LOGICAL MODELS OF COMPOSITE DYNAMIC OBJECTS CONTROL

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Abstract: The questions of designing multicriteria control systems on the basis of logic models of composite dynamic objects are considered.

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1. Introduction

The special attention in the class of control systems is deserved by multicriteria control systems of composite dynamic objects (CDO). As composite dynamic objects we shall consider such technical objects with a broad spectrum of states and plenty of permissible transitions between states, the control by which one consists in implementation of often and miscellaneous control actions in connection with often changes modes of exploitation, purposes, conditions of operation, preferences of the user, estimation's criterions.

It is necessary to take into account the following conditions at designing control systems of such objects.

1. A basic function of control systems is the selection of control actions ensuring optimization of a state of control object. For implementation of this function in multicriteria systems, the methods of vectorial optimization are used. In the basis, which one lay selection operations of alternatives by confrontation of their vectorial estimations by given criterions. The run time of these base operations depends first of all on organization of structure presenting the information on alternatives and criterions of estimation in memory of a management system. The structures used for representation of information should provide at all stages of control procedure selection of indispensable alternatives or criterions of estimation without looking through appropriate sets. The factor of processing speed is specially important for control in extreme situations. The designing of information structures accelerating processes of selection, is a problem of logical designing [1-3].

2. The problems of multicriteria vectorial optimization have no precise solution more often. Usually process of the initial problem solution ends getting sequence of effective not predominant alternatives (Pareto set). Further "improvement" of the solution can be obtained only at the expense of calling the additional information from person who takes decision [Decision taking Person](PTD). Attempts to "improve" the solution are implemented by means of sort out alternatives or criterions reflecting preferences PTD. An effective means of selection the "best" solutions become testing of versions proposed PTD. PTD preferences should be envisaged in a structure of a control system at a phase of its logical designing. For preliminary modelling and selection of the control solutions, which are taking into account preference PTD, it is useful in design organizations to use a special modelling solutions stand.

3. Formation of the control solutions is a complex process including such operations, as monitoring and estimation of a situation, modelling, estimation and selection of control operations.

Logical model of control of objects has to:

- Allow effective execution of the basic procedures of control;
- Assist the acceleration of the search-sorting operations;
- Contain the information about actions, variants of actions, sequence of actions, connections of actions with objectives, i.e. as a matter of fact, to show all the totally procedural knowledge about objects of control;
- Represent the states of the object of control that arise on the separate steps of solution of the task of control;

- Allow the description to terminology of the ending user;
- Allow the enter of the changes under the influence of information that comes in from without.

In the time of developing means of automation of complex control procedures, it is desirable to find a unified effective technical principle, which one would provide enough fast response time all components of complex process. In concordance with methodology of an artificial intelligence, such determining principle can be idea of organization representation and looking up of knowledge.

In modern intellectual systems such successful idea are traditionally connected to usage of network ways of a data representation, that allows to avoid having overcome large amounts of information during execution of search operations.

Report deals with logical designing of multicriteria control systems of composite dynamic objects on the basis of balancing networks [4-6].

2. Problem of Control

It is comfortably to consider the processes of choice of handling actions as a task of satisfaction of limitations (CSP - Constraint Satisfaction Problem). In the tasks of this class, states are described by sets of values of variables, and purposes are a set of limitations, with which these values must satisfy.

Let's consider a problem of such type.

There is an object of control

$$<X, P, D, Y, F, L>, \quad (1)$$

where:

X - set of entrance variables - set of numerical, Boolean or linguistic variables the values of which are not determined with the help of some functions or rules through other variables. In set *X* the subset *C of controlling* variables by which change it is possible to influence states of object of control is allocated. The controlling action changing its value is connected to each variable of set *C*;

P - set *of parameters* - numerical, Boolean or linguistic variables which values are considered set and constant during the decision of one task;

D - set *of derivative* variables - numerical, Boolean or the linguistic variables determined through other variables functionally or with the help of rules such as « if - that »;

Y - set *of target* variables, $Y \subseteq D$;

F - set of functions and rules « if - that », of derivative variables determining dependence of derivative variables on other variables;

L - set of restrictions of type $a_y \leq y \leq b_y$, where a_y, b_y - numerical constants, $y \in Y$.

