GIS FOR THE CITY ENVIRONMENTAL ASSESSMENT

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Abstract

The geoinformation system is considered consisting of two subsystems: information retrieval and prediction-analytical ones. The system as a whole operates in a common program environment that substantially improves its performance capacity. The prediction-analytical subsystem is principally distinctive from conventional expert systems, it is based on the pattern recognition theory algorithms.

The team of authors has developed the methodology defining the design and functioning of automatic data acquisition and processing systems within the framework of GIS conception. Basic principles of such systems are considered in [1]. In the present paper we consider a particular implementation of such a system organized according to those principles - a system intended for the city environment assessment.

The system's distinctive feature is the availability of two subsystems: the information retrieval and prediction-diagnostic subsystems.

The information retrieval subsystem is the reference cartographic data base equipped with the graphics interface. This subsystem provides the input of textual, table, and cartographic information, its storage, renewal, rescaling and output of the terrestrial information both to the computer screen and graphics plotter by using conditional symbols. This information can be also printed out as a digital terrestrial model allowing data transfer to other GIS systems.

The information retrieval subsystem comprises a number of databases comprising information about natural characteristics, technogenic impacts, nature-technogenic anomalies, and the environmental assessment results.

The source information is included in the data base as the city terrestrial digital models (the digitized graphical images of different scale maps, originally of the 1:10 000 scale) and, also, quantitative and qualitative characteristics.

These data bases (digital models) consist of a few sections [2].

The "Nature" section in its turn consists of six bases (geomorphology, geology, hydrogeology, geophysics, engineering geology, soils and vegetation), each of them characterized by a certain set of indications.

Thus, when describing the relief one uses the following indices: maximum and minimum absolute marks, slope steepness and erosion density. In addition, one should also identify precipices, shelves, and ravines. The surface hydrologic network is characterized by the following parameters: the extent of rivers, streams, channels, table area of natural water basins and water storages within the limits of the city locations. Underground water is characterized by the depth of the first aquifer reservoir nearest to the horizon surface, waterhead value, chemical composition, and temperature. Information about the hydrogeochemical features of the underground water allows one to make a conclusion on the water contamination degree and aggressiveness. The geological structure is characterized by data obtained in the engineering geological surveys, provided as the geological sections matched with the topographic reference. One can distinguish four basic indications: exogenic geological processes, their extension area, their manifestation intensity, etc.; characterization of wells, their location, depth, drilling time, company implementing drilling operations, etc.; lithological differences of soils and their physico-mechanical properties; characterization of geologico-genetic complexes. Each of those indications includes up to ten characteristics.

When characterizing geological and engineering-geological processes, one has to take into account the extension of these processes in time and space, for instance, the number of karst cones, landslides, etc.

The "Technogenic Impact" section includes six data bases:
1) city functional zones;
2) roads;
3) underground and surface communications;
4) industrial zones;
5) residential zones;
6) park zones.

By the functional zones are meant the industrial, residential, park, and reserved areas of the city.

In the residential zones one has to isolate multistorey and low-storey constructions. Such classification allows one to assess the static load of constructions depending on their density and number of stories, and, also, the feasibility of capital repair of deformed buildings and of new residential constructing projects. In addition, the residences are characterized by the quantitative indices: size, number of stories, balance price, etc., and, also, the qualitative indices - construction features of building, wall's material, etc.

The industrial zones are characterized by the occupied area, departmental belonging, character and amounts of raw and waste materials, amounts of consumed water and power resources. The areas occupied by vegetation are subdivided into forest-park zone, squares, parks, and local vegetation areas of microdistricts. The underground and surface communications are subdivided by the following types: water, gas, electric power, cable, and telephone communications. One should account their total length, cross section, material, time and depth of installation, etc. All the types of surface and underground transport (metro, trolley, and railway lines, and motor transport) are the sources of certain dynamic impact, physical and chemical contamination of the city environment. Besides, this section includes the data base on the architecture and historical monuments situated on the city area. The existence of historical and architecture monuments makes it necessary to account their value when analyzing nature-technogenic changes. Within the framework of the city one can also compute the area of closed zones (i.e., the areas covered with asphalten-concrete, occupied by industrial, residential, and other objects) where the natural water balance has been disturbed which caused the uplift of ground waterhead.

