The modeling humus soil based flows and stocks of carbon in soil humus and organic carbon do not humus source - organic residues and organic fertilizers.

Humus, carbon, agroecosystem, autonomy, productiveness.

UDC 681.3

METHOD OF SYNTHESIS OF FUZZY-REGULATORS

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The description of fuzzy-regulation system. Done base rules for fuzzy-PI controller. The method of fuzzy-controller configuration, which can reduce the requirements for the hardware and software parts and improve performance.

Fuzzy-rotary base rules approximation algorithm Mamdani, term, membership function.

Problem. One of the most common controls used in modern mechatronic systems is unclear or fuzzy-controller [1]. Using fuzzy-controller is justified in cases where there is no mathematical model of the object or regulation when available empirical material (base of expertise) of the regulation system. In any case, the same problem adjusting mechatronic system can

solved using both classical and non-classical controllers (fuzzy-regulators or regulators constructed based on artificial neural networks) [2].

One of the problems facing the developer fuzzy-regulator, is the choice of hardware and software, to which the controller will operate. It is necessary to take into account the requirements for speed digital hardware (microcontroller) and volume of his memory. This follows from the fact that when the calculation of the output fuzzy-controller, microcontroller should perform a significant amount of logic and arithmetic operations. Reducing the number of calculations performed by the microcontroller during the regulatory process, reduces the hardware and software fuzzy-regulator. This reduces the capital costs of developing the controller.

Analysis of recent research. In modern scientific and technical literature [3-6] in some detail issues highlighted synthesis fuzzy-regulators. All fuzzy-regulators are a classic case "phasing - logical conclusion - Defuzzification." The basic algorithm used in this scheme are proposed algorithm Mamdani [7].

For problems of modeling and design of fuzzy controllers used computer software Matlab / Simulink [8], Mathematica / FuzzyLogic [9], FuzzyTech [10] and others. The widespread use of expansion packs mathematical software, which perform fuzzy calculation indicates that they are necessary Engineers designers fuzzy systems management.

The purpose of research. The aim is to develop a method for setting fuzzy-controller, which enhances efficiency. To achieve this goal it is necessary to solve the following problem:

1. describe the method of synthesis of fuzzy-regulator by known methods;
2. build fuzzy-PI controller based composite knowledge base;
3. the description of the function approximation method for determining the output variable (output) fuzzy-regulator.

Results. The implementation of the algorithm fuzzy-regulation in mechatronic systems relies on fuzzy-controller. Development of the algorithm fuzzy-regulation is represented as a block diagram in Fig. 1.

As in any traditional system consisting of a system of fuzzy-control system can be identified regulation and facility management. The system of fuzzy-regulation consists of four blocks that perform consistently (three stages) procedure of forming algorithm as a function of regulating the output variable u of input variables x1, x2, x3, ..., n (Fig. 2). Block fazzyfikatsiyi (Ff) converts incoming physical variables (x1, x2, x3, ..., n) in terms of linguistic variables Ai and highlights for each point in time (for each time cycle) value of membership function μi (xi) for activated rules.

