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# APPLICATION OF GEOINFORMATION THECHNOLOGIES AND GRAPH THEORY FOR DESIGNING OF TOURIST TRAILS IN THE HISTORIACAL CENTER OF POLOTSK

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*In the article, the principles of geographic information systems for tourism in the historical center of Polotsk are presented. Potential of graph theory for interactive designing of tourist trails is discussed.*

Polotsk is the oldest city, historical and ecclesiastical center of Belarus. Thousands of tourists come here every year for sightseeing, for the spirit of the old days, for refreshment. Polotsk is included in some tourist trails in Belarus, which offer to visit the most famous cultural sights of the city.

In spite of developed touristic infrastructure, information support of cultural events in Polotsk, descriptive map material is insufficient, e.g. designed trails are typical and interests of individual tourists are often not considered. In fact, besides generally known, recognized sights, guests of the city are also interested in monuments, museums, giftshops, cafeterias and restaurants, shops etc. But each guest has his own priorities, own understanding of the rest.

To solve the task of information and mapping support of tourism in the region geoinformation system (GIS) is created. It allows systematizing information about sights of the historical center of Polotsk and touristic infrastructure as well as visualization in GIS environment and its interactive use. For designing a trial one needs to point out initial and concluding sites chosen from database of touristic objects. The instrument for designing of tourist trails depending on individual preferences is also presented.

Implementation of the task is conducted for the central (historical) part of Polotsk using geographic information systems and graph theory.

Graph theory is the section of discrete mathematics that studies graphs (classes of non-empty sets of nodes and edges). Edges connect nodes [1]. Depending on task specific objects, features may be chosen as nodes and edges, e.g. buildings, installations, even settlements are treated as graph nodes and roads, elements of engineering networks are treated as edges. Applying graph theory allows finding the shortest detour, planning the best route etc. Graph theory is often used in such fields as chemistry, social networks, communications, logistics, economics, informatics, programming, socio-economics, transportation, regional planning, geoinformation systems etc.

Modern GIS-programs have a large set of instruments for solving tasks of spatial planning, data systematizing, storage, displaying in easily readable forms. For solving some of the tasks of spatial planning they invoke graph theory, e.g. modules Network Analyst of ArcGIS, Road Graph of Quantum GIS etc implement principles and apparatus of graph theory. Grafoanalizator (Графоанализатор) for Windows and Rocs for UNIX are special software for graphs structuring. Scope of such special-built products for classical tasks of graph theory as a rule is wider than modules of GIS-program. With the help of such software one can design directed graph, assign weights of edges and nodes and the availability of map material is not a mandatory requirement. Speaking of GIS-programs, they are more focused on treatment of transportation tasks and similar.

Shortest path algorithms such as Dijkstra's algorithm, Bellman-Ford algorithm and others are the most common tasks of computations on graphs. Each of the shortest path algorithms has advantages and disadvantages and therefore is more or less appropriate to solve a certain problem. Operating principles of the most famous algorithms are implemented in modules Network Analyst of ArcGIS and RoadGraph of Quantum GIS and similar.

So, the first problem that is the designing of touristic GIS of the historical center of Polotsk is fulfilled using Quantum GIS (QGIS). The second problem than is designing the technological scheme for developing of interactive tourist trails is executed using module RoadGraph of Quantum GIS as well as Graphoanalyzator. Both programs are free software what was one of the main arguments when choosing the software.

Input cartographic data are data from service Openstreetmap for the area of historical center of Polotsk [2]. After data preparation including additional information insertion thematic data was grouped into the following layers:

- road network and pedestrian zones;
- buildings;
- sights (museums, monuments, etc);
- tourism (hotels, hostels, banking center, cash machines, etc);
- transport (automobile and rail transport, public transport stops);
- hydrography.

Fragments of attribute tables and GIS-project map for study area is presented in figures 1 and 2. As one can see initially for tourist trails designing only essential sights are included into database in order to test the algorithms of problem solving.

| | OSM_ID | NAME | MAN_MADE | LEISURE | TOURISM |
|---|---|---|---|---|---|
| 30 | 2788679869 | Борисов камень | NULL | NULL | attraction |
| 33 | 827458526 | Борисов камень | NULL | NULL | attraction |
| 37 | 2788686601 | Церковь Святой Софии | NULL | NULL | attraction |
| 54 | 2788687301 | Церковь евангелическая | NULL | NULL | attraction |
| 56 | 2788681661 | Коллегиум иезуитов | NULL | NULL | attraction |
| 63 | 2788681875 | Костел Святого Андрея Боболи | NULL | NULL | attraction |
| 66 | 2788681648 | Кляштор францисканцев | NULL | NULL | attraction |
| 72 | 2788683384 | Памятник войне 1812 г. | NULL | NULL | attraction |

Fig. 1. Fragment of attribute table of the layer "Sights".


Fig. 2. Fragment of GIS of historical center of Polotsk

Now we move to the second problem that is designing and choosing tourist trails with the help of graphs. Let us assume city streets as edges of undirected and weighted graph and touristic sights and other elements of touristic infrastructure as graph nodes. Since users are interested in the shortest paths between certain objects the weights of edges are equal to the distances in meters between nodes (touristic sights and elements of infrastructure) that edges connect.

