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ANALYSIS OF FUNCTIONS OF BELONGING AND ASSESSMENT OF THE STATE OF THE CONTROL OBJECT

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Abstract:

The analysis of functions of belonging and the assessment of the state of the control object are crucial processes in various fields, ranging from engineering and technology to social sciences and management. This article aims to delve into the significance and intricacies of these functions, exploring their impact on the overall performance and effectiveness of control systems. In today's dynamic and complex world, control systems play a pivotal role in ensuring efficient operations, mitigating risks, and achieving desired outcomes. The functions of belonging and the assessment of the state of the control object provide valuable insights into the relationships and interactions between different components within a control system. By understanding these functions, researchers, practitioners, and decision-makers can enhance the design, implementation, and optimization of control systems across diverse domains. Through this exploration, we hope to stimulate further research, collaboration, and innovation in the field of control systems, fostering advancements that can drive progress in various industries and domains. By gaining a deeper understanding of these functions, we can unlock new possibilities for designing and managing robust and resilient control systems that are capable of meeting the challenges of our rapidly evolving world.

Keywords: functional, transfer function, stationary system, nonlinear system, term-set, control object, automation, identification, dynamic parameter

1.INTRODUCTION.

The function of belonging entails identifying and categorizing various elements within a control system, determining their roles, and establishing their connections. This process aids in comprehending the structure and composition of the system, enabling a more holistic understanding of its functioning. By identifying the components that belong to the system, such as sensors, actuators, controllers, and feedback mechanisms, researchers and engineers can effectively model and simulate the behavior of the control system.

Moreover, the assessment of the state of the control object involves evaluating the current condition, performance, and behavior of the elements within the control system. This assessment can be quantitative or qualitative, involving measurements, observations, or subjective judgments. By assessing the state of the control object, researchers and practitioners can identify deviations from desired norms, diagnose faults or anomalies, and take appropriate corrective actions to maintain or restore system performance.

Understanding the functions of belonging and the assessment of the state of the control object is critical in several domains. In engineering and technology, these functions enable the design and optimization of complex control systems in fields such as manufacturing, robotics, aerospace, and automation. In social sciences, they aid in the analysis of organizational structures, communication networks, and decision-making processes [1]. In management, these functions contribute to enhancing efficiency, effectiveness, and adaptability within organizations. This article aims to provide a comprehensive analysis of the functions of belonging and the assessment of the state of the control object, highlighting their significance and potential applications. By examining case studies, theoretical frameworks, and practical examples, we aim to deepen our understanding of these functions and their role in improving the performance and reliability of control systems.

The analysis of functions of belonging and assessment of the state of the control object typically involves evaluating the effectiveness and efficiency of an object's functions or features, as well as determining its current condition or state. Let's break down each component:

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Functions of Belonging: Functions of belonging refer to the specific roles or purposes that an object serves within a system or organization. These functions can vary depending on the context and nature of the control object. For example, in a manufacturing setting, a control object could be a robotic arm responsible for assembly tasks. The functions of belonging for this object might include gripping, moving, and positioning items accurately. Analyzing the functions of belonging involves assessing how well the control object fulfills its intended purpose and meets the desired performance criteria[2].

Assessment of the State of the Control Object: The assessment of the state of the control object involves evaluating its current condition, performance, and overall health. This assessment can include various aspects, such as:

a. Performance Evaluation: This involves examining how effectively and efficiently the control object is operating. It may include analyzing metrics such as speed, accuracy, reliability, and productivity. Any deviations from expected performance levels may indicate a need for maintenance, calibration, or improvement [3].

b. Condition Inspection: This involves physically examining the control object to check for any signs of wear and tear, damage, or malfunctioning components. It may also include reviewing maintenance records and conducting diagnostic tests to identify potential issues [4].

c. Safety Evaluation: This aspect focuses on assessing whether the control object complies with safety regulations and standards. It involves examining safety features, protocols, and any potential risks associated with its operation.

d. Environmental Assessment: This involves evaluating the control object's impact on the surrounding environment, such as energy consumption, emissions, or waste generation. It may include considering sustainability aspects and exploring opportunities for improvement [5].

e. Reliability and Maintenance: Assessing the control object's reliability involves examining its history of failures, downtime, and maintenance requirements. It includes evaluating whether preventive maintenance measures are in place and determining the overall reliability of the object [6].

