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Use of geoinformation systems based on intellectual technologies in favour of a company

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Abstract. The paper considers the problem of processing information arrays of geographic information systems based on intelligent technologies. The authors note that geoinformatics is not only an area of scientific research, but also a technology for collecting, storing, transforming, displaying and distributing spatially coordinated information, the purpose of which is to solve the problems of inventory, optimization and management of geosystems. Geoinformatics as a field of production includes the production of software and hardware, the creation of databases and control systems. Moreover, the interrelation of cartography and geoinformatics is indicated, which is manifested in the following aspects: thematic and cartographic maps - the main source of spatio-temporal information; the systems of geographical and rectangular coordinates - the basis for the coordinate reference of all information received and stored in the GIS; maps - the main means of geographical interpretation and organization of remote sensing data and other information used in GIS (statistical, analytical, etc.); cartographic analysis - one of the most effective ways to identify geographical patterns, relationships, dependencies in the formation of knowledge bases included in GIS; mathematical-cartographic and computer-cartographic modeling - the main means of converting information in the decision-making process, management of expert reviews, making forecasts of the development of geosystems; a cartographic image - an appropriate form of presenting information to consumers. In order to solve managerial tasks, it is proposed to implement cognitive graphics in geoinformation systems based on artificial intelligence, which accompanies the process of problem solution and decision making on choosing a route based on criteria.

1. Introduction

Geoinformatics as a scientific discipline studies natural and socio-economic geosystems through computer modeling based on databases and knowledge bases. In addition, it can be focused on the solution of problems related to the technological and technical aspects of the formation of a spatial data bank on land resources. The main function of the modern information system is the formation of the information basis for land management at any level, the provision of processes for the adoption of effective management decisions based on reliable information with the necessary degree of detail.

In the 1990s, intelligent systems and technologies appeared which was clearly manifested in cartographic visualization in geographic information systems (GIS). In the theoretical field the

improvement of fundamental concepts, "intellectualization" of GIS, appeal to object-oriented models in GIS, development of the theory of "fuzzy knowledge", improvement of database management systems for spatial data and knowledge, branched user systems and network structures, as well as integrated modern GIS. Under modern conditions, geographic information systems face a number of problems. First of all, these problems are related to a geographic information analysis of the location, structure, relationships of objects and phenomena using methods of spatial analysis and geo-modeling.

Spatial analysis is a group of functions that provide analysis of the location, links and other spatial relations of spatial objects, including the analysis of visibility zones, the creation and processing of digital elevation models and spatial analysis of objects. It is connected with the processing of arrays of information to solve the above problems. Nowadays, artificial intelligence is increasingly used. This use include: perception and pattern recognition; perception, analysis and transformation of texts in natural language; Machine translation; the solution of problems presented in a natural language (informal tasks) [1].

2. Intellectualization of geographic information systems (GIS)

Intellectualization of geographic information systems includes tools and / or subsystems of artificial intelligence. " GIS intellectualization implies the use of artificial intelligence methods at any one or at all stages of the full data analysis function, which allows identifying several areas. The intellectualization of the processes of search and collection of data contains algorithms for search and recognition of the data that the system faces. This group of tasks includes: a knowledge base on information resources; methods of intelligent information retrieval in distributed systems (semantic web, etc.); problem solution of recognizing data types (models).

The availability of a knowledge base on spatial data resources allows collecting additional information for modeling and analysis, increasing the possibility of using heuristic approaches based on automated information collection. One of the directions for the development of a knowledge base on resources is the use of semantic network analysis technologies. The development and improvement of methods and approaches are inextricably associated with existing and used in GIS methods and ways of functioning of geographic information systems. It is required to conduct the analysis of the methods and approaches of GIS functioning that are applied in modern geographic information systems for the subsequent selection of directions of national developments in this sphere [7].

All the types of existing and prospective intelligent systems of geographic information systems can be presented in the form of a generalized system, the totality of the elements of which ensure the performance of any intellectual functions. The structure of such a system is shown in Figure 1.

Geoinformation systems based on intelligent technologies are designed to generate and display graphic information. In addition, the system implements cognitive graphics, which accompanies the process of problem solution with visual graphic information displayed on the monitor screen (intermediate human positions during the performance of various actions, the state of technical means, the order of the actions performed by various structural elements when developing a solution and organizing its implementation, etc.) [2].

With a carefully thought-out framework for displaying intermediate results, the images that appear in the dynamics on the screen provide significant assistance to a user during the identification of the effective methods for developing solutions that were previously unavailable to him. The linguistic processor, systems for speech analyzing and synthesizing, visual perception, graphic images, sensors and effectors form an intelligent interface that ensures the interaction of the intelligent system with a user and the external environment [5].

