

Method for Evaluating Information to Solve Problems of Control, Monitoring and Diagnostics

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Abstract. The article describes a method for evaluating information to solve problems of control, monitoring and diagnostics. It is necessary for reducing the dimensionality of informational indicators of situations, bringing them to relative units, for calculating generalized information indicators on their basis, ranking them by characteristic levels, for calculating the efficiency criterion of a system functioning in real time. The design of information evaluation system has been developed on its basis that allows analyzing, processing and assessing information about the object. Such object can be a complex technical, economic and social system. The method and the based system thereof can find a wide application in the field of analysis, processing and evaluation of information on the functioning of the systems, regardless of their purpose, goals, tasks and complexity. For example, they can be used to assess the innovation capacities of industrial enterprises and management decisions.

1. Introduction

Decisionsupport systems (DSS) are useful to improve the efficiency of complex systems management and make the informed management decisions, based on the latest information technologies. They allow one to convert and analyze the accumulated information and develop the information control action [1–3].

Usually, the indicator system of a complex technical, economic, or social object of study is a complex hierarchical structure with many private indicators, which, depending on the management tasks, may include various criteria, reflecting its status [4–9].

It is advisable for management tasks to have a generalized criterion of the scorecard (for example, reflecting the level of innovative capacity of the system to solve the problem of assessing the functioning of research and production enterprise), a comprehensive assessment of information system performance (including financial condition, intellectual support, quality personnel, manufacturing flow, corporate organization, culture of innovation, innovation receptivity in solving the problem of estimation of innovative potential of the enterprise) to characterize the overall information about the actual state of the system (technical, economic and social).

The actual problem is the creation of systems conversion, analysis, management and information processing, enabling a comprehensive assessment of various kinds of information collected from various sources and created in the process of functioning of complex technical, economic and social systems [10–16].



2. The problem statement and objectives

To solve the problems of efficiency increase of systems analysis functioning, processing and evaluation of information it requires the development of a new, improved method and a system that allows an integrated criteria-based assessment of heterogeneous information, on the basis of which one would produce management, control and diagnostics of better quality.

In particular, scientific and practical interest is the creation of assessing information system about the innovative potential of mechanical engineering enterprises, which allows the assessment of an innovative potential level of the enterprise in real time, to analyze and make decisions on enterprise management, while providing the enhanced functionality of the system, improving the efficiency of information processing about the innovation potential and to provide reasonable criteria-based evaluation of its components.

3. Description of the method and the system based thereof

A new method for evaluating information for solving problems of control, monitoring and diagnostics consists in reducing the dimension of information indicators of situations; conversion of figures in relative units; calculation of generalized information metrics; ranking them by characteristic levels; calculating an efficiency criterion of functioning of the system in real time. This method has been developed and the system has been designed on the basis thereof, for the analysis and information processing on the functioning of the systems. For example, they can be used to assess the innovation capacities of industrial enterprises and management decisions.

The task is to develop a new, improved method and a system enabling the integrated criteria-based assessment of heterogeneous information, on the basis of which better management, control and diagnosis could be implemented, solved by:

- a new workflow, which allows reducing the dimension of information indicators of situations that lead them to relative units, calculating generalized information metrics on their basis, ranking them by the characteristic levels, calculating the performance criteria of the system functioning for the current situation;
- reducing the number of decision-makers (DM) to one, eliminating the need for control over the timeliness of decision made by many decision-makers, eliminating the need of calculating weighting coefficients according to the i -th DM, the elimination of calculations to determine the likelihood of timely and correct decision, enhancing the visibility of information display about the results of the assessment of the current state of the system (by ranking the levels of information on performance situations);
- reducing time and amount of the required computational resources and memory, by avoiding the dimensionality (redundancy) of information and indicators of a number of calculations, improving the objectivity of information assessment.

The evaluating information method is aimed at assessing the effectiveness of decisions and functioning of the system.