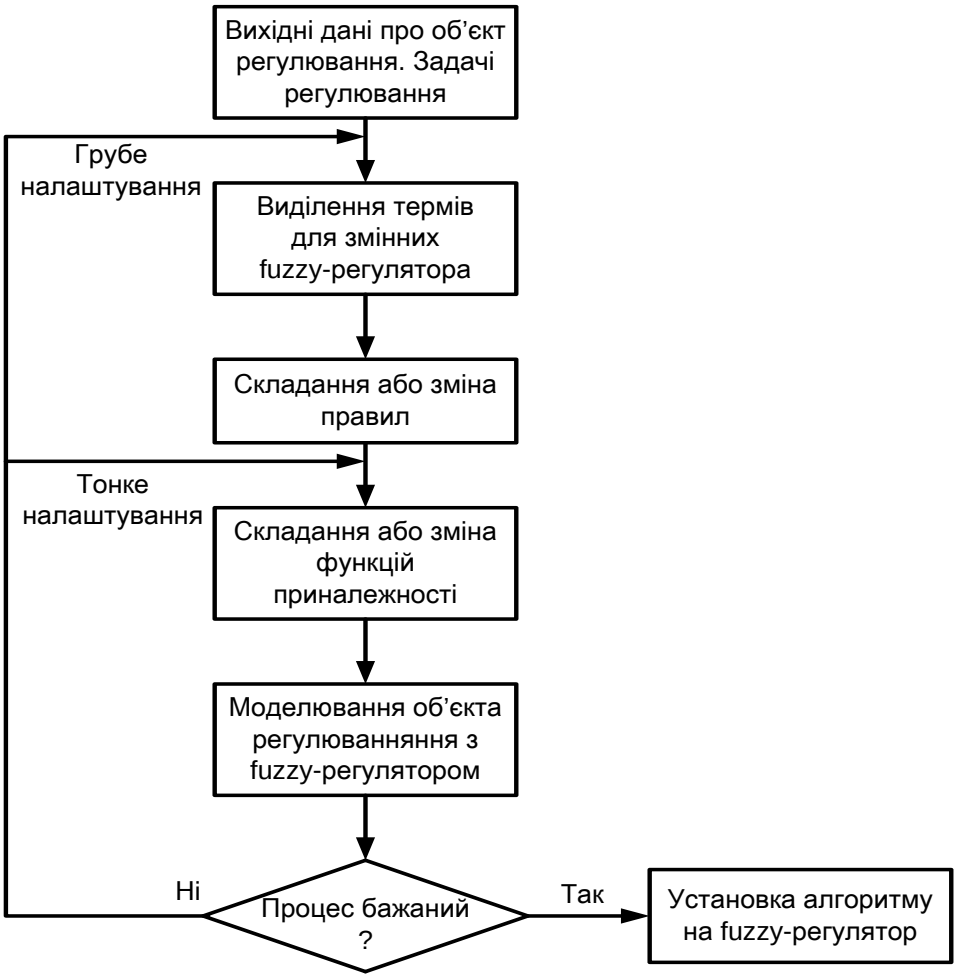

Fig. 1. Block scheme of the algorithm fuzzy-regulator.

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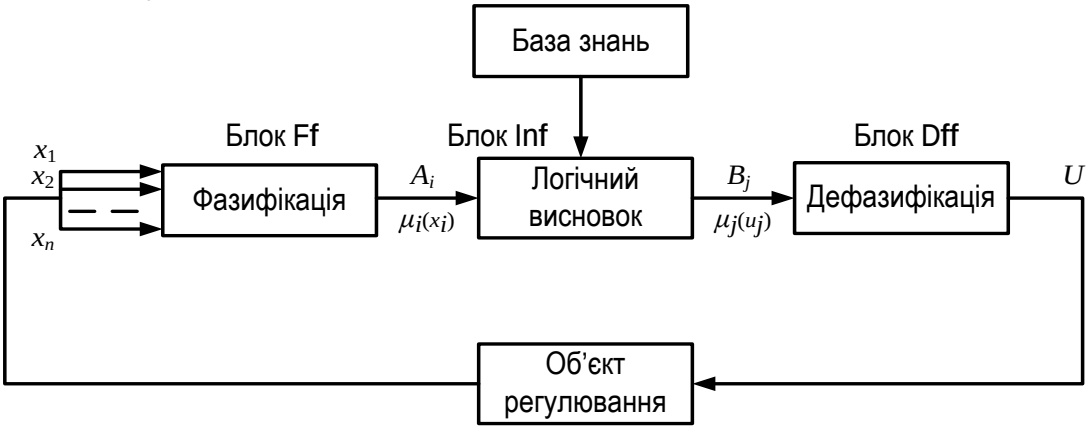


Fig. 2. Block structure of fuzzy-regulation.

Block inference (Inf) in accordance with the rules laid down in the block before an expert knowledge base defines terms Vj output linguistic variables and assigns them according to the principles of fuzzy-logic values of membership functions μj (uj).

The basis of the algorithm fuzzy-regulation is an array of rules, which is a block Knowledge Base. The rules consist expert based on his understanding of the objectives of regulation. When it comes to adjustable dynamic system with complex mathematical descriptions or incomplete, then the algorithm is based regulation can be, for example, accept the terms of system performance given movement with minimal deviation from the set speed. Rules are checked (experimentally or by means of calculation) and adjusted if necessary. In addition to the array of rules of composition algorithm includes membership functions that define the quantitative relationship of physical variables of linguistic, ie with terms. To form membership functions imposed minimum requirements by virtue of the principle of close regulation based on fuzzy-logic. The number of membership functions that occur at each physical variable chosen for reasons of quality control. With an increasing number of membership functions increases the quality of regulation, but it is complicated algorithm and increased demands on its performance. Available experience building systems with fuzzy-control showed that three to five membership functions for each input variable and five to seven membership functions for the output variable is sufficient for acceptable quality control. Consider the example of PI regulator is implemented based on fuzzy-logic. For this we consider the input variables: error adjustment parameter e, and its integral $\int edt$ (In what follows refer to the material used $\int edt = \gamma$).

In the synthesis of classical PI controller output signal (output variable) is defined by the following expression:

$$u = k_P e + k_I \gamma, \qquad (1)$$

where kP and kI - proportional and integral weights respectively, showing the importance of the respective component.

