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Research Article

An approach to organizing the configuration of information management systems for environmental monitoring

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Abstract
The problem of ecology in the world is global, therefore, scientific and practical developments in this area are complex and interdisciplinary. Search for a method for configuring an information system of environmental monitoring, depending on the view of an expert. The capabilities of information systems make it possible to develop new decision-making methods for analyzing the state of the external environment, which will allow obtaining a reliable forecast regarding their further development. The structure of information and control systems in the field of environmental monitoring, which meets the concept of configuration, is proposed. The structure of the system differs from the known ones by the presence of an intelligent module for choosing methods for processing physical data with the accumulation of experience, based on products formed by an expert. It is proposed to build modules of the data processing library based on the concept of soft computing, since this approach most fully reflects areas with a high degree of uncertainty, which include monitoring of the external environment.

Keywords: information systems, configurability of information systems for the data type, configuration method , environmental monitoring .

Introduction

Works in the field of environmental monitoring are associated with the processing of data from the investigated object of nature by applying certain algorithms. The sequence of these processing algorithms, implemented in the form of modules of information systems, is the view of an expert in the field of environmental monitoring [1,2]. The ability to change these views is the main challenge. Or in other words - how to change the method of processing data from the external environment depending on the expert's point of view on the environment.

From the architectural point of view, modern environmental monitoring systems are traditional in their construction for information systems [3]. Such systems can be called information management systems (IMS).

The classical approach to the functioning of such systems is based on considering only specific (fixed) views or aspects of the environment. Aspect is understood as an expert's opinion on the processing of physical observation data by any method.

The main problem of existing environmental information systems: how to change the method of processing data from the external environment, depending on the points of view on the environment.

The functional purpose of information systems for environmental monitoring is control (continuous or periodic) over the sources of emissions of harmful substances and compounds by industrial enterprises [4,5]. To create any information system, a preparatory stage is required, associated with the study and description of the subject area, objects or informatization processes, as well as various types of relationships between them. The result of the preparatory stage will be the collection, preparation and transformation of environmental monitoring data, obtaining information about the set of objects of informatization and their characteristics, which is presented in the form of special DB structures [6].

The design and development of information systems for environmental monitoring implements a methodology aimed at establishing the relationship between the input impact and the output result in order to control the process to limit its negative impact [7]. A review of the literature on environmental monitoring systems shows that existing systems have several shortcomings, and therefore modifications are constantly proposed [8,9].

The solution to the problems described above is possible by configuring the information system. By implementing configurability, we thereby act on increasing the functionality of the system or expanding the views or aspects of the environment. In addition, configurability is a critical system-wide property for adaptability, resiliency, and system availability.

Configuration is a fruitful idea for the study of control systems, including methods for solving problems [10]. The works [11-13] described systems based on new approaches, as well as their business context.

In general, the configuration of IS in general and environmental monitoring in particular is not widely reflected in publications. This is due to the complexity of the proposed approach. This is especially true for the lighting of the configuration from the point of view of changing the expert's view of the object under study.

The problem of organizing information systems for environmental monitoring

The use of rigidly defined analytical calculation schemes does not allow considering various aspects of the environment. And this narrows the possibilities of ecological systems. At the present stage, variability is needed, which would appear based on the results of the analysis of the input data stream. The result is a system with new analytical properties. This requires configuring the modular structure of the system. The existing approach is presented in Figure 1 .

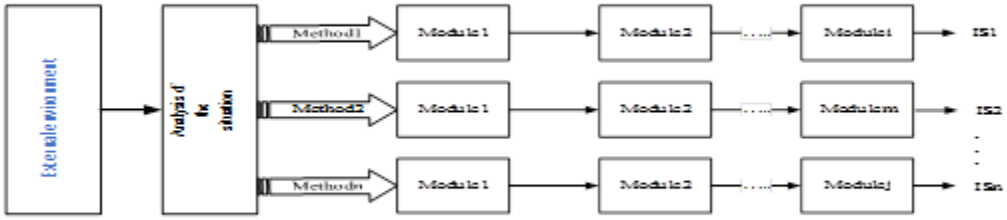

Figure 1. Existing approach to the implementation of environmental IS

The problem with the current approach: a rigid structure that does not allow consideration of alternative aspects of the environment. If it is necessary to expand processing methods, the development of new information systems - IS is required. In this case, IS is understood as a plurality of physical data processing modules, combined with each other in accordance with the processing method or expert opinion or aspect.