The necessary source data is stored in a storage device (SD) in the form of arrays of variables and constant values of information performance situations.

The following parameters are used as the initial information: the decision matrix A of dimension $m \times h$, where h is a number of solutions; the array B of the current situation of dimension m . A linguistic variable may be quantitative or qualitative characteristic of an argument that affects the choice of the solution. For example, if the argument is a certain dimension in some physical quantity, the linguistic variable can have values like “small”, “medium”, and “large”.

Performance management indicator W of systems with the automated decision making is evaluated by

$$W = P_{cd} \times P_{t,i}, \quad (1)$$

where P_{cd} is probability of correct decision; $P_{t,i}$ is probability of timely implementation of correct and timely decision (the correct and timely implementation of the decision refers to the timely delivery of properly executed solution to the performers on communication lines).

$$P_{cd} = \frac{1}{M} \sum_{j=1}^M R_j, \quad j = \overline{1, M}, \quad (2)$$

where M is a number of considered situations; R_j is correct decision for the j -th situation;

$$R_j = \sum_{i=1}^M R_{ij}, \quad j = \overline{1, M}. \quad (3)$$

Here

$$R_i = \begin{cases} 1, & \text{if a solution is found} \\ 0, & \text{if a solution is not found} \end{cases}; \quad (4)$$

$$P_{t.i} = \frac{1}{Q \times M} \sum_{j=1}^M \frac{C_j}{R_j}, \quad j = \overline{1, M}, \quad (5)$$

where C_j is a number of timely implemented decisions for the j -th situation;

$$C_j = \sum_{q=1}^Q C_{qj}, \quad q = \overline{1, Q}, \quad (6)$$

where Q is a number of communication lines corresponding to the number of performers;

$$C_{qj} = \begin{cases} 1, & \text{if } t_{qj} \leq t_{add.i} \\ 0, & \text{if } t_{qj} > t_{add.i} \end{cases}, \quad (7)$$

where t_{qj} is time spent on the implementation of decisions of the performers in the j -th situation; $t_{add.i}$ is time allowed for implementation of the decision.

After recording information in the storage device, the dimensionality of the data is reduced using the factor and correlation analysis, leading information indicators V_j for each j -th situation to relative units using the scales according to

$$V_j = \begin{cases} [0; 20), & v_j \in (-\infty; l_{2j}) \\ [20; 40), & v_j \in [l_{2j}; l_{2j} + 20u_j) \\ [40; 60), & v_j \in [l_{2j} + 20u_j, l_{2j} + 40u_j), j = \overline{1, M}, \\ [60; 80), & v_j \in [l_{2j} + 40u_j, l_{4j}) \\ [80; 100], & v_j \in [l_{4j}; \infty) \end{cases} \quad (8)$$

where v_j is an information indicator for the j -th situation; l_{2j} is a standard value of an information indicator corresponding to the second level (low value); l_{4j} is a standard value of an information indicator corresponding to the fourth level (highest value). Here is a step interval of the casting scale

$$u_j = \frac{l_{2j} - l_{4j}}{3} \times \frac{1}{20}, \quad j = \overline{1, M}. \quad (9)$$

The next step of the system is the identification of the generalized indicators of information situations for P_i groups with defined indicators of the system state, and calculation of the characteristic level for each group by

$$X_i = \begin{cases} \text{firstlevel}, & P_i \in [0; 20) \\ \text{secondlevel}, & P_i \in [20; 40) \\ \text{thirdlevel}, & P_i \in [40; 60) \\ \text{fourthlevel}, & P_i \in [60; 80) \\ \text{fifthlevel}, & P_i \in [80; 100] \end{cases}, \quad (10)$$

where X_i is the characteristic group-level indicators of the system state, here

$$P_i = \frac{\sum_{j=1}^M V_j}{M}, \quad (11)$$

$$K_{effect} = \left(\frac{\sum_{i=2}^n \frac{1}{2} P_i P_{i-1} \sin\left(\frac{360}{n}\right)}{\frac{1}{2} P_{great}^2 n \sin\left(\frac{360}{n}\right)} \right) \times 100\% =$$