Overall, the analysis of functions of belonging and the assessment of the state of the control object aim to provide insights into how well the object is performing its intended functions, its condition, and any areas that require attention or improvement. The results of this analysis can guide decision-making processes regarding maintenance, upgrades, replacements, or optimization of the control object.

2. MATERIALS AND METHOD

Several sources related to the research object can be cited. For example, in the scientific works of T.K. Bogdanova, the following is given on the research object: "Assessment of the state of the control object with the help of indicators, which are management and control tools, is actively used in many areas of the economy. As a rule, such indicators are built on the basis of internal data. However, with the increase in the volume of available open information, algorithms for assessing the state of certain control objects using open structured data appear" [7]. According to researcher E.Sh. Kremlevo and others, special attention should be paid to the following: "Some algorithms and methods usually work in calculations with strictly quantitative and data, however, taking into account the human way of perceiving information in verbal form. A person does not directly participate in the process of building a model, that is, its structure does not depend on expert or other human opinions, however, qualitative verbal information embedded in the algorithm in encoded form. Computational experiments presented" [8].

Mathematical logic, analysis and synthesis methods were used in the research process.

3.RESULTS

In the automatic control of a wide class of dynamic objects, the so-called fuzzy control systems (FCS) have been successfully used recently. The latter are a qualitatively new class of control systems that have proven themselves in the regulation of complex nonlinear indefinite dynamic processes, for which classical deterministic and stochastic controllers are unacceptable. A fuzzy controller is a knowledge-based controller in which fuzzy logic is used to represent knowledge and inference.

The current output y(t) of the controlled process 1 in the form of a clear signal is fed through the feedback line to the input of the system, where it is compared in element 3 with a clear task g(t). Error ε(t), if its derivatives $e'(t), e''(t), \ldots$, , the integral of the error $\left(\sum e_i(t)\right)$ are required, come in the form of clear signals to the input of the fuzzy controller (or regulator) 2. The latter includes a fuzzifier 4 designed to transform clear signals $e(t), e'(t), \sum e_i(t)$ and others into fuzzy sets $e^*(t), e^{*'}(t), \sum e_i^*(t)$ and others (Figure 1).

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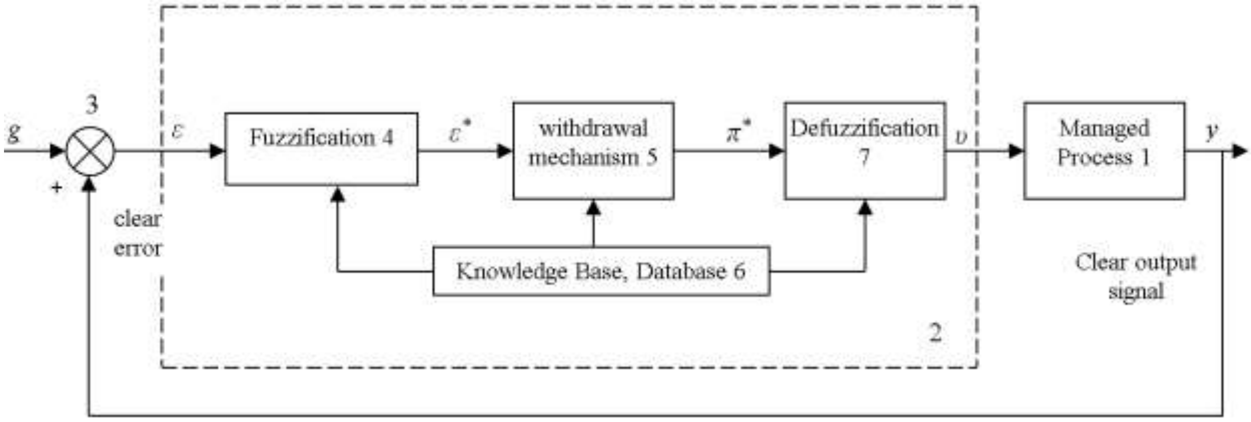

Figure 1. Basic structure of a fuzzy control system.