A fundamental task for such an organization is the development of an approach to configuring the architecture of the IS for the method of data processing and their effective design and implementation [14,15].

Proposed solution

The proposed solution to the problems described above lies in the field of configuring the structure of the information system [16,17]. That is, from the point of view of the systems approach, a change in the structure of the system will entail the acquisition of new qualitative characteristics by it [3].

The main idea of the proposed approach is shown in Figure 2.

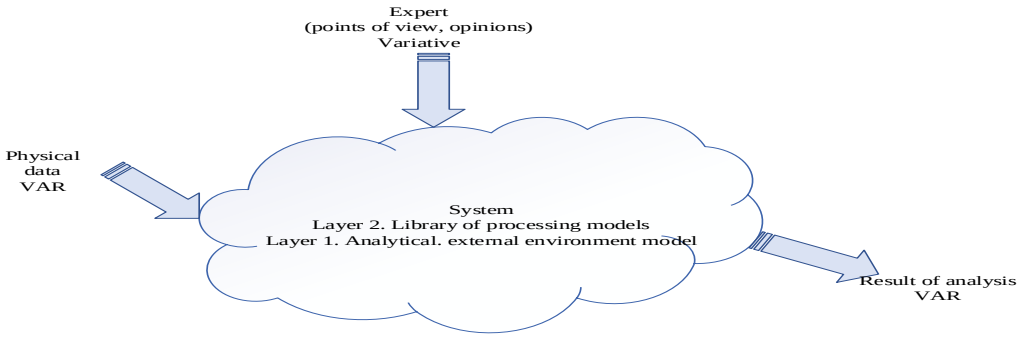

Figure 2. The idea of an approach to the implementation of environmental IS

The proposed approach is based on an analytical model of the subject area, as the 1st level (layer) of the presentation (organization) of the system, as well as the ability to analyze the object under study from various points of view (parameters) through a configurable set of modules - the 2nd level (layer) of the presentation (organization) system.

In the existing approach, external influences are a variable parameter and are applied to a fixed set of modules that formalize the view of the ecological situation. Therefore, when a view is changed (for example, new mathematical models of the dependences of physical parameters are obtained, etc.), it is required to create another fixed set of modules, and in fact, another IS.

This approach is costly in terms of developing information support for the decision support system. In addition, the adaptability of the system to changing views on the ecological situation in this case is very low.

The proposed solution consists in eliminating the described shortcomings by organizing a library of modules allowing the organization of several alternative processing structures based on several views or aspects of the ecological situation. For this, an intelligent configuration module is introduced into the system – Figure 3.