The task will consist in a finding in space of controlling variables of a point in which all restrictions of set *L* are carried out.

The target variable refers to *normalized* if its value corresponds to the set restrictions. The target variables, which are not corresponding to the restrictions, are considered *not normalized*. Controlling variables, which change causes change of value of a target variable $y \in Y$, refer to *relevant* as this target variable.

If mapping $X \to Y$ it has been set by some system of the equations, for a choice of the decision it would be possible to use methods of mathematical programming. In (1) mapping $X \to Y$ directly it is not set. The decision should be received only on the basis of the semantic information describing the environment and the purposes. The tool of the decision of such problems is balancing networks.

3. Balancing Models

A balancing network [1-3] is the oriented graph $< V, U >$ (illustrated by Fig.1), in which:

V - set of the vertices corresponding to variables of all types in model (1).

U - set of arches. The vertex corresponding to a variable $d \in D$, incorporates coming arches to the vertices representing variables which are used for calculation *d*.

To the left parts rules correspond Boolean variables which accept value 1 at performance of conditions of applicability of rules; the expressions which are included in the right parts of rules, are calculated only at value "1" of this variable. At use of a balancing network for representation of model (1) vertices, presenting controlling and target variables refer to accordingly controlling and target vertices of the network. Vertices proper to the derivative variables are provided with pointers, indicative functions or rules, which are used for determination of values of these variables.

The proper limitations from the set *L* contact with target vertices.

Alongside with such structures as «trees of decisions», «and-or graphs», «networks of utilities», balancing networks are the effective instrument of decision-making process. In the systems using balancing model, great value has the block providing automatic construction of the balancing network under the information (1), and also operative reorganization of the network at changes of the environment.

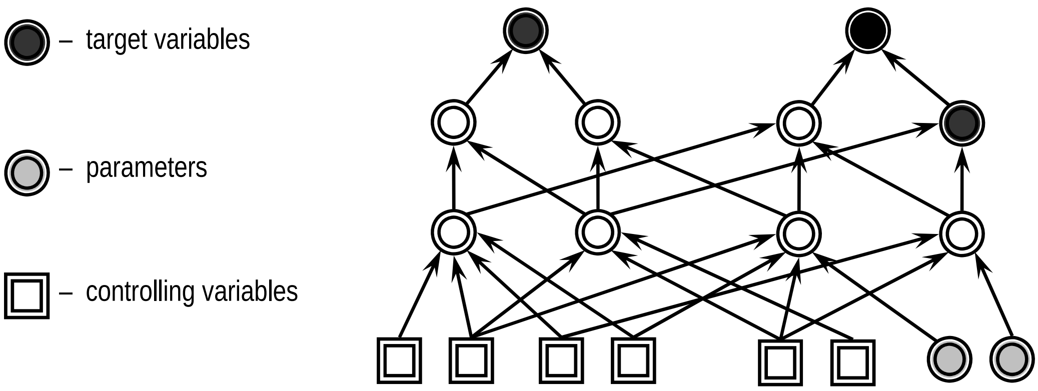

Fig. 1. A balancing network.

The balancing network is development of settlement - logic networks [4].

4. Choice of Controlling Actions

Constant watching of values of entrance variables, and also calculation of values of derivative variables are carried out in the system of control. If the set of values of target variables corresponds to a known class of situations, the system specifies the recommended sequence of actions fixed in its memory. Each carried out action causes change of value of a corresponding controlling variable and, as consequence, change of values of all variables dependent on it. If the arisen extreme situation does not belong to any known class of situations, procedure of a choice of controlling actions as a matter of fact solves a problem of multicriterion decision-making.

For the description of procedure, we shall enter the following designations:

Y'- set of not normalized target variables;

R - set of controlling variables, relevant to not normalized target variables;

h_r^y - a variable designating necessary "direction" of change by controlling variable $r \in R$ for normalization of a target variable *y*; the variable h_r^y - appropriates value 1 if value *y* is necessary to increase and value - 1 if value y needs to be reduced;

H_r - the variable designating "direction" of change by controlling variable *r* in view of all not normalized target variables.

In procedure of a choice of controlling actions, the following operations are used.

Operation 1. Search of relevant controlling variables.