Draw phasing of input and output variables. To do this, we assume that the input variable fuzzy-controller with five terms, and output variable - seven terms. We denote them as: NBe, NSe, Ze, PSe, PBe - terms for the variable e; NBγ, NSγ, Zγ, PSγ, PBγ - terms for the variable γ; NBu, NMu, NSu, Zu, PSu, PMu, PBu - terms for the output variable u. We will give a description of these membership functions, but only build their schedules (Fig. 3).

In constructing the graphs in Fig. 3 agreed that the L-shaped membership function to the terms of the input and output variable change in the range of -1 to 1. Z- and S-shaped membership function variables outside the range [-1; 1] is constant.

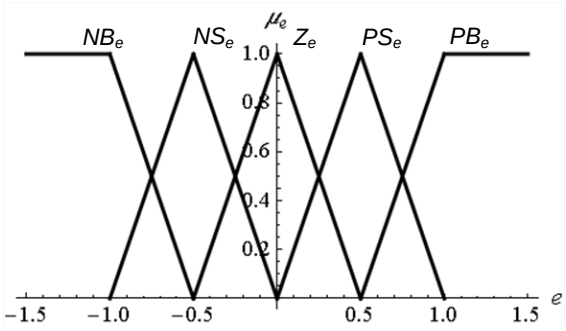
The next stage in the synthesis of fuzzy-PI controller - drawing up rules base. We use rules similar to those used within the classic PI controller. All rules present in the form of table. 1.

1. Base linguistic rules of fuzzy-PI controller.

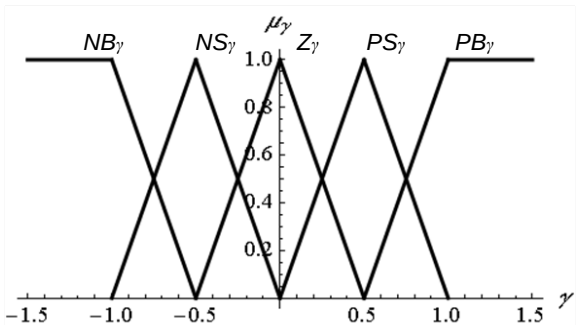
th / *γ*	*NBe*	*NSe*	*Ze*	*PSe*	*PBe*
NBγ	*PBu*	*PBu*	*PMu*	*PSu*	*Zu*
NSγ	*PBu*	*PMu*	*PSu*	*Zu*	*NSu*
Zγ	*PMu*	*PSu*	*Zu*	*NSu*	*NMu*
PSγ	*PSu*	*Zu*	*NSu*	*NMu*	*NBu*
PBγ	*Zu*	*NSu*	*NMu*	*NBu*	*NBu*

To calculate the output variable use Mamdani algorithm [7]. As a result, we find that the output variable u is a complex function of input variables e and γ, and membership functions to the terms of the input and output.

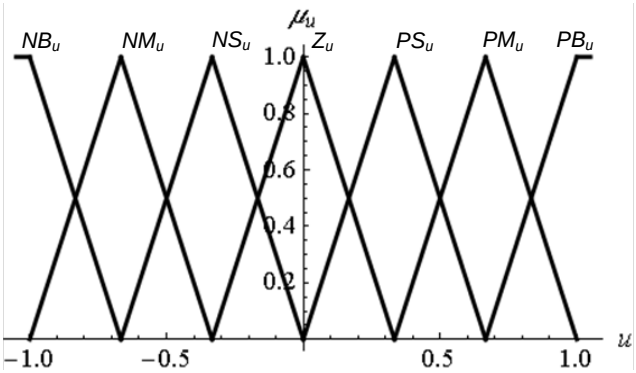
In calculating the output variable according to Mamdani algorithm is necessary to: 1) establish rules that are activated when the current values of the input variables: 2) determine the value of membership functions to the terms of the input variables for the current values of f and γ; 3) The operation of logical disjunction membership functions for each activated rules; 4) The operation of conjunction membership functions for activated rules; 5) perform Defuzzification find that the numerical value of the output variable using the method of the center of gravity. Consequently, the performance calculation software target variable of fuzzy-logic controller must perform and arithmetic operations. Note that as the number of input variables and terms requirements for performance digital system controller is significantly higher.



a)



b)



c)

Fig. 3. Graphs of functions belonging to: a) input variable e; b) input variable γ; c) the output variable u.

However, this can be avoided if the fuzzy-set up to determine the function of the regulator output. This function is defined only after it is determined that accepted fuzzy-controller settings provide the desired quality of the regulatory process. In the settings fuzzy-controller understood: the number of terms of input and output variables; membership function to terms; base rules; method for determining the output variable [7].

