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MOVING OBJECTS CONTROL UNDER UNCERTAINTY

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ABSTRACT

The purpose and objectives of this work is to develop methods for formalization and creation of a systematic approach in solving problems of mobile units under uncertainty. Control problems in the application of classical control theory in conditions of uncertainty regarding the parameters of the object, the conditions of its functioning, disturbances arising from the influence of the external environment, as a rule, does not give good results. The solution of the problems in the materials of the article carried out as follows. The analysis of the uncertainty and the possibility of formalizing a moving object control tasks at the incompleteness of the initial data. As part of this article deals with the application of the theory of fuzzy sets and possibility theory, and situational decision-making models to formalize the parameters of the tasks of decision making under uncertainty.

Keywords: control, uncertainty, decision-making, modeling, linguistic variable.

INTRODUCTION

Many well-known algorithms of moving object (software) [1] effectively used in conditions of certainty regarding the object model, and with an adequate description of the environment. In real operating conditions, these software requirements cannot be satisfied, for example, when performing maneuvers, unforeseen changes in modes of travel, suddenly appearing obstacles in the path of moving obstacles, etc. It can be argued that the operation of the software often carried out in conditions of incompleteness of the initial data and parameters of the environment of uncertainty and control software in these situations is the process of developing, making and implementing decisions.

Thus, with the certainty of the environment is effectively applied the theory of automatic control [2], and in case of incomplete data preference for decision theory [3, 25].

When making decisions under uncertainty to apply the theory of fuzzy sets and fuzzy logic. This approach is based on a person's ability to process information on the basis of perception. Terms of fuzzy logic provides a formal methodology for the linguistic rules that follow from the reasoning and decision-making based on fuzzy and inaccurate information. Software Control under uncertainty is carried out in the application of fuzzy systems, the development of which remains, at this point in time, an urgent task.

FUZZY LOGIC CONTROL

The formalization of uncertainty to define the term, qualitatively characterize the amount of missing information on the elements of the control tasks and also describes the sources of ambiguity, which are the external environment (physical uncertainty) and professional language (linguistic uncertainty) used by the decision maker. Meeting the challenges of control software under incomplete data should be attributed to the uncertainty associated with inaccuracies and fuzzy, caused by the external environment, the presence of aftereffect, no stationarity and intervention decision-makers.

The functioning of the system of intellectual position-trajectory control [4, 5] takes place in conditions of changing situations, disturbances and random actions, which determines the need to take adequate decisions with incomplete data.

The adoption of best control decisions related to complex control problems under uncertainty, including the impact of control, which requires a systematic approach and original mathematical models for the study of control tasks. To formalize the parameters of the tasks of decision making under uncertainty apply methods of the theory of fuzzy sets [6] and the theory of options [7], as well as situational decision model [3, 8].

The main difficulty in the autonomous movement on the presence of a large amount of uncertainty about the state of the environment. Application of the theory of fuzzy logic to reduce the uncertainty and incomplete information. Fuzzy logic provides a formal methodology for the linguistic rules that follow from the reasoning and decision-making based on fuzzy and inaccurate information. Getting uncertain logic control inputs determine the sequence of operations fuzzification, processing ambiguous information and defuzzification.

When fuzzification defines an uncertain set A description of the area X, defined by its membership

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function μA (x), x∈X, allowing you to set the correspondence between the values of the physical variables of the problem of control and fuzzy values.

Fuzzy information processing takes place on the basis of fuzzification values of the input variables that can solve the problem of decision-making using fuzzy rule base. This rule base is used to describe the relationship between the fuzzy inputs and fuzzy outputs of the model.

The inference engine provides a set of control actions in accordance with the fuzzification input values.

The application allows you to convert defuzzification fuzzy decision in a clear value control fuzzy logic controller.

In determining the behavior in the task of planning traffic on the main task is decomposed into simpler problems considered relatively independent behavior. In the application of fuzzy control the behavior of each composed of a set of fuzzy logic rules that determine the achievement of a specific set of goals. Typically, for example, can be defined as follows:

If the target is - next to the left and then turn left and proceed to the low speed.

The formalization of the environment description includes a description of objects in space, Action, spatial relationships between the objects of the environment as well as the software itself. To describe the spatial relationships between the objects of the external environment and the software used Extensional and intentional relationships [8 11].

Extensional relationships used to formalize the position and orientation of objects. For example, to describe the relationship between the two entities apply binary relations orientation, asked on the set of verbal elements:

f_1 - the object in front of the object a_1 a_2, similarly: f_2 - on the left and front, f_3 - to the left, and so on. etc. .; distance: d_1 - close, d_2 - close, d_3 - not close - not far, d_4 - far, d_5 - very far. The schedule includes a fuzzy membership function relationships that take into account the peculiarities of perception of spatial relations man. Figure-1 shows a possible assignment of membership functions for the linguistic variable "distance" with terms of d_i.

