Chapter 13
Optimization Problem: Systemic Approach

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ABSTRACT

A systemic approach to solving multicriteria optimization problems is proposed. The system approach allowed uniting the models of individual schemes of compromises into a single integrated structure that adapts to the situation of adopting a multi-criteria solution. The advantage of the concept of non-linear scheme of compromises is the possibility of making a multicriteria decision formally, without the direct participation of a person. The apparatus of the non-linear scheme of compromises, developed as a formalized tool for the study of control systems with conflicting criteria, makes it possible to solve practically multicriteria problems of a wide class.

INTRODUCTION

The essence of many practical problems in different subject areas is the choice of conditions that allow the object of research in a given situation to show its best properties (optimization problems). The conditions on which the properties of the object depend are expressed quantitatively by some variables $x_1, x_2, ..., x_n$, given in the domain of definition X and called optimization arguments. External actions r do not depend on us, but it is known that they can take their values from a compact set R. Usually it is assumed that the calculations are carried out for a given and known external action vector $r^0 \in R$, which ultimately determines the decision-making situation.

In turn, each of the properties of the object in the domain M is quantitatively described by the variable y_k, $k\epsilon[1,s]$, the value of which characterizes the quality of the object in relation to this property.

In the general case, the parameters $y_1, y_2, ..., y_s$, called the quality criteria, form the vector $y = \{y_k\}_{k=1}^{s} \in M$. Its components quantify the properties of the object for a given set of optimization arguments $x = \{x_i\}_{i=1}^{n} \in X$.

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As an example of technology can result in the design of the aircraft. Here, the discrete components of the vector of independent variables x can be schematic solutions (monoplane, biplane), characteristics of materials, etc. The components of the vector of quality criteria y are altitude, speed, maneuverability, cost.

In agrotechnology, x - crop rotation schemes (legumes for sunflower, black pairs, etc.). The components of the - gross yield, indicators of soil erosion.

In pharmacology, the x components of the composite drug. Criteria for the effectiveness of y - the duration of the cure of the disease, the presence of contraindications.

In the economy of x - tax rates, tariffs, excise taxes. Criteria y - gross product, standard of living, unemployment, income differentiation of citizens.

We draw attention to the fact that quality criteria are usually contradictory. The art of the researcher is in the system linking conflicting indicators. So, Jean Colbert (Minister of Louis XIV) in 1665 said "The art of taxation is to pluck a goose, to get the maximum amount of feathers with the minimum hiss".

More fully examples of applied multi-criteria tasks are given in Albert Voronin (2017).

SYSTEMIC APPROACH

The term "systemic approach" means that a real object represented as a system is described as a set of interacting components that implements a specific goal. At the same time, a finite, but ordered set of elements and relations between them is "cut out" from the variety of components of a real object. We can say that the system is a model of a real object only in the aspect of the goal that it implements. The goal, requiring for its achievement certain functions, determines through them the composition and structure of the system.

The goal isolates, outlines the contours of the system in the object. In this system (object model) only what is necessary and sufficient to achieve the goal will come from the real object. If the same object can realize several goals, then with respect to each it acts as an independent system. The systemic approach assumes that not only the object, but also the research process itself acts as a complex system, the task of which, in particular, consists in combining in a single whole various models of the object.

Thus, with the systemic approach, the researcher receives only that information about a real object, which is necessary and sufficient to solve the task.

OPTIMIZATION

If the object realizes only one goal, then the effectiveness of achieving the goal is quantitatively expressed by the single criterion of optimality y. The solution of the optimization problem involves reaching the extreme value of the criterion by choosing the set of optimization arguments.

The extremalization of the optimality criterion is often identified with the concept of goal realization, while in reality these are different concepts. We can say that the criterion and goal are correlated with each other as a model and an original with all the consequences that follow from this. This is understandable, if only because the original is usually put in line not one, but several models reflecting this or that aspect of the original. Some goals are difficult, and sometimes impossible to describe with the help of quantitative criteria. In any case, the criterion is just a surrogate of the goal. Criteria characterize the