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Intelligent information system for assessing the dynamics of natural disaster development

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Abstract. In the article some popular geoinformation systems are considered, and their main advantages and disadvantages are revealed. A geoinformation system is proposed that has the functions of geometric modeling of the dynamics of the contours of forest fires in the terrain. A module for processing and calculating mathematical models of contours has been developed.

1 Introduction

In the 1990s, information systems providing a set of functions for representing and visualizing geographic data saw intensive development. Among them are systems capable of simulating various dynamic situations. Notable examples of intelligent GIS include services like "Yandex.Maps" and "Google Maps." Their distinctive feature is the ability to create routes for vehicles and pedestrians, taking into account traffic difficulties, as well as user statistics for those using the service.

2 Materials and methods

The *Google Earth* geographic information system [1] is a desktop version of *Google Maps* [2] and fully implements all its functions. The service exists in two versions: a web application (Figure 1) and a desktop application with extended functionality (Figure 2). A distinguishing feature of the system is the use of a three-dimensional model of the entire globe for visualizing the final image. The service provides a "3D Buildings" layer with three-dimensional models added by developers or users themselves through the *3D Warehouse* service. The disadvantages of this system include the relatively large size of the geographic data, the inability to use third-party raster and vector layers, the inability to expand the system with custom geographic data, and the lack of modeling capabilities for various processes in the terrain.

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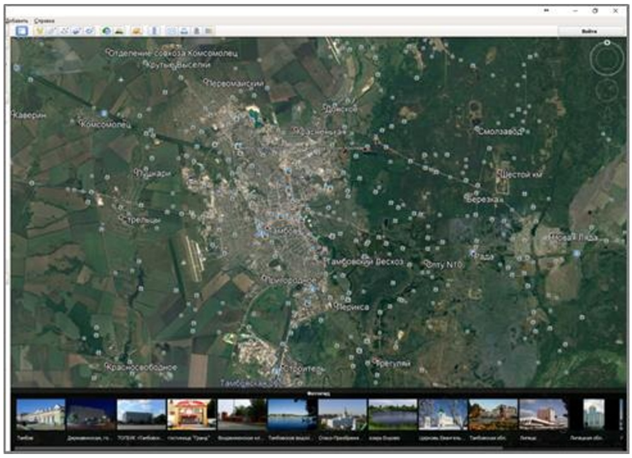

Fig. 1. Interface of the Google Earth geographic information system

Fig. 2. The web interface of the Google Earth geographic information system

2GIS [3] (Figure 3) is an international geographic information system created in 1999. A distinctive feature of this service is its provision of reference information about enterprises and organizations in many cities of Russia, as well as several cities abroad, including Ukraine, Kazakhstan, Italy, the Czech Republic, Chile, the UAE, Kyrgyzstan, and Cyprus. The main drawback of the system is the limitation on the displayed map area, usually restricted to a single city, the absence of the ability to use third-party geographic data, and the lack of support for modeling processes in the terrain.

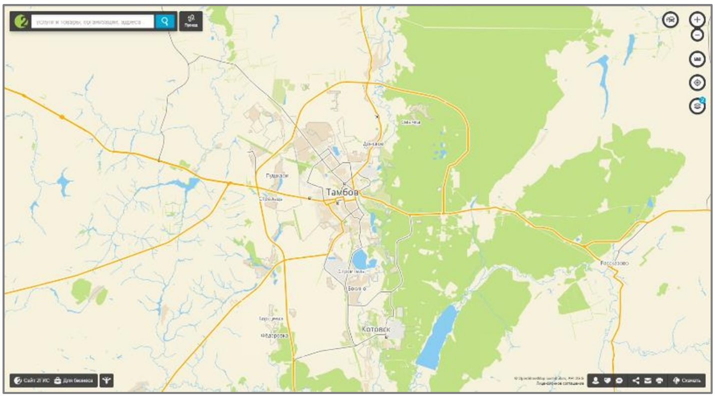

Fig. 3. Interface of the 2GIS geoinformation system

GRASS [4] (Figure 4) is a spatial information processing system developed since 1982 with the participation of the U.S. government, research institutes, and companies. This tool is built on a modular principle and integrates a variety of different modules that address tasks related to visualization, import, export, and more. Initially, the system was focused on command-line operation; however, it now supports two types of visual interfaces. The disadvantages of the tool include the inability to use common raster and vector layers, route building, and modeling various processes in the terrain.

