Error correction algorithms in on-board intelligent transport data transmission systems

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Abstract. The paper describes the problems of assessing the quality of intelligent transport systems related to organizational and technical systems based on the system analysis of information technologies. It provides the theoretical basis for describing the quality assessment process of intelligent transport systems. The paper also justifies the method of quality assessment of complex systems, which include intelligent transport systems. It is shown that the modern system of intelligent systems should not only be effective, but also not violate the required operation mode. The characteristic evaluating the effect of the target functioning has the properties of measurability, completeness and reliability. The intelligent transport systems may include systems that in the process of control ensure the achievement of set targets with the necessary quality of target functioning in a counteracting environment. In order for the system to function correctly, it is necessary to agree on a set of targets and a set of conditions, i.e. to implement an integrated approach to the functioning of the system as a whole. With an integrated approach it is necessary to agree on all the targets set for the system, as well as all the conditions under which it will operate.

1. Introduction
The quality of an object (system) is a generalized characteristic of its properties that determines the ability to satisfy the needs in accordance with the purpose, or a measure of utility of this object (system).

When assessing the effectiveness of the designed (existing) system after considering more than one solution to the problem, the final solution is possible if there is a quantitative assessment of the quality of each of the competing options [1–3].

There are not qualities, but only things (objects, systems) that have qualities, and moreover, they have infinitely many qualities. These qualities may be both positive and negative, and may not be comparable to each other. In attempts to overcome these methodological difficulties, various authors propose the use of integral quality indicators in the form of sums, products, fractions and other combinations, but all these indicators are incorrect or naive. For targeted (technical, organizational-technical) systems, the most objective and convincing indicator of all advantages and disadvantages, i.e. the general characteristic of the effect of the object (system) should be the removal from the target.

Quality characteristics based on distance from and derived from the target are applicable if the coordinates of the target in the system result space are known. If the target results are not known, the quality assessment is possible only when comparing all options with one of them, which in one way or another is chosen as the basic (best, according to a given definition) [4–8].
“Quality management” is fundamentally impossible, since quality is an abstract concept. We may say: to control quality, to monitor quality. It is necessary to manage the enterprise, the production process, and not for the sake of abstract “quality”, but for the sake of obtaining goods with certain consumer properties that correspond to a given level (standard, world level).

To develop a quality management system is to disorient managers, i.e. to direct the funds and attention of managers in the wrong direction. The problem of quality management is not solved automatically, only by improving control at the stage of production (operation of the system), but also much earlier, i.e. by those technical solutions that are laid down in the project for the creation of the system (enterprise), i.e. at the stage of invention and science. Therefore, the acceptance of products at the enterprise is not yet a quality management system.

The choice of quality criteria (performance criteria) is both science and art. Considering that the system may have several evaluation criteria (i.e. it is multi-criterion), and it cannot be reduced to one indicator, since it will not have a conceptual meaning, it may be considered an error to form one indicator as a sum (with the so-called “weights”, importance coefficients) or as their ratio (product) [9–13].

2. Materials and Methods
A pragmatic approach for analyzing a multi-criteria system may be implemented as follows:

- to determine the importance of each of the criteria and rank them according to the level of importance (i.e. to rank the criteria);
- to sequentially optimize the system first according to the most important criterion (the remaining criteria are taken into account as limitations), then according to the second criterion, then according to the third, etc., to the last criterion.

Criteria are usually ranked by experts, i.e. it is subjective, since sometimes it is more important to reduce the time to achieve the target, and sometimes the costs [14–19].

Having analyzed to the last criterion, we obtain options for a compromise solution in which the losses in the value of the main criterion are small, but additional criteria have an acceptable value.

The system thus formed will be most effective in solving a multi-criterion problem.

As is already known the overall characteristic of the effect of targeted systems should be the removal from the target. The purpose of the technical system, for example, the maximum achievement of the performance result in a given situation is determined by a certain ideal set of its parameters \( P^*(Z) \), where \( Z \) – target of the system, and

\[
P^* = \{ P_1, P_2, ..., P_n \} \quad \text{– ideal set of parameters in which the target of the system is achieved.}
\]

An arbitrary value of the result \( R_j \) corresponds to another set of parameters

\[
P_j = (p'_1, p'_2, ..., p'_n).
\]

The distance between two sets of variables, i.e. variants of the system may be determined in different ways. For example, the norm of the result difference vector (Hemming) [20–23] has the form:

\[
\delta(P, P') = \sum_k |R_k(P) - R_k(P')|
\]

where \( k \) – index of the system result component if it is a vector.

