The functionality analysis of the quantum GIS Geo-information system as a part of the small-scale maps creation

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Abstract. The article discusses the process of creating small-scale maps by means of a Quantum GIS geographic information system, and also highlights the current directions for the software products functionality development in order to automate and optimize the mapping processes in a GIS environment.

Introduction
Over the past few decades, the need for creating small-scale maps has increased tremendously due to the increasing mobility of people, the increasing number of geospatial relationships and the emerging problems caused by the irrational use of resources.

More and more data provided by means of the map are the object of scientific knowledge in the organization, planning, rational land use. The geospatial information analysis in accordance with the required accuracy for its mapping [1] is produced by GIS for general and special purposes: ArcGis, ArcView, MapInfo, Map 2011, Quantum GIS, etc.

When using GIS technologies, working with a digital map is carried out as with a discrete model containing all the analog map elements based on general requirements for this type of image [1-2]. However, in practice, often when creating maps using geographic information systems, one has to face several difficulties at the design stage of the mathematical basis and content of the map, the final layout formation for preparing the original map [3].

Materials and methods
For most of these tasks, the Quantum GIS (QGIS) open source GIS desktop system has a list of relevant tools. Despite of this product availability, its functionality is slightly inferior to the most popular geo-information systems (ArcGIS, MapInfo, etc.) and is rapidly expanding.

The sources of spatial data are the data in the digital video of the analog or vector representation: maps, plans, atlases and other cartographic works; Earth remote sensing data; data of field surveys and field observations; as well as the departmental and state statistics data.

Within the QGIS software, the task of gathering available geospatial information from public services is solved with the Quick Map Services module developed by the NextGIS team. This extension allows to work with a variety of ready-made map substrates, TMS-, WMS- and WFS-servers, as well as data sets in GeoJSON format, without causing errors during scaling. The advantages of the module also include a documented open API with the ability to access the entire catalog of services.
Often, when using the raster substrates and other types of displaying cartographic information, there is a need to vectorize the map objects. In this connection, it is appropriate to note that the way to organize data in a GIS is a layer model, the essence of which is to divide objects into thematic layers. The objects belonging to one layer are stored in a separate file and have their own system of identifiers and a certain character of localization (point, linear, polygon, vector).

The map objects identification in QGIS software is carried out by means of a style editor in the layer properties, providing the ability to create and edit complex conventions, as well as load symbol libraries from third-party resources.

At the same time, despite the countless number of symbols used, the number of cartographic image methods is limited. Today, when creating small-scale maps in classical cartography, the following basic imaging methods are used: icons, scatter, localized diagrams, linear signs, motion signs, contour lines, pseudo-isolines, area, qualitative and quantitative background, chart diagrams and cartograms.

The presented cartographic image methods are successfully implemented in the QGIS environment (Table 1). As an exception, a point display method can be given due to the impossibility of assigning weights to points by means of currently existing tools. In this case, it is possible to depict the mapped phenomena or objects when working with conventional values of the attribute data, taking into account that one point represents one conventional unit.

A point-like cartographic image analogue in a GIS environment can be heat maps, which are a tool for visualizing the density of point data when mapping the population, the number of road accidents, crime data, etc.

### Table 1. Tools for developing map content using QGIS software

| Tool name in QGIS                          | Map display method in classic cartography                                      |
|-------------------------------------------|--------------------------------------------------------------------------------|
| Common sign                               | Icons, linear signs, motion signs, range, high-quality background              |
| Unique values                             | Icons, linear signs, movement signs, area, qualitative background, quantitative background, cartodiagram, cartogram |
| Graduated sign rules                      |                                                                                |
| Random points inside the polygon (point weight = 1) | Separate                                                                    |
| Creating a heat map                       |                                                                                |
| Create contours                           | Isolines and pseudo-isolines                                                  |
| Contour plugin                            |                                                                                |
| Chart Layer Properties                    | Localized charts, cartodiagrams                                               |

Within the constructing and applying conventional symbols task framework, it is necessary to note that users with different levels of classical cartography basics knowledge are often involved in creating maps in GIS. In this regard, the issue of developing a tool for the informed choice of the cartographic image optimal method, taking into account the purpose of the map and the localization of phenomena, is relevant.

The choice of imaging methods is influenced by the scale and characteristics of the territory, which determines mainly the number of depicted phenomena and the degree of their generalization. The degree of generalization is determined primarily by the understanding of the creator of the mapped objects and phenomena content map, the ability to reflect their main features. From the geographic information systems point of view, the generalization process is an automatic process of spatial objects positional and attribute data generalization by means of programmed selection algorithms, as well as various tools of generalization.

The key role in the process of automatic generalization by means of modern GIS is played by the multiscale concept, which implies the use of data that form different levels of spatial and semantic
detailing. Each level is optimized for display in a certain range of scales, within which the data can be used without compromising map readability, display speed and aesthetics [4].

