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INTELLECTUALIZATION OF GAS TRANSPORTATION CONTROL SYSTEM

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Abstraction

The article discusses the technology of fuzzy control, common among intellectual technologies. Fuzzy control is one of the promising intelligent technologies that allow you to create high quality control systems. The advantages of such systems include: the possibility of using for complex processes when there is no simple mathematical model; expert knowledge about the control object or process can be formulated in verbal form; simplicity of structure; property of robustness or adaptability.

The author believes that the use of intelligent technologies based on fuzzy logic provides a solution to a wide range of problems of robust and adaptive control under uncertainty.

Keywords: math model, fuzzy logic, fuzzy controller, control object, underground gas storage, dynamic system, gas transportation.

Introduction

One of the most urgent tasks today in the field of automation of control systems for technological objects in various areas of production intelligent processing of control processes, improvement of research methods for intelligent control systems, creation of intelligent means of process control, identification of the reliability of monitoring and management of observations of objects under conditions of uncertainty.

In research on the development of a tool for creating intelligent control systems for objects using the achievements of modern information technologies in a number of priority areas of scientific research on the formation of mathematical models of objects, taking into account uncertainty; development of fuzzy models of process control processes; algorithms for intellectualization of object environment management processes; tools for environmental monitoring and management of natural objects; software complexes for solving problems of intellectual processing of natural objects management processes under conditions of uncertainty.

Most installations of the fuel and chemical industries from the point of view of control theory are useful control objects (OC) with the goals of inputs and outputs with the possibility of mutual influence of parameters. The presence of compatible parameters imposes requirements on the automatic control system (ACS) of operated facilities.

Implementation of engineering methods for solving problems associated with the allocation of resources, capital costs for equipment, reducing the cost of modernization, identifying results in the preparation of ACS for the implementation of the project, the implementation of which is the goal and

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achieving the expected results of production during use with a decrease in production costs due to assessing the quality of use of management resources.

Material

Taking into account the features of objects - the complexity of managing an object, significant non-linearity and non-stationarity, the construction of features of a dynamic model, the uncertainty of the interaction of elements, as well as large variations in parameters and insufficient information about the object, control systems built on the basis of fuzzy logic and neural networks are most effectively used.

most widespread among the intelligent technologies for the formation of robust and adaptive regulation and control algorithms in the field of complex technical and technological systems. Fuzzy control is one of the promising intelligent technologies that allow you to create high-quality control systems. The advantages of such systems include: the possibility of using for complex processes when there is no simple mathematical model; expert knowledge about the control object or process can be formulated in verbal form; simplicity of structure; property of robustness or adaptability.

The combined fuzzy controller is one of the most common applications of fuzzy logic in control systems. The reason for this is the efficiency of applying the fuzzy-set approach to many problems, the solution of which is associated with the need to handle uncertainties.

When looking for alternative solutions in the control problems of complex dynamic nonlinear objects containing uncertain parameters , the formation of a rule base (BR) of a large volume is associated with huge physical and time costs. Robust control is proposed to solve this problem.

The use of intelligent technologies based on fuzzy logic provides a solution to a wide range of problems of robust and adaptive control under uncertainty. The results of theoretical studies show that the use of HJI technology makes it possible to create high-performance high-speed controllers for a wide class of technical systems used in industrial, military, and household appliances, which have a high degree of adaptability, reliability, and performance under conditions of random disturbances and external load uncertainty.

Let us analyze the possibility of using fuzzy logic methods in the problems of process control.

The mathematical apparatus of fuzzy logic is solved to determine and formalize human experience and in solving complex problems of decision and decision analysis. The fuzzy logic control logs describe the control modes of complex technological processes, in the task of diagnosing equipment operation.

The dynamics of the control system can lead to the conclusion about the relationship of states:

$$x_{k+1} = F(x_k, u_k), k = \overline{0, N},$$

$$x_k \in X, u_k \in U, \quad (1)$$

where X - portal space, U - set of admissible controls , F - state transition function, generally non-linear

$$F : \mathrm{X} \times \mathrm{U} \rightarrow X .$$

Consider a nonlinear dynamical system with discrete time:

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$$x_{k+1} = F_k\left(x_k, w_k\right), k = 1,2,..., \qquad (3)$$

to define and state the debt recovery system:

$$z_k = H_k\left(x_k, v_k\right). \qquad (4)$$

In this index equation, k corresponds to the kth point in time;

F_k, H_k - non-linear functions of the corresponding arguments;

x_k - the state of the dynamic system,

w_k - fuzzy noise, given for each moment of time $\mu(w_k)$;

v_k - measurement error taking into account signs $\mu(v_k)$;

Possible and functional accessories for the initial state $\mu(x_0)$.

