Software in the field of information and analytical support for territorial management: a methodological approach to assessment

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Abstract. The article considers the approach to software evaluation, which is used for information and analytical support of the territorial administration. It is proposed to use a computational procedure based on determining the correspondence of the functional completeness particular alternative to a reference sample. A set of parameters has been formed that needs to be taken into account to select a specific information technology solution for the intended purpose. The proposed tools can be adapted to compare software systems for other purposes.

1. Introduction

Today's software market has developed a segment of standard design solutions for information analysis support of public administration, with a focus on management of social and economic territorial development. As expected, this results in the following situation: on the one hand, the development of such solutions allows customers to choose information systems that meet their needs best, while on the other hand, developers strive to integrate their systems with as many services as possible, with many of them completely irrelevant for the user, which results in a rather expensive product with excessive functionality. The authors propose to base the comparative analysis on a method for evaluation of automated information systems and technologies that checks the functional range of any solution against user requirements, a certain standard, or a technology that is being developed.

Today, there are several basic methodological approaches to the assessment of complex systems. They can conditionally be divided into general and specialized tools for the nature of objects. The first group may include classical and based on them modifications decision-making methods [1-4]: methods of the main criterion, composite (integral) criterion, ideal point, evidential reasoning approach. Their application requires additional research regarding the development of models for assessing the object. The second group is formed by methods originally intended for software research, which include Russian standards (GOST 28195-89, GOST RISO/IEC 25010-2015) and actual international standard for evaluating the quality of software products [5], as well as methods for assessing the quality and comparison of software products according to various criteria [6-8].

The research purpose is the description of the methodological approach to comparing complex software systems by the criterion of functional completeness. Our main contributions are to create a software evaluation model for information analysis support of regional development management with defining a set of key functions.

2. Software evaluation model

The methodology for evaluating automated information systems and information technologies for comparative analysis was adapted. The technique is based on verifying that the functional completeness of the solutions under consideration meets the user's requirements, a certain standard, or the technology being developed [9]. For comparison, it is proposed to use a ‘reference’ information system, which has functional software solutions characteristics available on the market that are significant in terms of managing the socio-economic territories development, and services that are based on new methodological and instrumental approaches (according to the paper authors software solutions include areas such as:information system's development and analytical support for the activities of authorities and management; an unified interdepartmental information and statistical system development; a state geoinformation portal creation providing the publication of basic spatial data and basic spatial information and metadata; provision of electronic state digital maps and plans). The above goal-determining provisions allow us to state the priority development of such functionalities as spatial analysis, which can be implemented using geoinformation technologies, and decision support based on both classical methods and data mining methods, developing, in turn, on the basis of the apparatus fuzzy logic.

Let $Z = \{Z_i\}$, i=1,2,..., n be a set of software and hardware solutions selected for comparison; $R = \{R_j\}$, j=1,2,..., m be a set that represents the dictionary of functions (features) implemented in solution $\{Z_i\}$. The initial information is represented in the form of a matrix $X = \{X_{ij}\}$, with its elements defined as follows:

$$X_{ij} = \begin{cases} 1, & \textit{if the function is implemented} \\ 0, & \textit{if the function is no implemented} \end{cases}$$

Assume that Z_k is the reference solution. The case makes use of the following designations: $P_{ik}^{(11)}$ is the number of functions implemented both in Z_i, and in Z_k, i.e. $P_{ik}^{(11)} = |Z_i \cap Z_k|$ is the size of the intersection of sets $Z_i = \{X_{ij}\}$ and $Z_k = \{X_{kj}\}$; $P_{ik}^{(10)}$ is the number of functions implemented in Z_i, but not in Z_k, i.e. $P_{ik}^{(10)} = |Z_i \setminus Z_k|$ is the size of the difference of sets $Z_i = \{X_{ij}\}$ and $Z_k = \{X_{kj}\}$; $P_{ik}^{(01)}$ is the number of functions implemented in Z_k, but not in Z_i, i.e. $P_{ik}^{(01)} = |Z_k \setminus Z_i|$ is the size of the difference of sets $Z_k = \{X_{kj}\}$ and $Z_i = \{X_{ij}\}$; $P_{ik}^{(00)}$ is the size of the union of Z_i and Z_k, i.e. $P_{ik}^{(00)} = |Z_i \cup Z_k| = P_{ik}^{(11)} + P_{ik}^{(10)} + P_{il}^{(01)}$.