In QGIS software, the described visualization principle is implemented by processing data “on the fly”, representing the queries sending to databases that determine the qualifications and rules for selecting objects displayed on the map. Along with algorithmic processes, generalization tools that allow the user to independently limit the display of objects in the scale series (the Scale Dependent Visibility function) and simplify their geometry to the extent necessary (Simplify Geometry, integrated GRASS module - v.generalize) can also be used.

One of the most important elements of the map on which the cartographic image is built is a mathematical basis. The search for the mathematical basis of the map suggests the choice of the mapping scale, the optimal cartographic projection, as well as the construction of the cartographic grid and layout [5].

The determining requirements when choosing the scale of mapping are to ensure a given accuracy, the ratio of the map format and the map size territory, as well as the completeness and detail of the map.

As noted earlier, the scale is closely related to the degree of generalization of the image. In QGIS software, working with a multiscale map allows to avoid difficulties with the generalization and simplification of objects in the event of a change in the scale of mapping. The program also includes a tool called Magnifier, allowing to zoom in / out the image without changing the scale.

In the issue of improving the accuracy of small-scale maps, an important role is played by the optimal cartographic projection choice. One of the criteria for choosing a cartographic projection is the distortion value obtained during the design process.

At present, there is no “ideal” projection, the distortions of which in all directions would not exceed the planned accuracy limits. In this regard, it is important to take into account the length distortions ratio, areas and angles, depending on the cartographic material purpose. However, the distortions calculation obtained by designing on a plane is a long, laborious and requiring in-depth knowledge of the process [6].

The functionality of QGIS in conjunction with a competent methodology, including aspects of mathematical analysis, allows you to partially automate and speed up the choice of the optimal cartographic projection. Automation and optimization of this process is achieved by using the external module Projection Factors, developed by the University of Zagreb scientists, to display all the distortion parameters and integrate the PostgreSQL database management system together with the Post-GIS extension that adds support for spatial data for storing a large data set. and its processing.

When designing a cartographic grid, its frequency should be taken into account, which depends on the scale and location of the displayed area. In QGIS, the grid can be created directly in the project window (using the functions of the f-Tools module - Create a grid, then Condense by number), and when creating a map layout, setting the required coordinate system and frequency.

The issue development actual direction of designing a cartographic grid in GIS is the creation of a tool for automated frequency selection depending on the scale and location of the territory.

Building layout is performed using and mutual agreement of all the considered elements of the mathematical framework. The QGIS software uses the Layout mode for the design and layout purposes. This mode provides the user with a wide range of functional capabilities:

1. placement of the cartographic image, inscriptions, frames, figures and other objects inside the frame and in the fields of the map;
2. changing the size, grouping, position and orientation of any element;
3. design of the symbols used in the map preparation;
4. adding numerical and graphical scale;
5. drawing the frame and cartographic grid;
6. atlases creation.

The issue of creating cartographic material closes its printing or export to image formats (PNG, BPM, TIF, JPG, etc.), as well as PDF and SVG.
Thus, within the framework of determining the modern GIS functional development directions, the need to develop tools for a reasonable choice of the optimal cartographic image method, the optimal cartographic projection, as well as the scale and frequency of the cartographic grid should be noted.

**Conclusion**

Despite the absence of the listed tools at the moment, the use of a wide functionality of geo-information systems makes it possible to increase the efficiency of creating small-scale maps by reducing the time and labor-intensiveness of the work, as well as to improve the accuracy of the cartographic material created. In connection with automating the process of creating a map and optimizing the choice of its elements, working in a GIS environment does not require the user to have a thorough knowledge of the cartography basics, but only a specialist in this field can competently create a cartographic work for further work with it on the local, regional, federal and global levels.

**Summary**

In connection with the above-mentioned, a number of main conclusions should be made:

1. The dominant type of cartographic works are remote sensing (RS) data, digital maps, with a gradual shift to the background plan of analog maps and other cartographic products.
2. The map properties are transformed due to a change in the formal presentation of the data:
   - Character (symbolism) of the image changed to a visual panoramic, while not always the ways of displaying information in the GIS environment correspond to the ways of the classical series image.
   - Map generalization is carried out in an automated mode due to the multiscale presentation of digital cartographic works, against the background of a thorough, meaningful manual generalization process being carried out for all the large-scale series of analog cards. Since this process is connected with the information presentation comprehension from the point of view of the territory geographical features, it is very difficult to qualitatively automate and is not always possible to provide an objective picture of the area;
   - The digital cartographic works construction mathematical law is associated with a promising high-precision data presentation, the method of creating and applying cartographic projections improvement.
3. The process development and improvement of creating modern small-scale maps with software means it is possible exclusively to automate subject-specific tasks, which can only be improved and modernized by an expert on the topic with a good level of knowledge and skills in programming and geo-information technology.

**References**

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