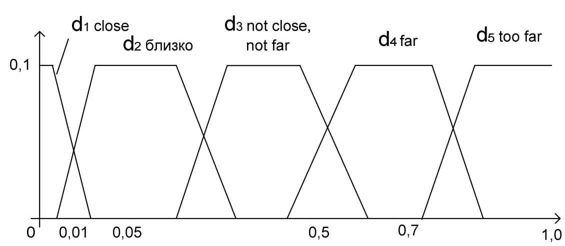

Figure-1. Membership functions for linguistic variable "distance", built from experimental data.

Intention binary relations determine the state of the software, such as the ratio specified in the elements of the set: R_1 contact; R_2 to be inside; R_3 be out; R_4 to be the center; R_5 be on one line; R_6 be on the same plane; R_7 have a nonzero projection; R_8 stand on the surface.

The collection of objects in space move the software set of relationships between them and the conversion rules constitute a formal language to describe the situation. Language description of the situation with the logic of the space-time relationship provides semiotic formalization of software and objects of the environment. For example, the spatial relationship of the A1 is on the far right to the plane S is formally defined as follows: ($a_1 R_8 S$) and ($a_0 d_5 f_7 a_1$), where a_0 - an obstacle against which articulated the relationship of distance and orientation a_1.

Status of environment PO, as the current situation, described by a system of binary frames (<object m>, <relation> <object m + 1>), m = 1, 2, M, where as one of the objects can act Sweat or external observer. Analysis on the state space is done using algorithms identify obstacles. Algorithms of identification - a system of fuzzy inference, is a set of classification rules situations fuzzy attributes of objects and components of the knowledge base on the obstacles.

As fuzzy classifier is proposed to apply Mamdani algorithm [9]. Fuzzy parameters of objects are defined by membership functions of fuzzy variables that make up the term set of linguistic variables. Membership functions are defined on base sets, the task of which is determined by technical characteristics of software and sensor system. Algorithms analysis on the external environment, given the membership functions, fuzzy rule system of a production output options allow the actual situation to determine the parameters and the nature of the obstacles, using fuzzy characters.

In [10] proposed to introduce a two-dimensional membership function. For example, in terms of linguistic variable "Object Height" membership functions are case-sensitive installation angle of the robot chassis. Depending on the distance change of the membership function of the orientation: "Left", "Right."

Status object space may change when moving, so you move through the description of the situation changes over time, which requires taking into account, in general, not only spatial but also temporal relations in space travel, for example, to be sooner or later, at the same time follow. Status in the space of movement is determined on the S frame, which slots are the names of the objects of space, the spatial and temporal relationships between objects.

ANALYSIS OF MODELS OF FUZZY INFERENCE

Applied ways of the NPS dismounting, as a rule, under the behavior of the software means its movement in space in order to reach the destination. To formalize the behavior and decision-making can be applied various situational model [3, 8, 11, 15]. A common feature of the models is a situational analysis and application in the formalization of expert knowledge to describe the

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parameters of the space objects and software. Consider the most common types of models.

Classification model. The input variables of the model behavior of the software are defined in the form of linguistic variables (LP) α_i, $i=\overline{1,n}$ and the fuzzy variables (NP) α_i^k, $k=\overline{1,m}$, which make up the term set LP α_i.

Experts define a plurality of control solutions $H = \{h_1, h_2, h_m\}$ and formulate decision rules. Decision rules is a table of correspondence between the sets of the NP and the elements of the solution set. The model decision is given as a set.

$$(X, \Psi, H), \tag{2}$$

Where X - a variety of symptoms factors condition the mobile unit; Ψ - partition of X into reference fuzzy classes $L_j, (j=\overline{1,|H|})$

The set $X_i \subset X$, $i=\overline{1,n}$ a base set in the determination of the PL α_i NP and its Thermo-sets $T(\alpha_i)$.

The table rows correspond to the "situation of action" formally define every possible situation on the verbal level and the corresponding control solution. Experts formulated the rules of the decision in the form of fuzzy rule modus ponens [11]. The total number of rules $/T(\alpha_1)/\times/T(\alpha_2)/\times\ldots\times/T(\alpha_n)/$. From the set of rules are allocated reference classes corresponding to one decision. For each determined reference-class membership function of the j-th solutions j-th reference-class:

$$\mu_{L_j}(x_1 x_2 \ldots x_n) = \bigvee_{(\alpha_1^j, \alpha_2^j, \ldots, \alpha_n^j)\in L_j} \mu_{\alpha_1^j}(x_1)\,\& \\ \&\,\mu_{\alpha_2^j}(x_2)\,\&\ldots\&\,\mu_{\alpha_n^j}(x_n), \\ x_i \in XI,\quad i=\overline{1,n},\quad j=\overline{1,|H|}, \tag{3}$$

Where n_j – the number of sets $\alpha_1^i,\ldots,\alpha_n^i$ belonging to j-th class of the partition.

The adoption of the control solution to determine the behavior of the software is as follows. Determine the physical condition of the software settings and objects space movements $(x_1^0, x_2^0, \ldots, x_n^0) \in X$ for the decision t_0 and the substitute these values into the membership function of the NP. Calculate the value of the degree of standard accessories classes $\mu_{L_j}(x_1^0, x_2^0, \ldots, x_n^0)$, $j=\overline{1,|H|}$, and then among all the values are the maximum value

$$\mu_{LS} = \max_j \mu_{L_j}(x_1^0, x_2^0, \ldots, x_n^0)\,. \tag{4}$$

h_s controlled solution with the index s is considered appropriate for this situation and taken to the degree of affiliation μ_{LS}.