For a given conditional $\mu(x_k|\bar{z}_k)$ function x_k if there is a sequence of measurements $\bar{z}_k = \{z_0, z_1, ..., z_k\}$ the best crisp estimate of the state at time k can be found from the fraction:

$$\mu\left(x_k^0\right) = \max_{x_k} \mu(x_k|\bar{z}_k).$$

The recurrence relation has a particularly simple form when the fuzzy noises of the system w_k and the measurement error v_k include in (3), (4) linearly:

$$x_{k+1} = F_k(x_k) + w_k;$$

$$z_k = H_k(x_k) + v_k.$$

In this equality of correspondence between v_k and w_k, z_k and v_k, are one-to-one.

In the case of dynamic system control, it is also possible to use the available models to specify the function F. For example, in the case of a linear model

$$x_{k+1} = \mathrm{A}x_k + Bu_k, \qquad (5)$$

where fuzzy restrictions are declared on the state and control and a fuzzy goal of the system functionality is set.

To reduce the uncertainty of the situation with possible solutions, it is necessary to use additional information about the measurements and studies carried out in the system.

Obviously, direct measurement of the entire vector x_k detection of the impossibility system state, the process of subsequent observation of the phenomenon

$$z_k = H(x_k),$$

where z_k - fuzzy vector of measurements; H - functional measurements.

For linear model (5) and linear measurement equation

$$z_k = Hx_k$$

you can save the system of recurrent rights

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$$\mu(x_{k+1,k+1}) = \sup_{z_{k-E}=Hx_{k-E}} \mu(x_{k+1,k}, z_{k+1}) = \mu(x_{k+1,k}) \wedge \sup_{z_{k-E}=Hx_{k-E}} \mu(z_{k+1}); \quad (6)$$

$$\mu(x_{k+1,k}) = \sup_{\mathrm{A}x_{k,k}+\mathrm{B}u_k = x_{k+1,k}} \{\mu(x_{k,k}) \wedge \mu(u_k)\}. \quad (7)$$

In the general case, when the functions F and H are nonlinear, equations (6), (7)

$$\mu(x_{k+1},_{k+1}) = \vee_{z_{k-E}} \mu(x_{k+1}|z_{k+1}) \wedge \mu(z_{k+1}) \wedge \mu(x_{k+1},_k);$$

$$\mu(x_{k+1},_k) = \vee_{x_k} \vee_{u_k} \mu_F(x_{k+1,k}|x_{k,k}, u_k) \wedge \mu(x_{k,k}) \wedge \mu(u_k).$$

Results

Let us now consider the principles of control of a fuzzy dynamical system for a function F of the form (2). Let us assume that fuzzy constraints are set $C_k \subset U$ on the control event at each moment of time u_k, characterizing the characteristics of objects $\mu_{C_k}(u_k)$ and a given initial state x_0. Let be $G_N \subset X$ a fuzzy goal that needs to be achieved at time N. This goal opens up wide possibilities $\mu_{G_M}(x)$.

Optimal clear control actions $u_0^0, u_1^0, ..., u_{N-1}^0$

$$\begin{aligned}\mu_D(u_0^0, u_1^0, ..., u_{N-1}^0) &= \max_{u_0,...\mu_{E-2}} \max_{u_{E-1}} \{\mu_{C_0}(u_0) \wedge ... \wedge \mu_{C_{E-1}}(u_{N-1}) \wedge \mu_{G_E}(F(x_{N-1}, u_{N-1}))\} = \\ &= \max_{u_0,...\mu_{E-2}} \{\mu_{C_0}(u_0) \wedge ... \wedge \mu_{C_{E-1}}(u_{N-2}) \wedge \mu_{G_{E-1}}(x_{N-1})\}\end{aligned} \quad (8)$$

$$\text{where } \mu_{G_{E-1}}(x_{N-1}) = \max_{u_{E-1}} \{\mu_{C_{E-1}}(u_{N-1}) \wedge \mu_{G_E}(F(x_{N-1}, u_{N-1}))\}. \quad (9)$$

The function can be $\mu_{G_{E-1}}(x_{N-1})$ implemented as a function for a fuzzy goal at time N-1 induced by the final goal G_N at time N.

$$\mu_{G_{E-j}}(x_{N-j}) = \max_{u_{E-j}} \{\mu_{C_{E-j}}(u_{N-j}) \wedge \mu_{G_{E-j+1}}(x_{N-j+1})\},$$

$$\text{where } \quad x_{N-j+1} = F(x_{N-j}, u_{N-j}), \; j = \overline{1, N}.$$

Knowing the development of fuzzy state $\mu(x_k)$, fuzzy contagion $\mu_{C_k}(u_k)$ and the induced fuzzy goal $\mu_{C_k}(u_k)$, at the moment of time it is possible to find a complex control u_k^0 according to (8), (9).

Conclusion

Developed on the basis of fuzzy logic , an intelligent gas transmission process control system makes it possible to increase the efficiency of process control.

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