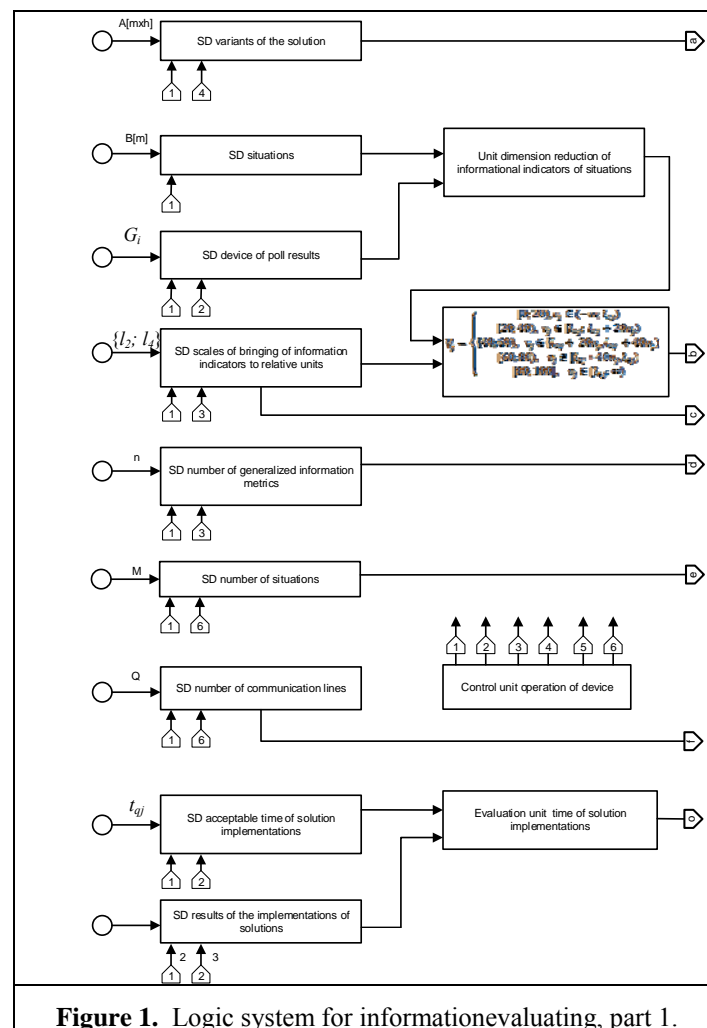
$$= \left(\frac{\sum_{i=2}^n P_i P_{i-1}}{P_{great}^2 n} \right) \times 100\%, \quad (12)$$