The inference engine 5, receiving these fuzzy signals using the database 6, where membership functions of fuzzy sets describing these signals are stored, and the knowledge base, where fuzzy control rules are stored, performs inference to obtain the output fuzzy signal $U^*(t)$ of the controller. Since a clear control signal U must be received at the input of the controlled process through the regulating body of the actuator, element 7 (defuzzifier) transforms the fuzzy control U* into a clear control signal U(t).

4. DISCUSSION

Database design in NSI includes: discretization, normalization of the universe, fuzzy separation of the space of inputs and outputs, as well as the definition of membership functions of fuzzy sets.

When discretizing the universe, scaling must be carried out, which converts the measured signal values into the value of the discretized universe. The choice of quantization level is associated with a priori knowledge.

Table 1
Quantization and primary fuzzy sets using numerical definitions

Level	Range	OB	OS	OM	zero	PM	PS	PB
-6	$x_0 \leq -3{,}2$	1,0	0,3	0,0	0,0	0,0	0,0	0,0
-5	$-3{,}2 < x_0 \leq -1{,}6$	0,7	0,7	0,0	0,0	0,0	0,0	0,0
-4	$-1{,}6 < x_0 \leq -0{,}8$	0,3	1,0	0,3	0,0	0,0	0,0	0,0
-3	$-0{,}8 < x_0 \leq -0{,}4$	0,0	0,7	0,7	0,0	0,0	0,0	0,0
-2	$-0{,}4 < x_0 \leq -0{,}2$	0,0	0,3	1,0	0,3	0,0	0,0	0,0
-1	$-0{,}2 < x_0 \leq -0{,}1$	0,0	0,0	0,7	0,7	0,0	0,0	0,0
0	$-0{,}1 < x_0 \leq +0{,}1$	0,0	0,0	0,3	1,0	0,3	0,0	0,0
1	$+0{,}1 < x_0 \leq +0{,}2$	0,0	0,0	0,0	0,7	0,7	0,0	0,0
2	$+0{,}2 < x_0 \leq +0{,}4$	0,0	0,0	0,0	0,3	1,0	0,3	0,0
3	$+0{,}4 < x_0 \leq 0{,}8$	0,0	0,0	0,0	0,0	0,7	0,7	0,0
4	$+0{,}8 < x_0 \leq +1{,}6$	0,0	0,0	0,0	0,0	0,3	1,0	0,3
5	$+1{,}6 < x_0 \leq +3{,}2$	0,0	0,0	0,0	0,0	0,0	0,7	0,7
6	$+3{,}2 \leq x_0$	0,0	0,0	0,0	0,0	0,0	0,3	1,0

Assume that the fuzzy controller has the following type of regulation rules:

$$l_i : ЕСЛИ\ l_i\ ЕСТЬ\ A_i\ и\ e_i'\ ЕСТЬ\ B_i,\ ТО\ U\ ЕСТЬ\ C_i.$$

An example of a fuzzy controller can be represented as

$$k_3[U(k)] = F[k_1 e(k), k_2 e'(k)], \quad (1)$$

where F is a fuzzy relation determined by the knowledge base; $K(i = \overline{1,3})$ – scaling factors

Table 1 shows an example of the discretization of the universe into 13 levels with seven terms (1).

The normalization of the universe is connected with the discretization of the latter into a finite number of segments, each of which is mapped to a suitable (corresponding) segment of the normalized universe.

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Table 2 shows the normalization of the universe [-6.0; -4.5], which is transformed into a normalized interval [-1, +1].

