Models of expert assessments and their study in problems of choice and decision-making in management of motor transport processes

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Abstract. The article deals with decision making concerning transport tasks on search iterations in the management of motor transport processes. An optimal selection of the best option for specific situations is suggested in the management of complex multi-criteria transport processes.

1. Introduction
Management of motor transport processes depends on the efficiency of rolling stock, which is reduced to logistic problems and their solutions. The investigated motor transportation problems from a sufficient number of parameters and signs of influences which enter the process are described by models of multi-criteria optimization, entering into a difficult situation among them. In this case, the whole set of possible solutions is enumerated. The choice of the optimal solution can be a random one. At the same time, there is no objective justification for the made unmodified decisions.

The theory of mathematical modeling, as well as models of expert assessments in the problems of choice and decision making in the management of motor transport processes, is the most effective device, enabling to obtain the best solutions from a variety of existing ones for a particular situation.

2. Results and Discussion
An important feature of a decision-making stage is the presence of additional information on the subject of choice, which, especially in the vector case of non-dominated alternatives, is often able to be provided only for a decision maker. Classes of a priori, a posteriori and adaptive models of decisions can be defined, depending on the possibilities of identifying the required additional information for decision-makers on the considered variants of decisions used to form structure $\sigma$ on $X$ multitude [1, 2].

There is certain optimality principle $Opt$ in a priori models of the required additional information, according to which the selection rule of choice $\pi$ is formed. The $Opt$ operator is represented explicitly, either by a formula relation between estimates of the properties of the alternative, or by the concept of
a better solution, the determination of which becomes possible on the basis of binary dominance relation on the set of estimates.

The basis of posteriori models is the assumption that the formal model of the choice problem does not contain sufficient information on which the decision maker can formulate the optimality principle corresponding to the target installation [3]. Therefore, here the authors are faced with the task of complete recovery of optimality principle on the whole set of alternatives in an explicit form on partial additional information. The renewable principle of optimality defines a formal model for describing the system of preferences of decision makers.

The choice of the problem in adaptive models does not suppose introduction or complete restoration of the optimality principle in an explicit form. Here information about the preferences of the decision maker is used directly at the iteration of searching for a better alternative. Thus, in adaptive models, the optimization problem is solved by an implicitly defined optimality principle. Here one can note man-machine methods [4], which take advantages of the interactive mode of problem solving.

The above mentioned a priori, a posteriori and adaptive models of choice problems are used to solve numerical vector schemes, but they have not been formalized earlier in the search iterations. The construction of such models would allow creating powerful, universal, and flexible algorithms.

The decision-making process is also a classic case of choice. In the tasks theory of multicriteria optimization experts are most often involved and models of expert evaluations are used at this stage [3, 5].

In this paper, formalization of these models in terms of the theory of choice as one of their selection mechanisms and the use of this mechanism for dropping the solution on search iterations is proposed. Methods of expert assessments are methods of organizing work with experts and processing opinions of experts expressed in a quantitative and (or) qualitative form with the purpose of preparing information for decision-makers [5].

The primitive approach of the so-called "qualimetry" [2] is widespread, according to which an object can always be estimated in one number. But each object is evaluated by many quality indicators. It is very difficult to bring them together. A specific (narrow) statement of the problem is important to the experts. But there are often no such statement of the problem, and generalized quality indicators are not objective in nature.

An alternative to a single generalized indicator is a mathematical apparatus of the type of multicriteria optimization, the Pareto set. Research in this area allows us to build expert procedures of decision making quite accurately and to rank the initial set of alternatives, and using the apparatus of the theory of choice provides the basis for constructing a general algorithm for ranking the initial set.

In [5], the problem of expert ranking for a group of objects has been considered. The experts were offered a limited sample, based on the rankings, which weighed the coefficients for the project variants and then ordered the whole set. Various methods of determining the weight coefficients for the linear utility function have been investigated. It is shown that, with a small confidence of experts in their preferences, the maximum likelihood method is the most preferable one [2, 5].

In these studies, one of new and promising approaches to the problem of collective selection is considered - an approach based on the method of extrapolation from the maximum likelihood function. This is due to the fact that it works most correctly under conditions where a certainty of the experts is different, and, moreover, allows building a utility function.

Three assumptions are assumed [8]:

– Each variant of the solution is interpreted by a point in the space of criteria, in which each particular criterion has some principle of quantitative measurement, unknown at the moment and intuitively estimated by experts;
– Ranking of decision options is associated with some unknown objective function, which is also assessed by experts intuitively;
– Set of unmodified alternatives obtained at each stage of the search is a discrete one, that is, it consists of a finite number of variants.
Models of extrapolation along a vector, according to a cone, satisfying examination and maximum likelihood function, are considered in detail.