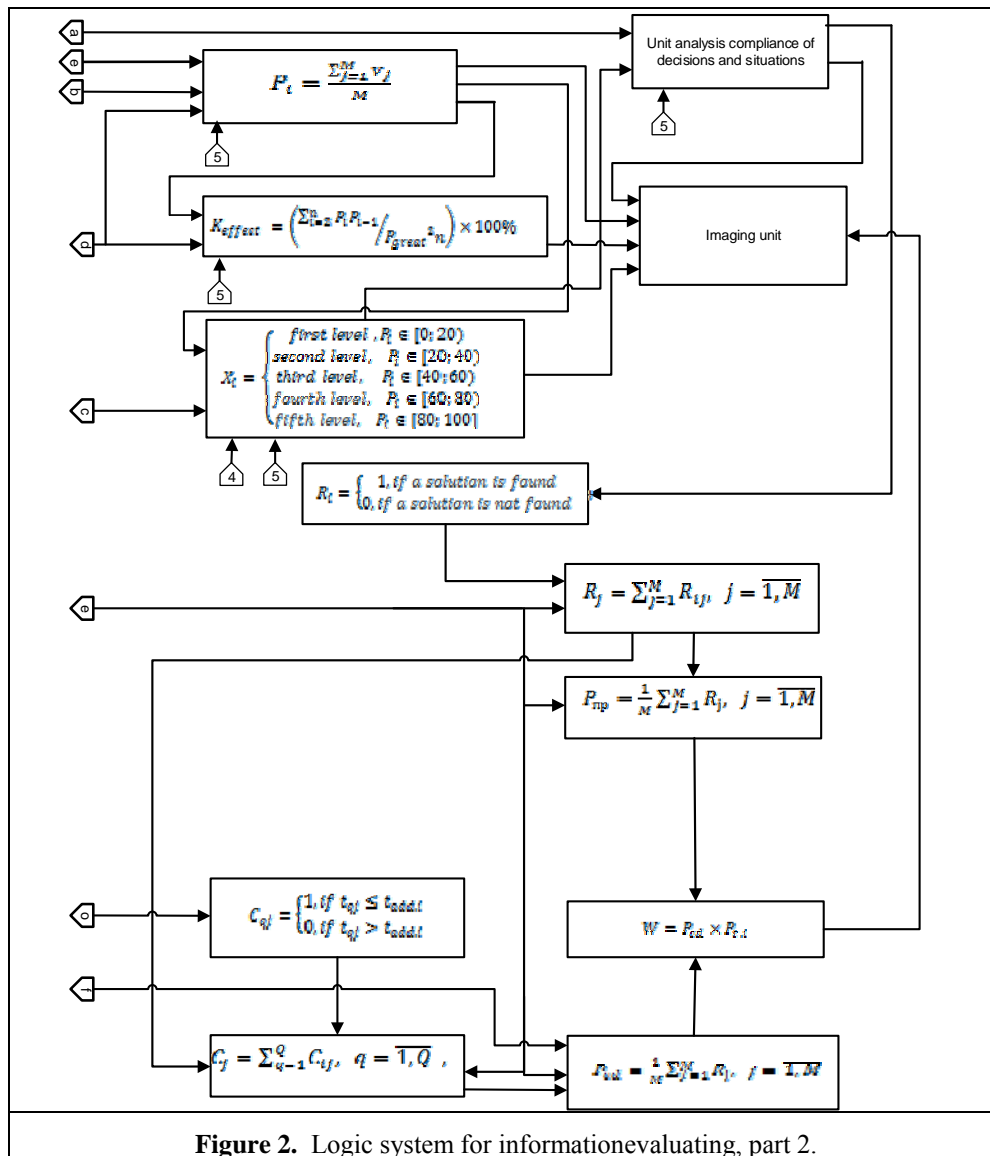
where P_{great} is the maximum possible value of the information indicator of the situation on the scale of these values ($P_{great} = 100$); n is a number of generalized information indicators.

The next step is to analyze the compliance options and situations, then output information about the situation on the display unit screen.

After determination the probability of good decision-making and the probability of timely implementation of decisions, we determine the value of the management efficiency indicator by (1), output on the screen of the display unit, and analyze the received information.

Logic systems for information evaluating on the basis of the proposed method are presented in Fig. 1 and Fig. 2, where signs marked \bigcirc are the inputs of the system, and \square is the relationship between the elements.





The essence of the proposed approach to the assessment of information is to produce associations between qualitative and quantitative results of the evaluation components included in the model evaluate the information and solutions possible under the current situation.

4. Results and Prospects of Their Use

Below there are the estimation results of innovative potential of research and production instrument-making enterprise using the developed evaluation information method.