Confidence and explanation systems form a justification block used in expert systems in order to justify the results of the solution of management problems.
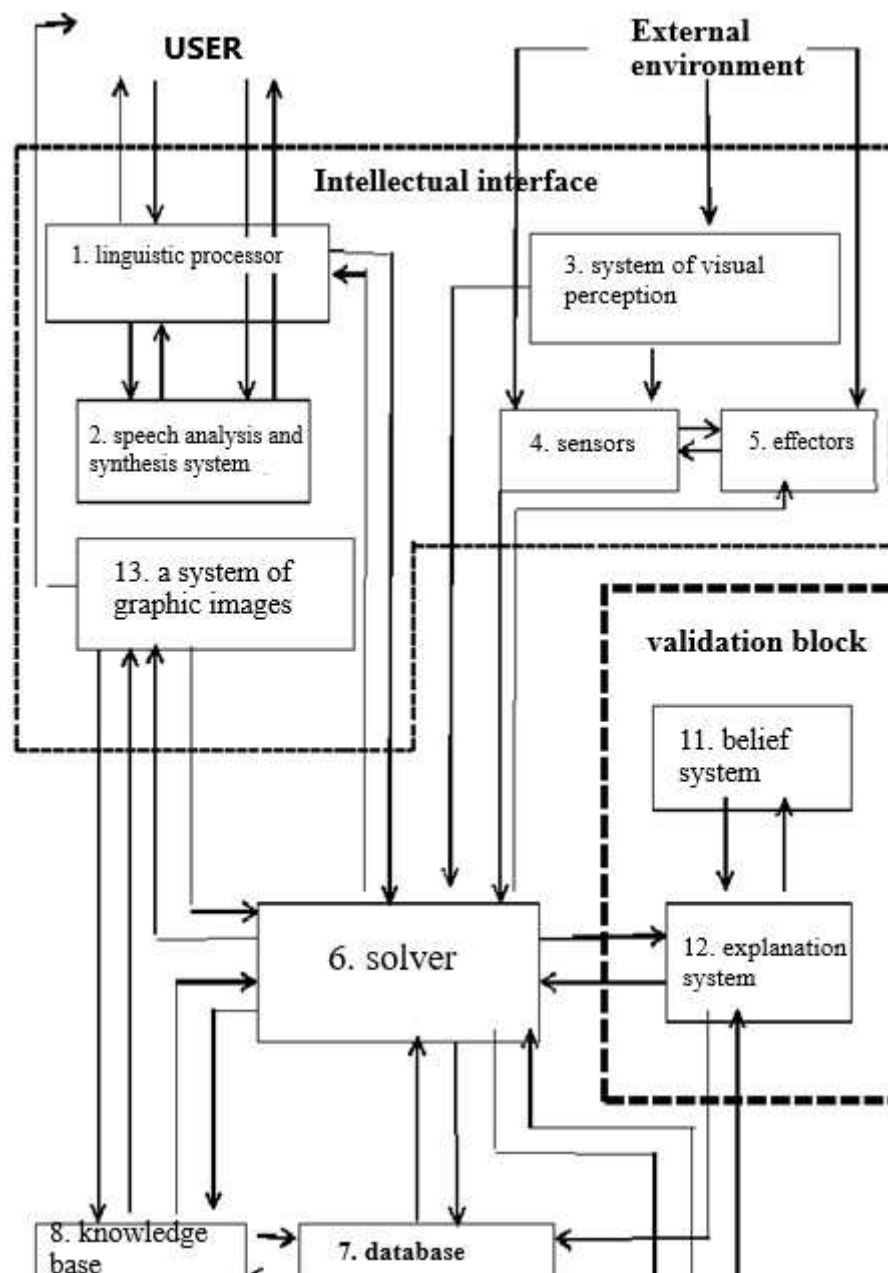
Figure 1. The generalized structure of intellectual geographic information system, which contains the following main blocks (elements): 1 - linguistic processor; 2 - speech analysis and synthesis system; 3 - system of visual perception; 4 - sensors; 5 - effectors; 6 - solver; 7 - database; 8 - knowledge base; 9 - training system; 10 - planning system; 11 - belief system; 12 explanation system; 13 - a system of graphic images.

These blocks perform certain functions.
- The task of the system management is formed when the situation changes. The following basic methods of geo-data analysis are used in GIS:
- With regard to the display on the map: taking into account the spatial location of the object;
- Without regard to the spatial location of the object;
- The calculation the density of the displayed geo-data on the cartographic segment [6].

The situations in geographic information systems are formed using the natural language. In some cases they may contain incomplete or fuzzy data necessary to clarify the problem and organize the subsequent decision-making process. In addition, it is advisable to use the methods of perception, analysis and transformation of texts in natural language, which can be implemented in a system oriented to the corresponding class of managerial tasks [3]. With the increase in the functionality of geographic information systems, data transformation involves not only geo-objects rotation operations (in the narrow sense), but also the formation of descriptions (additional attributes) sufficient for decision-making (in the broad sense), which requires knowledge of the data storage structure and their formats, the formation of the structure of the output information and data for decision making, and therefore, the need to develop methods and a method for data transformation.