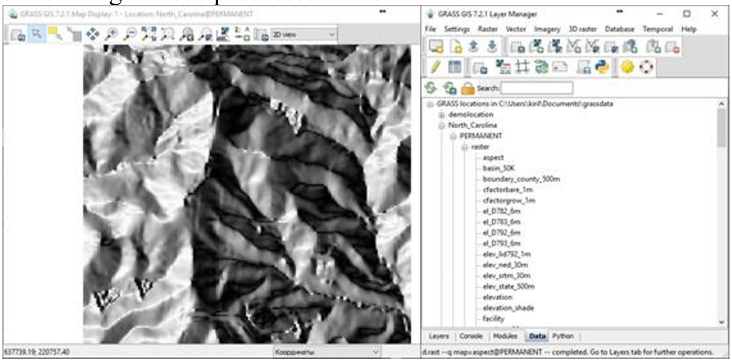

Fig. 4. Interface of the GRASS geographic information system

A summary table 1 has been created based on the reviewed geographic information systems, reflecting the advantages and disadvantages of these software tools.

Table 1. Summary of the advantages and disadvantages of GIS

№	System	Advantages	Disadvantages
1.	*Google Earth* [1, 5, 6, 7, 8]	Open access Map detail 3D street panoramas Route planning Information search View the map from any angle to the horizon	No system for adding third-party layers Users cannot edit information No system for modeling processes in the terrain Closed source code Absence of the ability to extend system functions with third-party modules
2.	2*GIS* [3, 9, 10, 11, 12]	Open access Map detail	No system for adding third-party layers

№	System	Advantages	Disadvantages
		Street panoramas Route planning Information search Extensive reference information about organizations	Limited number of street panoramas Users cannot edit information No system for modeling processes in the terrain Closed source code Absence of the ability to extend system functions with third-party modules
3.	*GRASS* [4, 13, 14, 15, 16]	Open access	No system for loading layers from open services No routing system No information search system Users cannot share information No system for modeling processes in the terrain Closed source code Absence of the ability to extend system functions with third-party modules

The analysis of the data presented in Table 1 allows us to conclude that most modern publicly accessible geographic information systems have a very limited set of functions, possess a closed structure, and lack the ability for expansion by the user community.

Most modern geographic information systems have the architecture shown in Figure 5, which implements a minimal set of functions for processing geographic data and their representation.

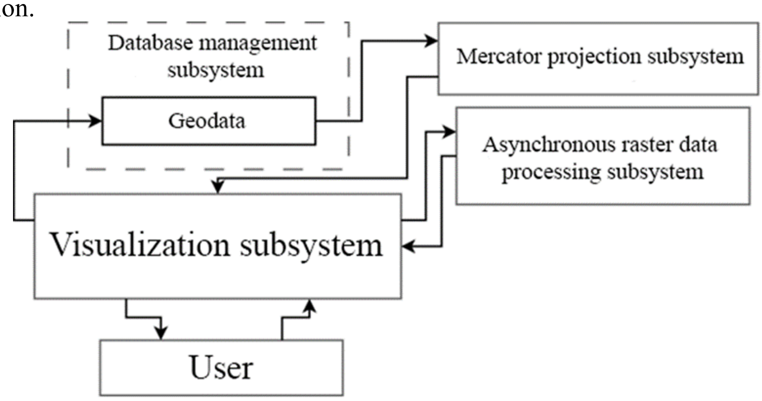

Fig. 5. GIS Architecture

However, this architecture lacks modeling capabilities and decision-making tools, which prevents its use in risk assessment during technological accidents and disasters, such as forest fires, whose management is directly related to the ability to predict their development.

We will expand this structure with knowledge subsystems, rule systems, and decision support systems, including blocks for processing qualitative information, linguistic, and mathematical models. The resulting architecture (Figure 6) will enable the processing of qualitative information about the environment and, based on this processing using linguistic and mathematical modules, will allow for the modeling of dynamic geoprocesses.

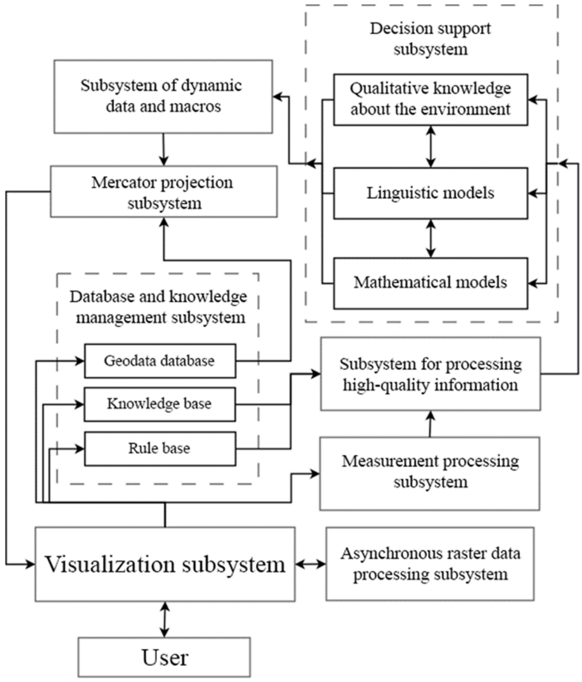

Fig. 6. IGIS Architecture

The core of the system (Figure 7) is proposed to be organized in a way that ensures the most flexible operation of the main elements of the systems. It consists of a set of 15 classes responsible for loading and unloading data from the repository, facilitating interaction between existing geo-objects, and providing access to the minimal functionality of the entire system at the level of a text command line:

- *SQLite* – class for handling SQL queries to the SQLite3 database;
- *List* – parent class for all ordered data structures in the system;
- *MercatorProjection* – class for processing geographic and Cartesian coordinates;
- *CPoint* – class organizing work with serialized geo-coordinate arrays, aggregates the *MercatorProjection* class;
- *CPointList* – class (derived from List) providing indexed access to aggregated *CPoint* objects;
- *CParameter* – class organizing work with constants and variables used in the system;
- *CParameterList* – class (derived from List) providing indexed access to aggregated *CParameter* objects;
- *CMethod* – class describing and executing mathematical models used in the system, aggregates *CPointList* and *CParameterList* objects, and performs intelligent composition of models;
- *CMethodList* – class (derived from List) providing indexed access to aggregated *CMethod* objects;
- *CParameterValue* – class describing parameter values in the system;
- *CParameterValueList* – class (derived from List) providing indexed access to aggregated *CParameterValue* objects;

- *CObject* – class defining geo-objects, aggregates *CParameterValueList* and *CPointList* objects;
- *CObjectList* – class (derived from List) providing indexed access to aggregated *CObject* objects;
- *CLayer* – class describing the layers used in the system, aggregates *CObjectList* objects;

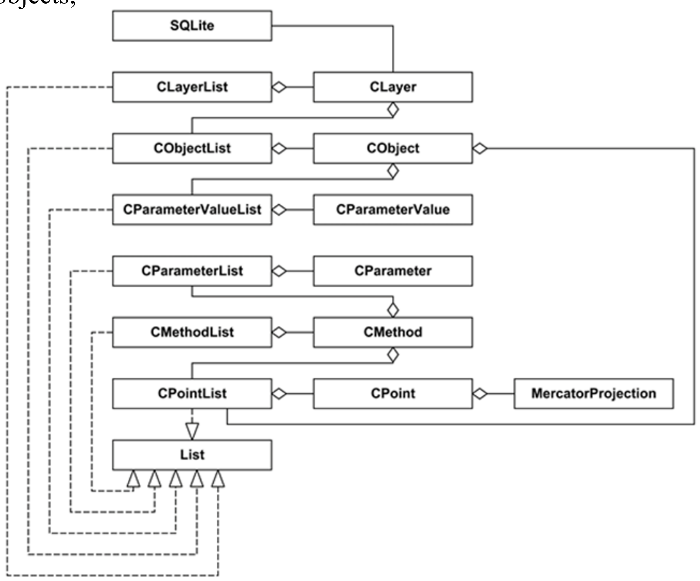

Fig. 7. The interaction scheme of the application core classes

3 Conclusions

The core of the system assumes the use of an interpreted programming language to describe the models of fire contour dynamics. One of the most interesting elements of the core is the class responsible for processing objects obtained during mathematical modeling. The code for this module consists of a set of static and object methods.

The study examined the advantages and disadvantages of several geographic information systems. An architecture for a new intelligent geographic information system for modeling the dynamics of forest fire contours was proposed. Based on the described architecture of the proposed system, a model for the application core was developed. The main elements of the core were described, and a class for processing the modeled objects was developed.

References

1. K.B. Shchukova, Modern technology and technology **12(52),** 137-139 (2015)
2. L.M. Faleichik, O.K. Kirilyuk, N.V. Pomazkova, Herald of ZabSU **6,** 64-79 (2013)
3. N. Chadil, A. Russameesawang, P. Keeratiwintakorn, Electronics, Computer, Telecommunications and Information Technology 393-396 (2008)
4. E.M. Demidovich, D.A. Masalsky, Development of the geolocation mobile application. Actual problems of social and economic development of enterprises, industries, complexes. 114-120 (2015)

5. A.S. Lavrentev, A.N. Krasnoperov. API geoinformation system 2GIS. Information technology in science, industry and education, 51-54 (2016)
6. A.M. Gudov, S. Yu. Zavozkin, A.Yu. Popov, Eurasian Scientific Association **1(3),** 4-5 (2015)
7. I.S. Tleubaev, Youth and modern information technologies **2,** 30-31 (2014)
8. V. Paramonov, Web-Based Analytical Information System for Spatial Data Processing. International Conference on Information and Software Technologies, 93-101 (2013)
9. M.Yu. Dubinin, D.A. Rykov, Geoprofil **2,** 34 (2010)
10. O.l. Zhizhimov, Bulletin of Novosibirsk State University **9(1),** (2011)
11. B.E. Vieux, N. Gauer, Computer-Aided Civil and Infrastructure Engineering **9(4),** 263-270 (1994)
12. S.M. Koshel, University School of Geographic Cartography, 198-208 (2005)