The portion (share) of functions of solution Z_i that are also implemented in Z_k can be assessed using the value $H_{ik} = P_{ik}^{(11)} / (P_{ik}^{(11)} + P_{ik}^{(10)})$. Correlation between Z_i and Z_k is assessed based on the values $P_{ik}^{(11)}$ and $G_{ik} = P_{ik}^{(11)} / P_{ik}^{(00)}$ ($0 \le G_{ik} \le 1$), where G_{ik} is the "similarity measure".

By choosing various threshold values (ε_h and ε_g) one can construct logic absorption H^0 and similarity G^0 matrices for matrices H and G:

$$H_{ik}^0 = \begin{cases} 1, & \text{If } H_{ik} \ge \varepsilon_h,\ i \ne k; \\ 0, & \text{If } H_{ik} < \varepsilon_h \text{ Or } i = k \end{cases}, \quad G_{ik}^0 = \begin{cases} 1, & \text{If } G_{ik} \ge \varepsilon_g,\ i \ne k; \\ 0, & \text{If } G_{ik} < \varepsilon_g \text{ Or } i = k. \end{cases}$$

We propose six groups for comparison of software and hardware solutions for information analysis support of territorial development – more than 40 different parameters as examples of key functions (Table 1-6).

Table 1. Example of properties of software and hardware solutions
(Group of parameters 'Analysis and forecasting of social and economic development of territories')

#	Parameter	Software and hardware solution		
		1	…	*n*
1	Monitoring of key indicators of social and economic development in the region, implementation of targeted investment programs, and delivery of key indicators of economic development			
2	Integrated assessment for social and economic, tax, investment operations of territories			
3	Multivariate scenario forecasting of social and economic development of the region			
4	Generation of standard reports			
5	Specification of algorithms for calculation of indicators			
6	Visualization of social and economic information using business graphics			

Table 2. Example of properties of software and hardware solutions
(Group of parameters 'Performance appraisal for governance and administrative bodies')

#	Parameter	Software and hardware solution		
		1	…	*n*
7	Generation of summary reports on results and main activities of executive authorities in the region			
8	Evaluation of inefficient spending of regional authorities			
9	Calculation of indicators for monitoring and evaluating the government activities effectiveness in the subject of the Russian Federation			
10	The ineffective expenses amount of the government in the subject of the Russian Federation determination			
11	Medium-term variant forecasting of regional government's performance indicators			

Table 3. Example of properties of software and hardware solutions
(Group of parameters 'Territory passport support')

#	Parameter	Software and hardware solution		
		1	…	*n*
12	Presentation summary information on various fields of activity in the region			
13	Monitoring the status of management objects			
14	Information about socio-economic development in the region, municipalities and enterprises representation			
15	Attributive information about objects on the territory representation			
16	Information on the political situation and the results of opinion polls			

Table 4. Example of properties of software and hardware solutions
(Group of parameters 'Decision support system')

#	Parameter	Software and hardware solution		
		1	…	*n*
17	Maintaining the function of formal logical inference and decision making based on the information available in the database, reference and information block and the results of spatio-temporal analysis and modeling			
18	Analysis based on fuzzy modeling			
19	Conducting medium-term and long-term forecasting the performance of regional government using elements of fuzzy logic			
20	The user preferences function formation			
21	Use of formal optimization and ranking methods by vector criterion			

Table 5. Example of properties of software and hardware solutions
(Group of parameters 'Geoinformation functionality')

#	Parameter	Software and hardware solution 1	…	*n*
22	Using the GIS module			
23	Attribute information maintenance			
24	Layer Support			
25	Maintaining the spatial analysis function			
26	Maintaining spatio-temporal modeling			
27	Geographic information analysis problems solution			
28	Evaluation and interpretation of relationships between geographic features			
29	Display on the map several indicators for the cause-effect relationships analysis			
30	Service oriented architecture availability			
31	The ability to dynamically expand the functionality of analytical data processing			

Table 6. Example of properties of software and hardware solutions
(Group of parameters 'Technical implementation')