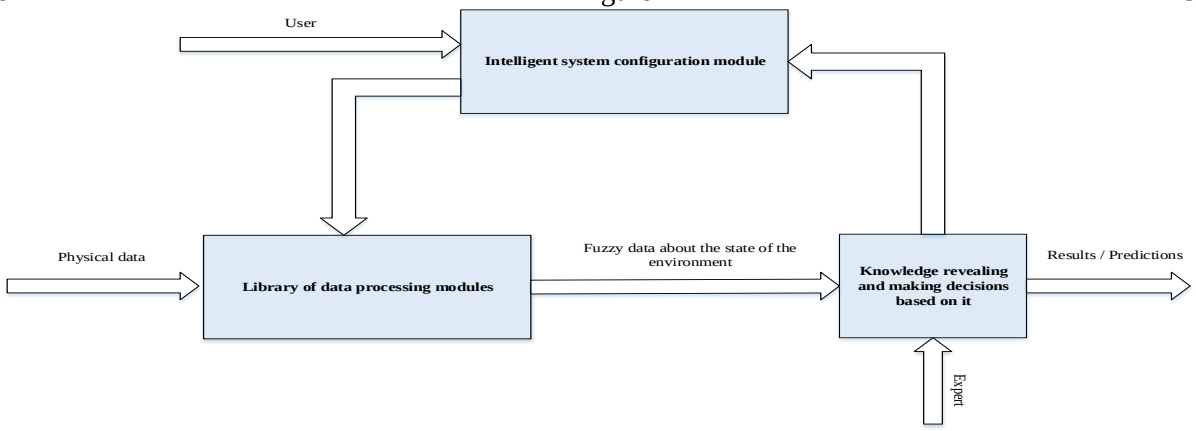

Figure 3. Proposed approach eliminating the shortcomings of existing systems

Physical data about the state of the external environment is sent for processing, which is performed by the physical data processing modules. These modules are stored in the library. Modules form the basis of information software. The library contains modules for the implementation of algorithmic support for the preparation, processing and analysis of data, as well as decision-making in environmental monitoring tasks. The library receives requests from the intelligent system configuration module. This module has a built-in production knowledge base containing the knowledge of environmental experts and rules for determining the order of work of data processing modules from the library.

The parameters of the call to the intelligent module will be the knowledge revealed as a result of monitoring, obtained in decision-making modules based on soft computing, identifiers of module structures from the library of modules and a user's request indicating a typical task. The input data for the block of knowledge identification and decision making are fuzzy data about the state of the environment, obtained as a result of the library modules. An expert works with the block, as a result of the work, knowledge is obtained in the form of identified patterns between physical data using soft calculations. This knowledge goes into the knowledge base of the intelligent module. In addition, the work results in forecasts of the ecological state of the external environment. The user through the interface of the intelligent system configuration module works with modular structures or ready-made solutions in the field of environmental monitoring.

With the help of the apparatus of relational calculus, a set-theoretic model has been developed for representing the modular structure of the IS as the basis of the configuration method.

The objects of configuration are elements of the library of modules, as the basis for various options for views on the environmental situation. Naturally, in the formation of different views, reflected in the connections of the modules, relationships arise. We will use the relational calculus as an apparatus for the set-theoretic description of the configuration model. The modules that form the information support of the system are located in the database. In this case, we will understand that several modules that implement one or another information process of data processing form a modular structure. Thus, in the space of a relational database, it is necessary to have the following relationships: "Modular structure", "Module".

Let's denote the relation “Modular structure” MS, the relation “Module” M. Then we can write the k-ary relations for the relational database in the following form:

$$MS(D_{MS1}, D_{MS2}, \dots, D_{MSk}) \quad (1)$$
$$M(D_{M1}, D_{M2}, \dots, D_{Mk})$$

where DMSi is the i-th domain of the "Modular structure" relationship,

DMi - i-th domain of the "Module" relationship.

Let's designate the set of domains of the introduced relations "Modular structure" and "Module"

$$M(D_{M1}, D_{M2}, \dots, D_{Mk}) \quad (2)$$
$$D_M = \{D_{M1}, D_{M2}, \dots, D_{Mk}\}$$

In general, the intersection of many domains of relations "Modular structure" and "Module" is not empty:

$$D_{MS} \cap D_M = D_{MSM} (\neq 0) \quad (3)$$

It follows from this that there are many domains belonging to only one of the relations "Modular structure" and "Module":

$$\mathrm{D_{MS}} - \mathrm{D_M} = \mathrm{D_{MS\,MS}}$$

(4)

$$\mathrm{D_M} - \mathrm{D_{MS}} = \mathrm{D_{M\,M}}$$

Domains of the “Modular structure” relation determine the identifier of the modular structure, the list and links of modules combined into a modular structure, and the parameters of the information process required for data processing by this structure (expert data, probabilistic characteristics, MPC values, etc.). These domains form a view (point of view) on the ecological situation.