To determine the function of the output variable must perform tasks digitization regulation, that is used in the calculation only discrete values of input variables that are within their paces Δe and Δγ: variables f and γ respectively. The fewer moves Δe and Δγ adopted in the calculation, the more accurate will be found function output. However, if a sufficiently large number of input variables to be chosen small steps Δe and Δγ, because it significantly increases the number of calculations. Indeed, for n input variables estimated number of N discrete values of the output variable is defined by the expression:

$$N = \prod_{i=2}^{n} \frac{X_i}{\Delta x_i}, \qquad (2)$$

where Xi - region changes i-th input variable; Δhi - step change in i-th input variable.

Later discrete values of input variables the calculation output variable Mamdani algorithm. Thus, a multidimensional data set in which discrete values of input variables corresponding to discrete output. Fig. 4 shows the surface that includes a point with coordinates calculated. The graph in Fig. 4 built at Δe = 20 and Δγ = 20.

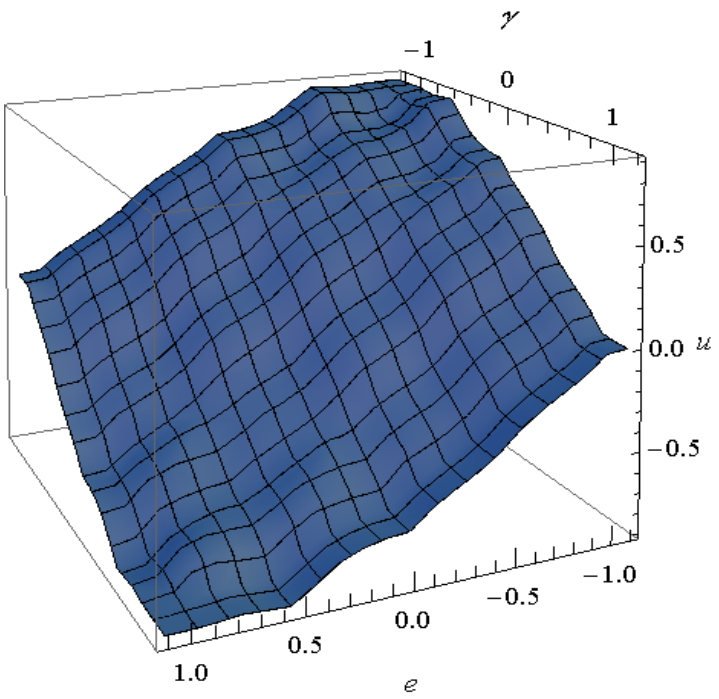


Fig. 4. Graph the function output variable u.

All the above calculations should be performed in software, and the resulting data set is written in memory of microcontroller device on which fuzzy-based controller. Of course while performing an adjustment process input variables take values that do not exactly correspond to discrete values of output variables in multidimensional array. In this case, the calculation of the discrete value of the output variable is performed by interpolation.

To reduce memory microcontroller device and reduce the number of calculations that it performs in the regulation, when setting fuzzy-regulator may be performed by a polynomial approximation of multidimensional array with n arguments. Indeed, the resulting multidimensional data set represents a certain tabulated function. "Recovery" or "score" of this function can be performed, for example, the method of least squares.

Once approximating function is found, it can be preset microcontroller. In the management of the known approximation function, the calculation output variable u. Note the calculation function approximation output variable polynomial some members may be statistically significant, so they can be rejected - this will help simplify the approximating function. You can spend a certain analogy between the approximating function and expression of the classical PI regulator (1). The function of the output variable u classical PI regulator linearly dependent on the input variable and its integral. In contrast, the function of the output variable nonlinear fuzzy-controller depends on the input variables, as shown in Fig. 4.

Conclusion. Thus, the basic idea of the proposed method for synthesis of fuzzy-controller is that the number of payments in the management reduced through the use of approximating functions output variable or multidimensional array. The price increase peredekspluatatsiynyh settings fuzzy-controller solves the task of improving its performance and reducing the hardware and software parts.

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Powered Description fuzzy-system regulation. Sostavlena base rules for fuzzy-PI-regulator. Proposals setup method fuzzy-regulator, allows us to kotorыy umenshyt requirements for ego apparatnoy and prohrammnoy parts and povыsyt bыstrodeystvye.

Fuzzy-rotary base rules approximation algorithm Mamdani, term, Function accessories.

The description of fuzzy-system regulation has stated. The base rules for fuzzy-PI-regulator has designed. The method for fuzzy-controller setting has proposed. It allows to decrease the objectives for its hardware and software and to increase the speed of fuzzy-controller.

Fuzzy-controller, base of rules, approximation, Mamdani's algorithm, term, membership function.

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