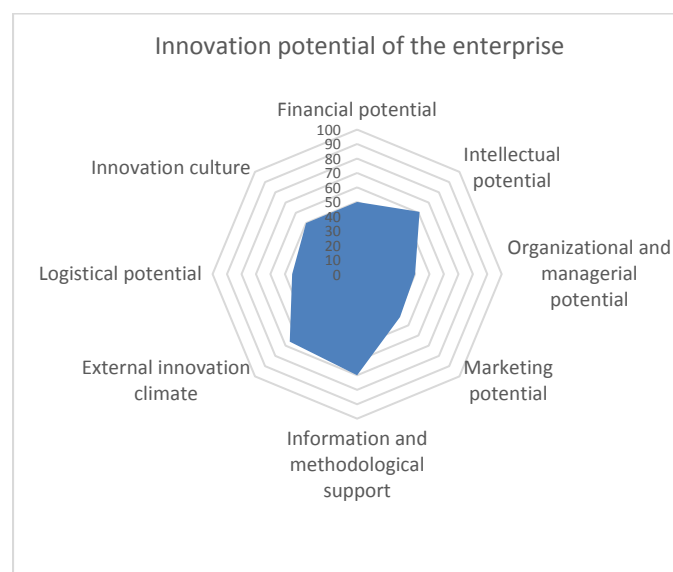
Table 1 provides numerical values of information indices in relative units (the maximum possible value is of 100 relative units) and the numbers of levels of groups of information indicators (1 to 5) obtained using the described method of evaluating information.

Table 1. Values and levels of information indices groups of innovation potential of the enterprise

Information IndicesGroup	Value	Levels
Financial potential	50	<i>thirdlevel</i>
Intellectual potential	61	<i>fourthlevel</i>
Organizational and managerial potential	40	<i>second level</i>
Marketing potential	42	<i>second level</i>
Information and methodological support	70	<i>fourthlevel</i>
External innovation climate	66	<i>fourthlevel</i>
Logistical potential	45	<i>second level</i>
Innovation culture	50	<i>thirdlevel</i>

By the numerical values of the groups and the numbers of levels of information indices of innovative potential, shown in Table 1, it is possible to draw a conclusion about the adequacy or inadequacy of a specific index group, based on the specified requirements.

Fig. 3 shows a radar chart with the values of information indicators groups depicted in Table 1. As you can see from the chart, the selected object for research – research-and-production instrument-making enterprise – had a relatively low organizational and management capacity during information evaluation, and it was being increased. The average level was characterized by the marketing potential, experience of realization of innovative projects, the potential of material-technical base and innovative culture of the enterprise. The intellectual capacity, information and methodological support, external innovation climate had a high level.

**Figure 3.** A radar chart for the system efficiency.

The efficiency indicator of the investigated object (the system company) functioning, calculated by (12), has a value of

$$K_{effect} = \left(\frac{50 \times 61 + 61 \times 40 \dots 45 \times 50}{100^2 \times n} \right) \times 100\% =$$

$$= \left(\frac{3050 + 2440 + \dots + 2970 + 2250}{70000} \right) \times 100\% = 28.5\%$$

The example confirms the efficiency of the proposed method and the possibility of its use to evaluate the information about the object, which can be any technical, economic and social system.

The developed method can be used to evaluate the information in the tasks of management, control and diagnostics of technical, economic and social systems. In particular, it can be used to assess the level of innovative potential of the enterprise in real time, analysis and decision-making in the enterprise management. While it provides the enhanced functionality of the system, it improves the efficiency of information processing about the innovation potential, and allows a proper evaluation of criteria-based components of the innovative potential.

5. Conclusion

The example confirms the efficiency of the proposed method and the possibility of its use to evaluate the information about the object, which can be any technical, economic and social system.

The advantage of the proposed method and the system for information evaluating based on thereof is its application to assess both quantitative and qualitative information. Heterogeneous information is evaluated and presented in the form of numerical values of the information indices of groups and numbers of the group levels. And the performance score of the studied object as a whole is determined by the values of information indices groups.

The method and the system for evaluating information to solve the problems of management, control and diagnostics can be used in the analysis, processing and evaluation of information on the functioning of technical, economic and social systems, regardless of their purpose, goals, tasks and complexity. For example, they can be used to monitor and diagnose complex equipment to evaluate information about the innovative potential of the instrument-making enterprise.

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