In particular, removing an arbitrary version of the system from the target:

\[
\delta(P, P^*) = \sum_k |R_k(P) - R_k(P^*)|
\]

3. Results
Minimizing the distance from the target in principle allows finding the values of the system parameters that are optimal for all components of the result. At the same time, practical convenience represents a relative assessment of the system quality as follows:

\[
\varphi(P, P^*) = 1 - \frac{\delta(P, P^*)}{\delta_0(P, P)}
\]
where \( \delta_n = \max \delta(p_i, p') \).

Relative magnitude \( \omega(P, P') \) – one of the possible characteristic functions, which allows evaluating the effectiveness of the system.

The difference of values:

\[
\Delta \omega = \omega_i - \omega_j = 1 - \frac{\delta(p_i, p') - \delta(p_j, p')}{\delta_n},
\]

is called the degree of targeting of the system \( i \) relative to the system \( j \) at a given target.

In general, the result mismatch indicator has the form:

\[
Q = |R - Z|,
\]

and the quality of result

\[
q = \frac{R}{Z}.
\]

When designing performance indicators, two tasks are set:

- evaluation of the system functioning quality;
- evaluation of the effectiveness of investment (economic efficiency).

If the comparison of variants is carried out by cost, which is characteristic of the design of production objects (systems), the characteristic function serves an indicator of consumer efficiency:

\[
\eta_n = 1 - \frac{N_i}{N_o},
\]

where \( N_i \) and \( N_o \) are the given costs of the alternative and basic variants.

When comparing the systems according to the value of the functioning result or its quality, the efficiency indicator has the form:

\[
\eta_s = \eta_a = 1 - \frac{R_i}{R_o},
\]

and upon agreement of the result:

\[
\eta_o = 1 - \frac{Q_i}{Q_o},
\]

If the result of the system is significantly influenced by random factors, then the probability of achieving the target \( P \) is used to evaluate the functioning of the system, while it should be borne in mind that the probability estimate is a dimensionless quantity, which is an indicator of the effect, and not the effectiveness of the system. The relative characteristic function of the efficiency of solving a problem takes the form:

\[
\eta_p = 1 - \frac{P_i}{P_o},
\]

where \( P_i \) and \( P_o \) – probabilities of achieving the target by the system with alternative and basic parameter variants.

4. Discussion

The objective function should reflect the degree of the system excellence, the degree of achievement of the target, i.e. be a measure of the system effectiveness. In relatively simple cases, one of the properties of the system may be taken as the objective function – power, volume, cost, accuracy, etc. A more general solution is to use one of the characteristic functions as the objective function. The feasibility of using a particular performance indicator cannot be determined a priori, regardless of the type and purpose of the system being created (designed), its connections with other systems and external factors acting on the system and affecting the achievement of the target set by the system.

The target of the system is usually verbal; the objective function cannot take into account all the factors that determine the behavior of the system, since this may cause computational difficulties, for example, during calculations.
The theory and practice of system analysis, decision-making and operation research allows formulating a number of requirements for the mathematical properties of the objective function, namely:

- objective function should have a quantitative measure and allow for an objective assessment (objectivity);
- change of the objective function value should affect the achievement of the set tasks (targets) by the system (criticality);
- objective function should clearly reflect the performance of the system (visibility);
- function must be computable, i.e. analytically accessible and be able to determine its numerical values.

The simultaneous satisfaction of these requirements is not always feasible, since it depends on the number of parameters considered that are included in the objective function. At the same time, an unfavorable combination of properties of target functions leads to the so-called “curse of dimension” (Bellman).

When defining or selecting an objective function, the least significant factors should be “screened out” in order to obtain acceptable solutions in an acceptable time. The objective function is always single and scalar.

There are global and local targets and criteria. Several approaches to the scalarization of target functions shown in Table 1 are used to take into account multiple targets (system requirements) in the practice of system analysis (including methods for optimizing complex functions).

| Scalarization of the objective function | Application features |
|----------------------------------------|----------------------|
| Method of the generalized criterion     | Common high-level target |
| Method of the uniform success criterion | Equal importance of private targets of the system |
| Method of compromise resource allocation| General resource constraint |
| Method of sequential optimization       | Priority relationship between private targets |
| Method of the main (defining) criterion | Lack of information on the importance of private targets |
| Method of the relative importance criterion | Large dimension of the problem |

5. Conclusion

Common to intelligent transport and control systems are two main ideas used in studying the quality of operation of complex systems. Namely, the priority of its targets and functions leading to the structure of the system – a functional approach. Thus, it is necessary to determine the price of achieving the corresponding result. The general idea of the system approach when solving problems related to the quality of intelligent transport systems is the comparison of the necessary and sufficient effect and resources.

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