Domains of the "Module" relationship define the module identifier, functional purpose of the module, belonging to the module structure and data parameters necessary for its operation. One module can belong to several module structures.
Domains in the relationship "Modular structure" and "Module" informationally support the configuration mechanism. This will allow you to move on to developing a method for configuring the modular structure.
A method for configuring the modular structure of the IMS has been developed for two modes of operation: "Expert" and "User" Figure 4.

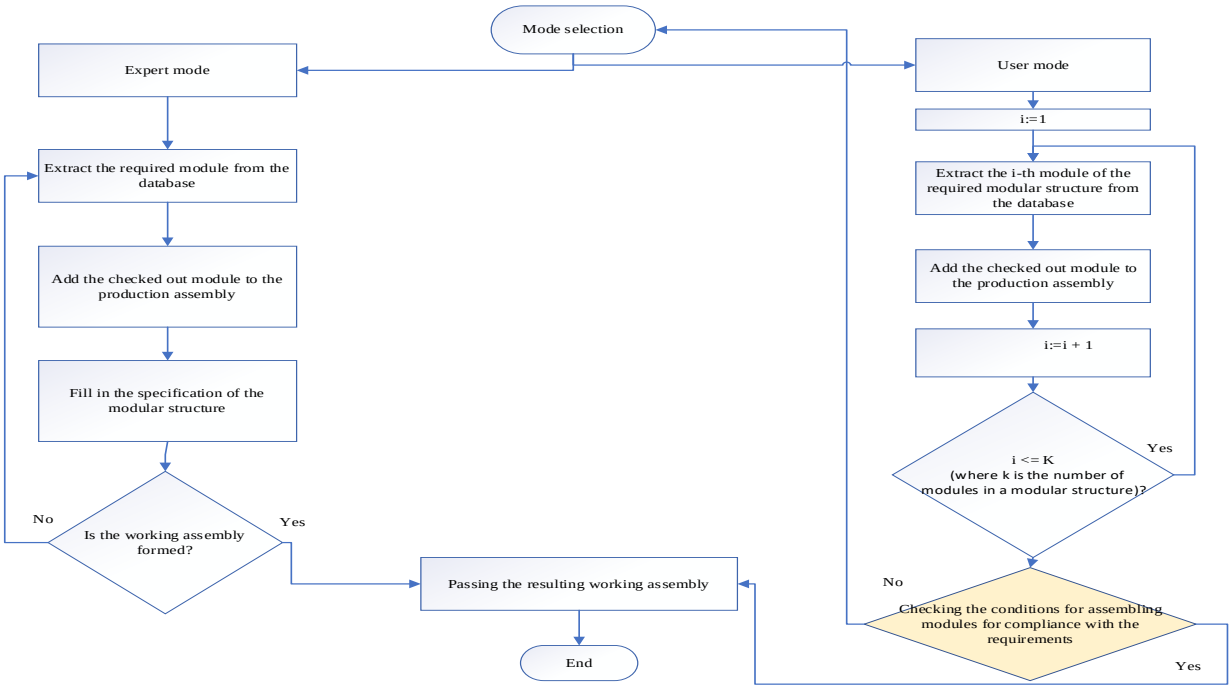

Figure 4. Method of configuring modular structure of IS

Results

A set-theoretic representation of the process of configuring a modular structure using the apparatus of relational calculus has been developed (1-4).
On the basis of the developed representation, a method for configuring the modular structure of the environmental monitoring IS is proposed Figure 4.
Individual modules of the data processing library in the MATLAB environment have been implemented.
The architecture of one of the developed modules is shown in Figure 5. The server part is implemented in the MATLAB environment, the client part is implemented in the Delphi language.
The server side is designed to handle client requests. It waits for the client to connect, registers it, and handles requests to the fuzzy model implemented in MATLAB using FuzzyToolBox.