Extrapolation according to the vector satisfies expertise. It is assumed that the resulting set of non-dominant alternatives $X$ consists of $T$ decision options and sample $x \in X$ of limited volume $\tau << T$ ($\tau = 5 - 9$) is given for examination. The processing of the results of the examination according to decision options has made it possible to determine the ranking:

$$x^1 > x^2 > \ldots > x^T$$  \hspace{1cm} (1)

Comparing the solutions in (1), the expert has intuitively estimated the quality of each alternative $x = (x_1, \ldots, x_m)$ by some utility function $f(x) = f(x_1, x_2, \ldots, x_m)$, according to which $x > y$ and only if $f(x) < f(y)$, then:

$$f(x) = \sum_{p=1}^{m} \alpha_p x_p$$  \hspace{1cm} (2)

where $\alpha = (\alpha_1, \ldots, \alpha_m)$ – unknown weights of the utility function, corresponding to the relative significance of the particular criteria of the problem.

If we introduce the additional normalization condition, that is, the vector $\bar{\alpha} = (\alpha_1, \ldots, \alpha_m)$ has unit length, and then $f(x)$ is the projection of $x$ onto $\bar{\alpha}$, and the ranking of the vectors in the utility function $f(x)$ is their ranking by projection size for some selected direction. Then the problem reduces to determining such direction of the vector $\bar{\alpha}$, which projections of the vector $x = (x_1, \ldots, x_m)$ onto the vector $\bar{\alpha}$ are ordered in the same way as $x$ themselves according to the expert ranking (1).

The obtained ranking of the form (1) with allowance for transitivity is equivalent to some set of paired comparisons (the first vector with the second one, the second with the third, etc.). Each pairwise comparison defines a certain hyperplane separating the admissible vectors $\bar{\alpha}$ from those that contradict the real expertise. Moreover, the further $\bar{\alpha}$ from this plane, the more confident is the preference over $x$ and, consequently, the more stable it is with respect to the model’s inaccuracies and other perturbing factors. The complete information about the expert ranking is adequate in the indicated sense of the inner part of some polyhedral cone $A$ with vertex at the origin such that any vector from this cone is suitable for choosing it as $\bar{\alpha}$.

Extrapolation on the guiding cone, satisfying examination. The replacement of the guide cone $A$ by one vector is convenient for the subsequent ranking, but it introduces a noticeable uncertainty in the interpretation of expert preferences. You can try to do without such a substitution, using the entire guide cone $A$ simultaneously to extrapolate the ranking

For these purposes, it is proposed to construct $X_0 \subset X$ set, whose elements are found by comparing $f(x)$ of all possible pairs $x, y \in X$ over all $\bar{\alpha} \in A$ and weeding out the worst of all. Thus, the set $X_0$ contains only elements that are controversial with respect to $\bar{\alpha} \in A$.

It is shown [3], that if $x > y$ over all edges of the cone $A$, then $x > y$ by any $\bar{\alpha} \in A$. This allows us to construct an efficient algorithm for extracting $X_0 \in X$; for which it is sufficient to determine the fundamental set of solutions for the system $f(x) = \sum_{p=1}^{m} \alpha_p x_p \leq 0$ (edges of the cone), compare and sift through the utility function $f(x)$ solutions. Note that ranking over the entire guide cone as a whole is analogous to the partial ordering of elements in spaces with a cone used in functional analysis.

In contrast to the vector extrapolation model, which allows ranking all vectors $x \in X$ so that repeated calls to experts have been required only to refine the ranking, when the entire guide cone is ordered along the whole, there some amount of incomparable solutions defining the set $X_0$ remains. Therefore, it is necessary to repeatedly appeal to experts to put things in order in $X_0$.

Thus, the use of vector and cone extrapolation adequate to expert estimates in models of multicriteria step-by-step choice of solutions would, allowing for the preferences of the decision maker, reduce the power of the set of unmodified alternatives. From the above variety of approaches and methods of expert ranking in this paper, we consider in detail the approach to the problem of group selection, based on the method of extrapolation from the maximum likelihood function [6, 7].
This is due to the fact that it works most correctly under conditions when the certainty of certain experts is different, and besides it allows you to quickly and effectively build the utility function of a design solution of a complex structure. However, modern methods of using this and similar methods have low efficiency, since they are used mainly at the last stage of decision making. In addition, there is insufficiently developed practical use of experts, in view of poorly developed software support for the work of the expert group [9].

The use of expert procedures already at the search stages is of particular interest, to minimize the loss of "good" solutions. However, this in its turn requires the presence of a developed analytical apparatus, including a scheme for working out the most typical situations that arise in the process of solving vector optimization problems.

3. Conclusion

The authors propose a block-diagram, invariant to the object region, reflecting the main stages and tasks arising in vector optimization models of motor transport enterprise control in figure [1].

Expert models of expert assessments and their study in selection tasks and decision making in the management of motor transport processes can find wide application in other tasks of applied importance. These may include the tasks of design, planning, resource allocation, as well as other tasks of multi-criteria optimization modeling.
Using the apparatus of expert assessments would significantly improve the efficiency of finding solutions. Since the entire search process is essentially a chain of choice situations, it would be natural to describe such schemes by choosing a theory of choice.

Using the choice of solutions in the iterations of search in numerical vector schemes in modeling of urban transport systems will allow us to evenly distribute transport flows on the road network, improve traffic safety, reduce the number of traffic accidents and delays, increase the average speed of passenger flows, improve sanitary and hygienic state of the air basin, save fuel and reduce road maintenance costs, and create other comfortable conditions for participants of pedestrian and traffic flows.

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