The "Natural-Technogenic Anomalies" section includes data about the technogenic sediments (thickness, composition, accumulation period, and extension area); industrial-domestic dumping areas (type of wastes, area and duration of impact on the natural components); degree and character of contamination of surface and underground waters, soils, grounds, and, also, data concerning the action of the chemical contamination on the vegetation cover (these data comprise the results of analyses of point samples; these data are used in drawing the maps of geochemical maps); technical state of industrial and other objects; changes in the depth of the ground water horizon nearest to the surface, which are accompanied by the drying of territory or its flooding (in both cases this causes changes in the properties of the ground serving the basement of constructions and defining their stability, the oppression of vegetation, etc).

The prediction-analytical subsystem is distinctive from conventional expert systems. Latter are usually based on the riles formulated by experts, they are designed to solve rather specific range of substantially idealized problems. Such an approach constraints the range of solvable problems and available information. The same restrictions are characteristic of the approach which assumes that a complex assessment of the area is found from a known expression with fixed coefficients.

So it seems expedient to take some moderate way in the creation of such systems: such a system should comprise only most general propositions and a practical specialist is allowed to "complete" the construction of the system in accordance with his specific problem and his own understanding of this problem.

Changes may be entered into the knowledge base through the keyboard unit in each user's session. The situation where the functions of expert and user have to mutually coordinated imposes specific requirements upon the interface - it should have enough intelligence and be rather flexible to help user to pass from one problem solution stage to another one.

In the system proposed both the expert and user who acts as an expert participate in the problem statement, formulation of criteria for the reliability of estimates and results obtained. Besides, the user is allowed: a) change coefficients in the given algorithms used for estimating terrestrial characteristics interactively through the keyboard; b) introduce new assessment criteria based on the available data; c) make use of additional information by integrating it with existing data sets.

Consider a few problems which were solved in the system under consideration.

The engineering-geological zonation program has been implemented by using databases "Geomorphology", "Geology", "Hydrogeology", and "Engineering Geology". In the program design we took into consideration an original technique for a similar zonation which accounts of the structural-geological, geomorphological, and engineering-geological features of the territory.

The program for territory zonation by the ecological situation is based on the resulting computations of appropriate estimates.

The program of assessing the geoecological situation is based on the map of integrated zonation of the territory and the source data taken from the "Nature" and "Technogenic Impacts" databases. Later characterize the state of particular natural components, man and engineering objects. It is essential since the assessment criterion is the extent of changes in the state of each of recipients. We also used data of the information standard section in the implementation of this program. As the result of the program implementation one obtains an overall estimate of geoecological situation in each of terrestrial operational areas. As a result of these estimates the fourth section comprising the "Assessment results" data base is formed.

The problem of assessing the terrestrial fund is reduced to the following procedures. As known, in the assessment of terrestrial areas of primary value are the soil quality and the vegetation character. These factors have both qualitative characteristics and quantitative estimates. Besides, soils which have the same composition may have different price estimates depending on the natural environmental conditions and local infrastructure. The value of terrestrial areas and the terrestrial fund as a whole will also vary depending on the actual situation (new constructions, another economic situation, changes in the ecology, etc.).

This problem can be solved in a few stages:

- determining the spatial arrangement of each elementary site within the limits of territory under consideration with respect to each of the natural factors and infrastructure;
- building the heuristic expert model for the price estimate within the limits of a particular territory with due regard of the soil quality and spatial arrangement of each elementary site with respect to natural factors and infrastructure;
- computing various price variants for the terrestrial areas over the whole territory concerned by using the geoinformation system. The group of experts of the municipal board has built a heuristic estimation rule which is based on the information weights assigned by experts to particular indication ranges, and on the above factors.

As a result of the problem solution, the zonation of terrestrial areas within a given territory has been carried out with due regard of natural factors and infrastructure of the territory. This zonation has allowed to refine an overall price of terrestrial fund - it has grown 1.7 times. Such approach can be applied to selection of construction sites for various purposes, it will account for certain restrictions on the ecology, natural conditions, infrastructure, etc. It can be also applied in the assessing the natural damages from various catastrophes, both of natural and natural-technogenic characters.

One of the components of the prediction-analytical subsystem is the multipurpose analyzer of geoinformation. This block uses:

- principally new method for transforming maps into a discrete form which makes the "computer imaging" close to the man's cognition of complex spatial situations;
- an original heuristic modeling method;
- high-efficient pattern recognition algorithms.

The multipurpose analyzer of geoinformation allows to substantially improve the extraction of useful information from available cartographic materials (more than ten times).

References

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