these drawings with a cartographic basis is a central point of our publication.

On the other hand, geographical context facilitates using textual information from these documents in various sorts of studies such as investigation of social relations in Russian villages (Kivelson 2006), reconstruction of the facades of churches, that have disappeared over time (Nikolaeva 2017), studying of historical Russian town planning, changes in landscape, etc.

There are many internet resources in the world currently sharing historical maps. But most of them are dealing with small-scale images or drawings that may be easily geocoded by popular transformation algorithms. Russian drawings of the 17\textsuperscript{th} century were not made on a mathematical basis, usually they have no universal scale. Most of them are pictures or large scale schemes made by the visual method. Usually the craftsman had no goal to constrain proportions with which real objects were connected. Literally, "geocoding" cannot be applied to these artifacts. Some attempts to correlate recognizable points of the image with landscape features on the map show that, in many cases, the result changes the initial image beyond recognition (Fig. 1-3). So it cannot be effectively used to relate the images with a map. As a result, our decision was to use only a primitive transformation algorithm (Helmert transformation) that could demonstrate only approximately the positions of objects depicted on the drawing.

\textsuperscript{1}http://rgada.info/geos2/
Fig. 1. "Geocoding" of the drawing № 305 by "thin plate spline" algorithm.

Fig. 2. "Geocoding" of the drawing № 359 by "thin plate spline" algorithm.
Two pairs of points were enough to "georeference" a drawing. For more precise and informative relation of the image with a map, we have omitted geocoding of the raster. For each drawing that could be correlated with locality, we created a vector polygon which approximately covers the territory depicted on the drawing. First, we explored objects lying at the edges of the drawing to find them on a map (Fig. 4-6). The current and historical state of the area was analyzed using a number of cartographical resources published on the Internet such as Yandex maps\(^2\), Google maps\(^3\), Marshruty.Ru\(^4\), EtoMesto.ru\(^5\) etc. Whenever possible data of the General Land Survey (dated from the middle 18\(^{th}\) to the 19\(^{th}\) century) were also used. This way we traced margins of the depicted locality, taking into account relief and other features of landscape, names of heathlands and natural boundaries. Some polygons have a very sophisticated configuration which demonstrates the appropriate degree of distortion of reality that the drawing has.

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\(^2\) https://yandex.ru/maps/
\(^3\) https://www.google.ru/maps/
\(^4\) http://www.marshruty.ru/
\(^5\) http://www.etomesto.ru/
Fig. 4. Alignment of historical image with map (a) and appropriate territory covered by the drawing №305 (b).
Fig. 5. Alignment of historical image with map (a) and appropriate territory covered by the drawing №359 (b).
Fig. 6. Alignment of historical image with map (a) and appropriate territory covered by the drawing №779 (b).
In 2014—2018, we managed to localize more than 740 Russian drawings of the 17th century. All the results are integrated into the web-GIS "Drawings of the Russian State of the 16th-17th centuries"\(^6\). The project materials are represented in three dimensions.

1) The basic dimension (Fig. 4–6) is represented by a map with a layer of pins marking centroids of polygons (the left part of display) and a table with brief information about each drawing (the right part of display). In many cases, several polygons overlap or intersect each other on map. Sometimes, they are situated in close neighborhoods to one another. To make perception of the appropriate pins better, we used clustering. The color of clusters differs from the amount of pins that the cluster united. The clustering changes during scaling the view. The pink polygon with red contour emerges when the mouse pointer appears over the pin. The click on the pin brings the georeferenced raster. Its transparency is flexible and changes by the scroll bar. OpenStreetMap substrate layer facilitates the orientation of the polygon and raster in relation to the locality. The user may choose among three variants or switch them all off.

Besides substrate layer with modern topography the web-GIS is provided by layers reflecting administrative structure of Russian State in the 17th c. This date facilitates to integrate data from drawings to historical context. One layer renders historical borders of basic administrative units called “uezds”. Another layer shows towns that served as centers of “uezds” (Fig. 7). In the current version of web-GIS these two layers are static, but we realize that this functionality needs further development that should be given in the future. Project development plans include the integration of this kind of historical data with a server of a dynamic map of Russia's historical borders. It is assumed that as a result, the user will be able to obtain cartographic data on the historical administrative division for a specific year using the timeline tool. The concept of dynamic map is developed by the Laboratory of Historical Geoinformatics of the Institute of World History of the Russian Academy of Sciences and implemented on the base of Runivers project "Russia’s Borders from 850 through 2018" (Frolov 2017)\(^7\). It involves loading thematic layers on the web pages of various historical resources from a geoserver, which contains the original copy of the corresponding historical geodata.