Graph structured for the purpose of tourist trails designing using Quantum GIS is presented in figure 3.

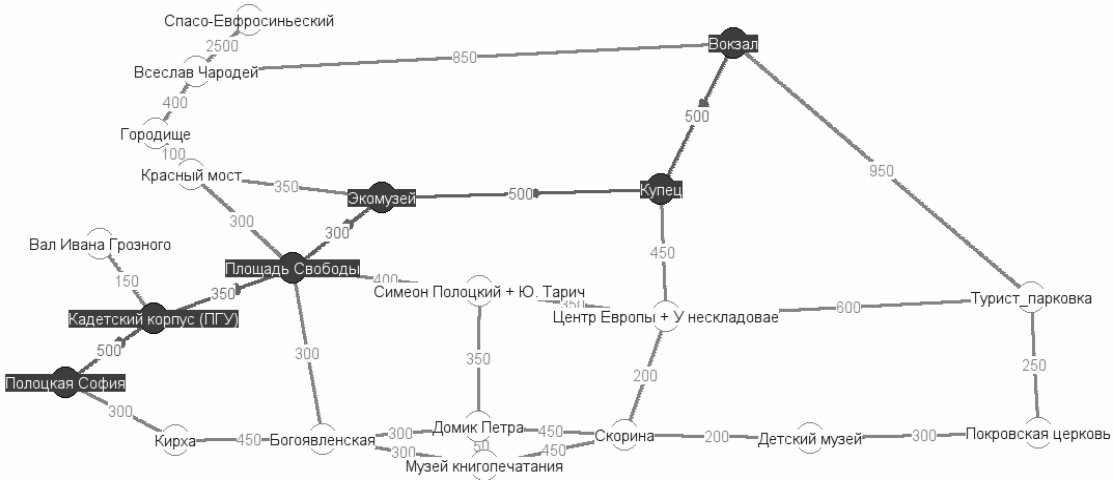


Fig. 3. Sights and streets of Polotsk as graph.
The shortest path between station and Polotsk Sofia is highlighted

This graph has 21 nodes and 30 edges. 13 nodes of them are uneven (it means that uneven number of edges come to each of them). The graph:

- is planar (edges do not intersect);
- is circuit graph (has cycles);

– is connected (all nodes are connected);
– has Hamiltonian chain (path which visits each node only once);
– does not have Hamiltonian and Eulerian cycles.

Therefore such classical problems as "travelling salesman problem" and "seven bridges problem" do not have solution for the graph since it does not have Hamiltonian and (or) Eulerian cycles.

For designing of tourist trails we tested shortest path algorithms such as Dijkstra's algorithm, Floyd-Warshall algorithm, Bellman-Ford algorithm. In figure 3 the results of Dijkstra's algorithm is presented. The initial and end points of the trail are station and Polotsk Sofia consequently.

All of three algorithms for the current trail presented equal results. Beyond that Hamiltonian path and Eulerian cycles are tested. Dijkstra's algorithm is the simplest in computations. Also for spatial tasks Dijkstra's algorithm is often enough.

For problem of trails designing solving the list of objects and their characteristics for cafeterias, restaurants, hotels, squares, giftshops, different kinds of shops, pedestrian zones, roads, means of transport, public transport routes is to be expanded. The scope of criteria determining weights of edged and nodes is also to be expanded in order to use the opportunity of indicating tourist trail themes, age of tourists, means of transportation including public transport with stops and timetable. Study area is also to be enlarged and to be included Polotsk region and Novopolotsk.

GIS of historical center of Polotsk may be used for:

– recording and systematizing of data about historical, architectural and cultural sights of Polotsk,
– designing of excursion tours and trails of diverse theme, focus and timing in Polotsk,
– planning and optimization of touristic infrastructure,
– designing of excursion trails for city schoolchildren of different age,
– designing of mobile application, virtual tours,
– implementation of similar projects for other places as well as designing tourist trails at the republic-wide level,
– teaching geoinformation systems and tourism management.

Graph theory has great perspectives in geographical science what says about the actuality of such research. Joint use of GIS and graph theory makes possible to solve problem of tourist trails designing using different criteria. The list of criteria and their quantification effecting the weights of edges and nodes needs additional correcting.

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## RESEARCH OF SURFACE ROUGHNESS AT MILLING BY FACE BLOCK-MODULAR MILLING CUTTER

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*The results of research of surface roughness during machining by face block-modular milling cutter compared to milling cutter designed by VNII instrument are presented.*

One of the most commonly used processes in industry and mechanical workshops for machining with the exact size and shape is milling. With the release of high-quality tools for milling using the modular principle layout , which provides inter-type unification and reducing the cost of the cutting tool. Production of modular mills in domestic enterprises is limited by high demands on their reliability and the need to use modern high-precision equipment for it production. Therefore, in the department of technology and equipment of machine-building industry design modular face mill was developed, which allows to minimize the disadvantages of used mills. The modularity of it millings is achieved by using a unified cutting block [1, 2]. The reliability of the developed system of fixing the cutting insert in the cutting block and cutting block in housing module considered in [3, 4]. Stiffness of modular cutting tools discussed in [5].