#	Parameter	Software and hardware solution 1	…	*n*
32	Using Data Warehouse			
33	Enabling multi-dimensional data cubes			
34	Setting a data slice: adding/deleting measurements, changing the sequence of measurements in a slice			
35	Configuring the display of hierarchies in dimensions			
36	Data slice graphical representation: setting the type of chart, facts to be displayed, scale, legend, signatures, etc.			
37	Setting up the database structure in accordance with the additional requirements of specific executive bodies of the constituent entity in the Russian Federation			
38	Tools availability for creating and changing arbitrary reporting forms			
39	Reporting using templates			
40	Exporting data to various formats availability (Excel, XML, etc.)			
41	Web-interface's availability			
42	Direct interface with Google Earth map services, Yandex map			

Similarity (Figure 1) and absorption (Figure 2) graphs based on the logic matrices G^0, H^0 offer a visualization of interrelation of the solutions in question (in terms of their functionality). The bidirectional edge of the graph between vertices Z_k and Z_1 means that systems Z_k and Z_1 are mutually absorbing, i.e. the functionality of system Z_k is completely absorbed by system Z_1 and contrariwise: the functionality of system Z_1 is completely absorbed by system Z_k.

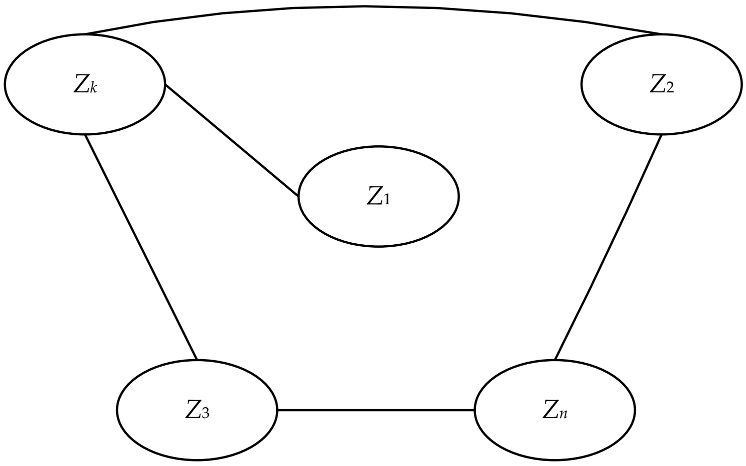

Figure 1. Example of a similarity graph.

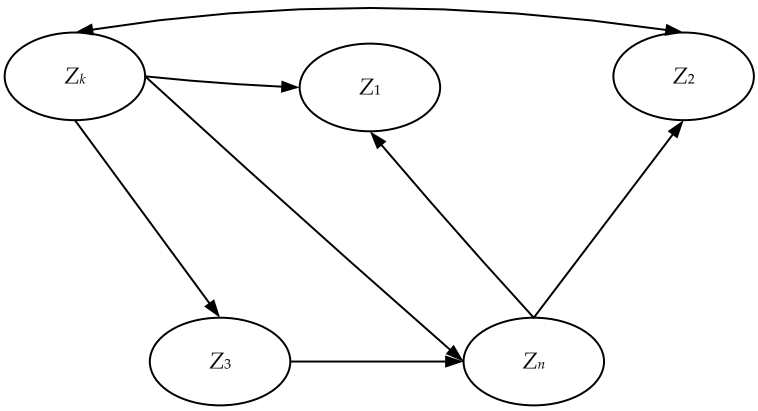

Figure 2. Example of an absorption graph.

3. Results and Discussion
Despite the overall transparency of the approach, the result will largely depend on the assumed values ε_h and ε_g, as defined by the expert. Therefore, overestimated similarity and absorption coefficients will lead to the impossibility of correlating the systems under consideration with the reference system. The opposite situation, when these coefficients are underestimated, they can also lead to the impossibility of choosing the best system, since all the systems under consideration will be similar to the standard and mutually absorbed, which devalues the entire comparison methodology. Thus, a significant role is assigned to the decision maker, both in terms of compared indicators selection and in determining the most suitable similarity and absorption coefficients. In case if the choice of the system will be difficult and / or impossible with rather high values of ε_h and ε_g, it is advisable to use additional selection criteria to make a definitive final one, for example, to evaluate the cost indicators, warranty obligations and support conditions.

4. Conclusion
The considered comparison technique can be used when choosing complex software products (for example, [10]). It should be noted that the adequacy of the method directly depends on the number of compared functions (parameters) and with a small number of functions will give an unreliable result. In this case, one must either decompose the functions into elementary processes or use additional comparison parameters, such as cost indicators, reliability, maintainability, productivity.

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