Model calculation of the degree of truth of fuzzy inference rules: The model is defined by a triple $X\times H \xrightarrow{T} H$, where T - fuzzy matching on the set X×H. Set H the set of NP sets PL-term "control solution." Experts selects elements of T in the form of rules of fuzzy inference decision $\{\pi_j\}$, $j=\overline{1,l}$. For each statement π_j determine the membership function

$$\mu_{\pi_j}(x_1, x_2, \ldots, x_n, h_i)\,. \tag{5}$$

For the ratio of the T values of the membership function is determined by the generalized operationσ, so

$$\mu_T(x_1, x_2, \ldots, x_n, h_i) = \sigma_{\mu_{\pi_j}}(x_1, x_2, \ldots, x_n, h_i)\,. \tag{6}$$

For the adoption of the control solution t_0 determine the coordinates of objects and states over the space of movement $x^0 = (x_1^0, x_2^0, \ldots, x_n^0) \in X$. To determine the values of x_0 membership functions $\mu_{T(\pi_j)}(x^0, h_i)$ fuzzy logic control solution of choice h_i, which depends on the values of the degrees of membership of solutions μ_{h_i}.

Choose the solution is considered to be a value of the base set of the LP "control solution", where the value of the membership functions $\mu_{T(\pi_j)}(x^0, h_i)$ it has the maximum value:

$$\mu_{T(\pi_s)}(w^0, h_s) = \max_j \mu_{T(\pi_j)}(w^0, h_i)\,. \tag{7}$$

Situational model. Fuzzy inference is a choice of control decisions based on analysis of real situations in the fuzzy space Move around and comparing them with standard fuzzy situations, ask the experts. Each reference fuzzy situation, experts mapped to the control solution.

In the derivation of control solutions make real fuzzy situation $\widetilde{S}_i$ with reference fuzzy reference situation $\widetilde{S}_j^*$, $j=\overline{1,R}$ by applying the equity operations fuzzy or fuzzy comparison.

The general models of decision-making is that the experts on the basic sets $X_1, X_2, \ldots, X_n$ set of membership values of fuzzy variables and decision rules. In deciding factors determine the coordinate's $(x_1^0 x_2^0, \ldots, x_m^0) \in X_1 \times X_2 \times \ldots \times X_n = X$ space displacements and software and accessories value of the

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degree of fuzzy variables. Each model has its advantages and disadvantages, and the withdrawal of their application should be made when the final statement of the problem of decision making under uncertainty.

The use of situational model allows a priori identify patterns of behavior software, which also have the form of production rules, «If the situation is, S_i, the tactics - T_i».

In conditions of uncertainty by tactics in many studies to understand a set of rules of conduct aimed at achieving the goals set for the software, with the rules governing the adoption of decisions are usually put in the products and the respective types of situations predetermined move through the space.

The behavior of the software in general is determined by the frame: <current situation S_i> <object control a_0> <operation name> <attendant object> <terms of the feasibility of the operation>. The frame contains the terms of the feasibility of the move given the current situation and your environment movement, for example, the kind of terrain and soil properties, the quality of the clutch wheels or tracks with the ground, the nature of the obstacles.

Thus, when applying situational model comparing the observed situation with reference situation performed using fuzzy criteria proximity situations. Prepared by the assessment of the situation is formalized human evaluation.

CONCLUSIONS

Many control tasks autonomous software or software group interaction [14] decide under uncertainty as respect the object model and the state of the environment [1, 4, 5, 8, 10, 15], with the solution of control problems in these papers in conditions of uncertainty connected both with the formalization of uncertainty and decision-making in the search for control actions to ensure the optimal values of criteria defined functions that determine, in turn, the efficiency of the control systems.

In this study it is determined that for the formalization of tasks of decision making under uncertainty should apply in the first place, the theory of fuzzy sets theory and fuzzy logic. Terms of fuzzy logic provides a formal methodology for the linguistic rules that follow from the reasoning and decision-making based on fuzzy and inaccurate information. The tasks of software control, particularly in critical conditions, control is considered as the process of making adequate decisions in conditions of uncertainty.

Designed in this paper a systematic approach to the problem of governance in conditions of uncertainty, it differs from the previously reviewed elsewhere integration of the individual steps for solving the problem of control. Achieving this goal is due to the fact that the implemented formalization of spatial relationships between the objects of the external environment and software based extensional and intentional relations. The formalization of the behavior of the software on the basis of classification models, calculate the degree of truth of fuzzy inference rules, situational model allows managers to find adequate solutions. Considered context-dependent behavior of the software implies the division of general behavior in the components separate, independent behavior, focusing on the performance of certain tasks. Developing elementary of Conduct in the external environment: the movement toward the goal, avoiding obstacles, to move along the wall, emergency, allows you to coordinate the behavior of software in the basic conditions of uncertainty and implement simulation movement on the various options for the location of obstacles.

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