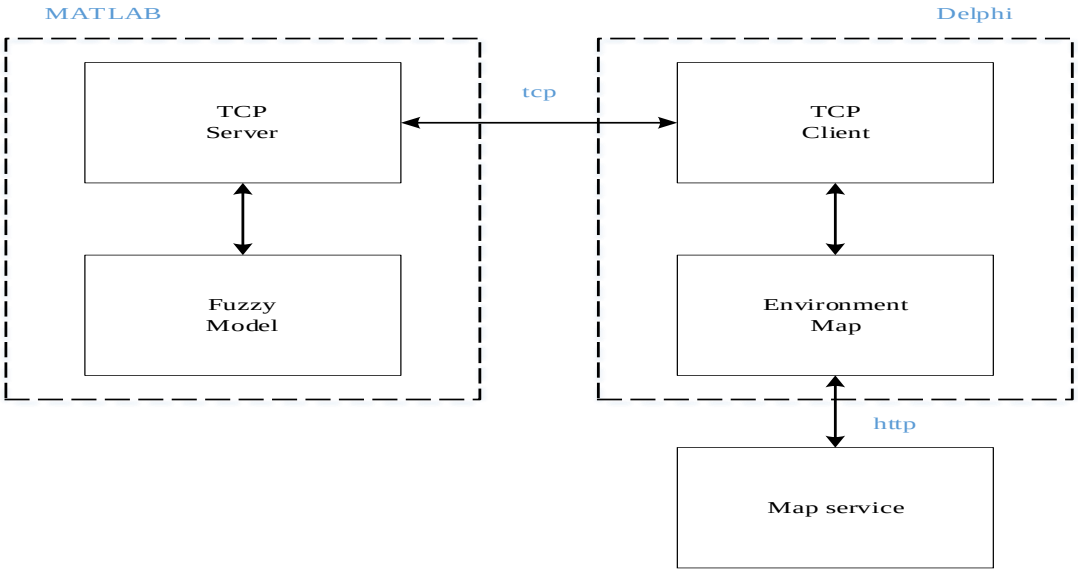

Figure 5. The architecture of the environmental monitoring data processing module

A client application was developed to demonstrate the work. It consists of 2 parts: a tcp client responsible for communication with the MATLAB environment and the Environment Map module, which visually displays cartographic data such as tile maps, zones and displays the results of a fuzzy model developed in the MATLAB environment. To access the tile maps, various map services from Google and Yandex were used, which allow displaying both classic maps and satellite information.

The work of the server side of development and the results of queries are displayed in the command window (Command Windows) are shown in Figure 6.

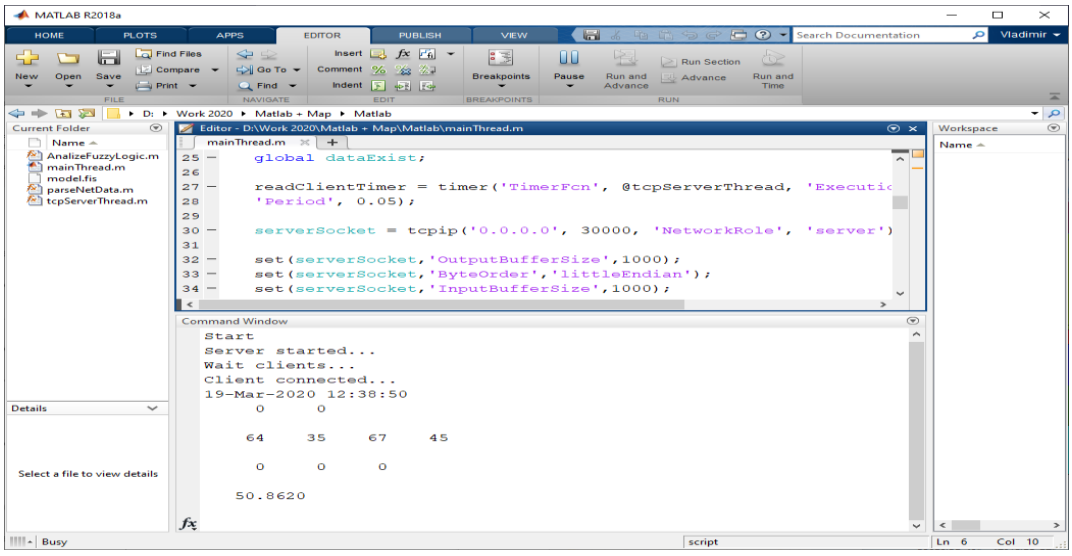

Figure 6. Server side work (MATLAB)

The implementation of the client side is shown in Figure 7.