The research showed that methods allow analyzing and then systematizing the tasks based on the existing knowledge base. A number of methods present both the basic utility formula for a multicriteria alternative and all its parameters. The example is the following type of dependency:

$$U = \sum_{i=1}^{N} [(x_i - x_i^*) / x_i^*]^2$$

where x_i^* - the best value according to the ith criterion, x_i - actual assessment by the ith criterion.

With this dependence, a quadratic penalty for deviating from the best value is applied to all the criteria [4].

3. Study of application of information processing methods in GIS

In practice, the most suitable type of dependence is chosen from the set of possible ones, according to its ideas on their adequacy to the real conditions of the decision-making problem. For the subgroup of methods, the background information is the data presented in Table 1. The aggregates of the utility of alternatives are introduced in the table with the external conditions that characterize the situation after decision-making.

Table 1. Background information for decision-making purposes

Alternatives	Variants of external conditions			
	B_1	B_2	...	B_m
A_1	U_{11}	U_{12}	...	U_{1m}
...	...	...	...	...
A_N	U_{N1}	U_{N2}	...	U_{Nm}

A decision-maker can choose the preferred alternative (with utility) based on one of the following criteria:

1. *Wald maxmin rule* (of maximum caution). Is selected

$$U^* = \max_i \min_j U_{ij} ,$$

where i - row index, j - table column index.

2. *Minimax regret criterion* (Savage index). The concept of regret is introduced for the ith alternative under the ith variant of external conditions, that is

$$C_{ij} = \max_i U_{ij} - U_{ij} .$$

Next, an alternative with utility is chosen. U^*, for which

$$U^* = \min_{i} \max_{j} C_{ij}.$$

3. *Maximax criterion* (radical optimism):

$$U^* = \max_{i} \max_{j} U_{ij}.$$

4. *Hurwitz criterion.* Let for ith alternatives

$$m_i = \min_{j} U_{ij}; M_i = \max_{j} U_{ij}.$$

For each alternative A_i the indicator is calculated

$$U_i(\alpha) = \alpha m_i + (1-\alpha) M_i,$$

where $0 \le \alpha \le 1$.

Next, we select (for a given α) $U^* = \max_{i} U_i(\alpha)$. Coefficient values of α reflect the degree of optimism of a decision-maker. If we take $\alpha = 1$, then this criterion passes into the Wald criterion.

5. *Laplace criterion.* For each criterion A_i the indicator is calculated $U_{icp} = (1/m) \sum_{j=1}^{m} U_{ij}$.

6. Then, we choose

$$U^* = \max_{i} U_{icp}$$

The choice of criterion for the assessment and selection of the best alternative is carried out by the use of the above mentioned methods under the conditions of partial uncertainty associated with the lack of data on the probabilities of external conditions.

In a number of methods for the assessment and selection of alternatives, the main form of dependence is postulated, but its parameters are directly assigned to decision makers. The main methods of this group include:

1. *Weighted Amount Method.* The utility of alternative U is determined as

$$U = \sum_{i=1}^{N} w_i x_i,$$

where w_i - weight (significance) of ith criterion defined by a decision maker; x_i - the assessment of alternatives by the ith criterion; moreover

$$\sum_{i=1}^{N} w_i = 1.$$

If $w_i = 1, (i = 1,...,N)$, and x_i is measured in whole numbers (points), then the method is called scoring. The rationale for the weighted amount method is the idea of the general utility of the alternative as the amount of the estimates according to several independent criteria of various importance.

2. *Multiplicative method.* The utility of alternative U is determined as

$$U = \prod_{i=1}^{i=N} w_i f(x_i)$$

.

Usually $f(x_i) = x_i$ is taken. The rationale for the multiplicative method is the idea of assesments by the criteria as the probabilities of the achievement of certain quality indicators.

3. *Lexicographic criteria ordering.* In this method, the criteria are sorted by importance (ranked). After that, the one that has the highest rating by the most important criterion, regardless of the ratings by other criteria, is determined as the best alternative.

A number of methods are based on the determination of probability assessments of various outcomes on decision trees. The main idea of these methods is as follows. Let us suppose that there are two options for route A and B. Suppose that when choosing option A the exact result is not known in advance and there are three alternative outcomes 1, 2, 3, the attractiveness of which can be estimated in money equivalent C_1, C_2, C_3.

Let us suppose that the probabilities of these outcomes are known: p_1, p_2, p_3. Then the utility of option A is determined by the formula:

$$U_A = \sum_{i=1}^{3} p_i C_i .$$

The utility of option B is assessed in the same way. The choice between A and B should correspond to a larger utility value.

4. Conclusion

Thus, in order to determine all the possible outcomes of various actions, a so-called decision tree is created on the basis of the sequential analysis of all possible events. This is achieved through the use of geo-information systems based on intelligent technologies in the interests of a company, which provides unique opportunities for its application in a wide range of tasks related to the analysis and prediction of phenomena and events of the surrounding reality.

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