Table 2

Normalization and primary fuzzy sets using functional definition

Normalized universe	Normalized Segments	Range	U_j	σ_j	Primary fuzzy sets
[-1,0; 0; +1,0]	[-1,0; -0,5]	[-6,9; -4,1]	-1,0	0,4	OB
	[0,5; -0,3]	[-4,1; -2,2]	-0,5	0,2	OS
	[-0,3; -0,0]	[-2,2; -0,01]	-0,2	0,2	OM
	[-0,0; +0,2]	[-0,0; +1,0]	0,0	0,2	zero
	[+0,2; +0,6]	[+1,0; +2,5]	0,2	0,2	PM
	[+0,6; +1,0]	[+2,5; +4,5]	0,5	0,2	PS
			1,0	0,4	PB

The fuzzy division determines how many terms will participate in the term set. The power of the term-set of the input space determines the maximum number of fuzzy control rules in the knowledge base [9, 10].

Usually, a heuristic trial and error procedure is used to select the optimal fuzzy partition.

There are two methods for determining membership functions of a fuzzy set: numerical and functional. They depend on the type of universe (discrete or continuous).

In the case of the numerical method, the degree of the membership function of a fuzzy set is represented as a numerical vector, the dimension of which depends on the degree of discretization

In this case, the membership function has the form

$$\mu_A(U)=\sum_{i=1}^{n}\frac{a_i}{\pi_i}. \qquad (2)$$

In the second case, the membership functions of fuzzy sets have a certain functional form (bell-shaped, triangular, trapezoidal, etc.).

5.CONCLUSIONS

Determining the response function of a control object based on fuzzy logic offers several advantages. Here are some key conclusions regarding the benefits of using fuzzy logic for response function determination:

1. Linguistic Representation: Fuzzy logic allows for the use of linguistic variables and fuzzy sets, which can capture and represent human knowledge and expertise in a more intuitive manner. Instead of relying on precise mathematical models, fuzzy logic provides a framework for expressing and reasoning with imprecise and uncertain information [11].

2. Flexibility and Adaptability: Fuzzy logic enables flexibility and adaptability in modeling complex systems. It can handle nonlinear relationships and accommodate gradual transitions between different states. This flexibility is particularly useful when dealing with systems that have imprecise or changing dynamics.

3. Robustness to Uncertainty: Fuzzy logic can handle uncertainties and variations in the system by incorporating fuzzy rules and membership functions. It allows for the modeling of imprecise or incomplete information, making it more robust in real-world scenarios where precise data may be unavailable or unreliable.

4. Knowledge Integration: Fuzzy logic provides a means to integrate expert knowledge and heuristics into the control system. By using linguistic terms and rules, it becomes possible to incorporate human insights and domain expertise directly into the control design process. This can lead to more effective and customized control strategies.

5. Improved Performance: In many cases, fuzzy logic-based control systems have shown superior performance compared to traditional control approaches. The ability to handle complex and nonlinear relationships, adapt to changing conditions, and incorporate expert knowledge often results in better overall system performance, stability, and response [12].

6. Reduced Design Complexity: Fuzzy logic can simplify the design process by eliminating the need for precise mathematical models or extensive system identification. It allows control engineers to focus on capturing the essence of the system's behavior rather than intricate mathematical modeling, thereby reducing complexity and development time.

7. Interpretability and Transparency: Fuzzy logic provides a transparent framework where the decision-making process can be easily understood and interpreted. The linguistic rules and fuzzy sets used in fuzzy logic control systems allow for human-readable

explanations of the control actions, making it easier to validate and troubleshoot the system.

8. Cost-Effectiveness: Fuzzy logic-based control systems can often be implemented using low-cost hardware and software, making them an attractive solution for applications where cost is a consideration. Additionally, their adaptability and robustness can reduce maintenance and tuning efforts, further enhancing their cost-effectiveness.

It is worth noting that the advantages of using fuzzy logic for response function determination may vary depending on the specific application and system characteristics. However, these conclusions highlight the general benefits that fuzzy logic can offer in control system design and implementation.

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