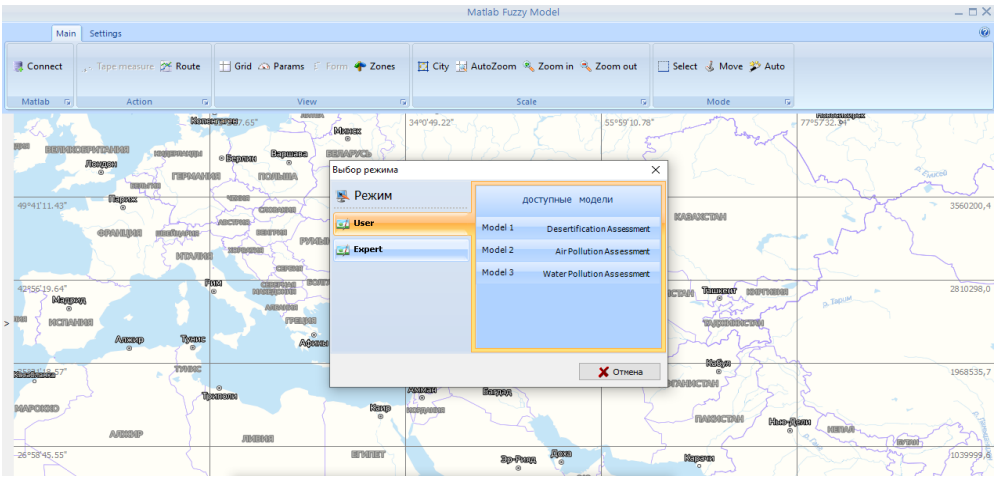

Figure 7. Client side work (Delphi)

Setting the parameters for operation is shown in Figure 8.

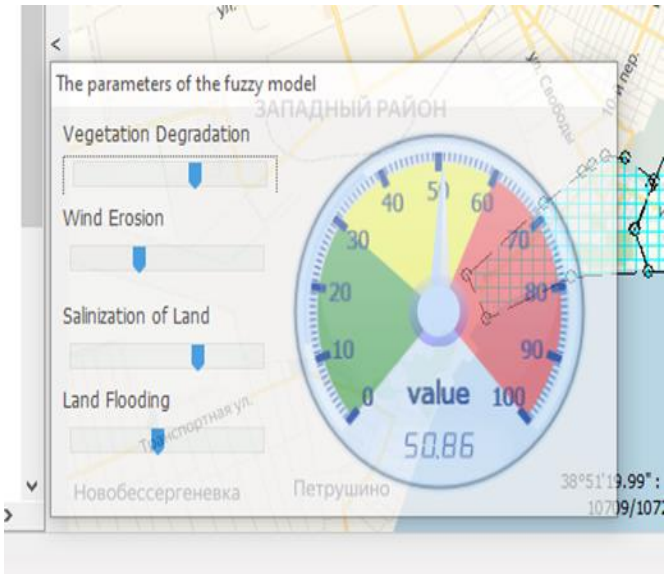

Figure 8. Setting parameters for the model

Conclusion

The proposed approach is based on the possibility of analyzing the studied situation of environmental monitoring from various points of view through feedback and changes in the composition of analysis and decision-making modules. The approach to configuring an information system differs from the known analysis of the factors that determine the change in the structure of the system. The implementation of the proposed approach differs from the known ones by the addition of an intelligent module for choosing methods for processing physical data with the accumulation of experience based on products formed by an expert.

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