For each not normalized target, variable relevant controlling variables and the necessary direction of their change are defined by viewing against arrows of the ways coming into corresponding target top. As a result of performance of operation 1 set *R* is formed and values h_r^y are defined for all $y \in Y'$.

Operation 2. Calculation of values of variables H_r.

For everyone $r \in R$ value of a variable H_r is calculated $H_r = \sum_{y \in Y'} h_r^y$.

If $H_r > 0$, it is expedient to increase value of a controlling variable *r*, if $H_r < 0$ - to reduce.

Operation 3. A choice of the "best" controlling variable.

As the "best" the controlling variable having $\max|H_r|$ can be chosen. This integrated criterion is used for a choice of the controlling action rendering normalizing influence on the greatest number of not normalized target variables. Applying various integrated criteria, it is possible to change strategy of control.

Operation 4. Modelling of application of the controlling action corresponding to the chosen controlling variable.

Controlling action changes value of the chosen controlling variable *r*. Depending on a sign H_r value *r* increases or decreases for some fixed size which is a priori underlined by experts for each controlling variable.

Values of all variables corresponding to vertices, which are connected by coming ways to the changed controlling variable, are recalculated.

Result of application of controlling action is normalization available and, probably, appearance of the new not normalized target variables.

For a new state of the network if in it still there are not normalized variables, all set above operations repeat.

In case of success procedure forms sequence of controlling actions, i.e. some plan of achievement of the normalized situation.

If changes of each of relevant controlling variables causes both positive, and negative changes of not normalized variables, it means, that full normalization of a situation with the help of the procedure is impossible, as, according to the theory of decisions, the space of not dominating alternatives (set of Pareto) is achieved.

Preferences of the person accepting the decision can be taken into account with the help of weights, which are entered for controlling or target variables and are used at a choice of controlling variables.

The described method is realized as program system.

Let's consider his application for the decision of the problems arising at operation of the helicopter.

The helicopter at absence of visibility as shows sad experience, is on occasion deduced on the modes leaving on corners and speeds of flight for established restrictions that result sometimes in destruction of the device and death of people. It is necessary on parameters of spatial position of the helicopter, modes of flight, works of the screw and engines to warn crew about danger and to give recommendations on controlling actions.

The specified task enters a class of problems where the system - on the basis of a balancing network can be used.

For decision of the task model (1) is formed.

1. Set of entrance variables: *X*. $X_\theta, X_\beta, X_\gamma, \ldots$ - controlling variables which, influencing on the screw, change parameters of the helicopter on corners θ, β, γ, speeds *V*.
2. Parameters, which for separate modes of flight because of their slow change can be accepted as constants, among them are weight of the helicopter, height, external temperature, sometimes speed, etc.
3. Derivative variables - speed, corners, angular speeds - *V*, $\theta, \beta, \gamma, \omega_x, \omega_{at}, \omega_z$, ... which can be determined through controlling variables and parameters. These variables are connected by the differential equations of the second order (the equation of movement of a firm body under action of external forces).
4. Restrictions on corners are set θ, β, γ, to speeds, etc.

The decision of the task can be divided into two stages.

- Finding of a point in space of derivative variables in which all restrictions on corners and angular speeds are carried out.
- On the basis of limiting restrictions of dynamics of changes on corners and speeds, taking into account functional dependence of corners and speeds on moving controls the area of change of controlling variables is defined.

5. Summary

In the resulted procedure of formation multicriterion controlling decisions:

- search operations as much as possible become simpler due to the advanced associative opportunities of a balancing network;
- selection of controlling actions is carried out by the analysis of a target situation without taking into account any aprioristic information about utilities, priorities or probabilities of the purposes, conditions and actions though such information can be taken into account by giving weights to vertices and connections of a balancing network;
- the formed plan of action is directed on achievement of balance between conflicting criteria of a choice of the decision;
- the uniform organization of memory for a data storage and knowledge as a balancing network plays a role of the link connecting components of complex process in system and, thus, promoting achievement of compactness hardware and the software;
- processes of formation of a balancing network suppose an opportunity of operative reorganization of a network at a choice of decisions in dynamic environments.

On the basis of the described approach it is expedient to create the stands for the modelling and selecting controlling decisions in the projecting organizations.

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