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\(^6\) http://rgada.info/geos2/

\(^7\) https://map.runivers.ru/?year=1720
The brief information table on the web-GIS main page is provided by the search line. The search tool helps to find any specified drawing by text fragment contained in basic sections of the drawing description. The data about chosen drawing appear on the place of the brief information table (the right part of display). Besides textual data one can find here a preview image of the drawing. We should note that in the current version of the web-GIS the content of our table follows after the Catalogue, which reflects the text of drawings in far from complete form. In the coming year we are planning to update the content of the table and replace the Catalogue text by our own results of reading. One more filter of table content concerns chronology. User has an opportunity to collate drawings dated to specific period.

2) For more details about the drawings, users can go to the full version of the table and use the text filter to search in every specified field (Fig. 8). These fields are as follows (mainly according to Kusov with some supplements): Catalogue number, Title, Archival Code, Size, Art Technique, Watermarks, Comments About Artifact, Lower Date, Upper Date, Conventions, Text on the Front Side, Text on the Reverse Side, Bibliography, Context of the Document. From any record, the user may go to the map space by click. In this case, the map becomes centered by the chosen drawing.
3) The third dimension of the project is represented by the large format image which may be accessed in a separate window by clicking on the preview image in the right part of display. The large format image is not transformed by geocoding. The window is provided by toolbox to facilitate the navigation: zooming, moving, rotation (Fig. 9). But simple reproduction of drawings online cannot guarantee relevant perception of the text for the majority of users. The handwritings of the 17th century are not always easily read even by an experienced archaeographer (Fig. 10). That’s why we included one more feature on the canvas: each fragment of the drawing containing text is covered by semi-transparent polygon with tooltip including literal reproduction of the text. The layer of polygons refers to inscriptions on drawings and may be enabled or disabled. All this content is saved in *.xml files. After being checked, information of these inscriptions will be inserted into the brief and full versions of the table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Size</th>
<th>Layer</th>
<th>Polygon</th>
<th>Tooltip</th>
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<td>...</td>
</tr>
</tbody>
</table>

**Fig. 8.** Full version of the table of attributes with text filters for search.
Fig. 9. Large format image of drawing with toolbox for navigation and polygons with tooltip including literal reproduction of the text.

Fig. 10. The 17th century handwriting sample from the drawing №239.

The preliminary results of the project:

1) We introduced, for scientific use, a significant part of the Russian drawings that had been preserved since the 16th and 17th centuries, about 1000 artifacts are described in
the table, more than 740 of them were mapped (Fig. 11, 12). This resource attracts the attention of scholars (historians, cartographers, geographers and others), and all people interested in geographic information of historical sources;

2) We elaborated methods of publication of historical materials via GIS technologies, and we discovered the original technique of tracing the area depicted on the drawing by means of polygons covering the appropriate locality;

3) We accomplished some studies about Russian pre-Modern drawings as a historical source, comparing with materials of the 1st part of 18th century and General Land Survey (2nd half of the 18th century);

4) The constant interest to historical maps leads to the idea of publication of plans and maps of the whole 18th century. On the base of “Drawings…” we still are working on a GIS-system concerning General Land Survey materials of contemporary territory of Moscow landscape;

5) The project approved Zoomify software to be perspective for exposition of almost all the materials (for example inventories) of our archive’s site, because this method has the possibility to index text materials and save them in full-text form.

Fig. 11. Fragment of layer with polygons covering zones depicted in the drawings.
Some technical aspects of the project

- desktop GIS software for data mining – QGIS (installation boxes by OSGeo, NextGIS, QGIS KyngChaos);
- three-tier architecture of web-GIS;
- operation system of the NextGISWeb geoserver – Ubuntu 16.04 LTS;
- cartographic projection – EPSG:3857;
- raster files – GeoTiff, six pyramids, downloaded via NextGISManager;
- vector files – *.shp, *.GeoJSON and Postgis;
- operation system of the application server – Ubuntu 14.04 LTS;
- spatial library – Leaflet;
- to accelerate the download of polygons and rasters to the client and reduce the traffic they should be swapped only after choosing the pin by click;
- exchange by text data via GeoJSON using Javascript and PHP;
- large format images are disposed on the base of Zoomify PRO.

References

Frolov, A. A. (2017). Dinamicheskaya karta kak osnova istoricheskoy karty v srede GIS. 


