EVALUATION OF THE CORRECTNESS OF SELECTING THE RULES OF FUZZY LOGIC AND FUNCTION OF ACCESSORIES IN AUTOMATIC CONTROL SYSTEMS

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Abstract: *in this paper, the possibility of using the Mamdani algorithm in automatic control systems is presented, an example of the application of this algorithm is considered and calculations are performed using the program MATLAB R2014b. A comparative analysis of two developed automatic control systems with different selection of rules and different membership functions is carried out. The analysis found that the use of a large number of rules contributes to the sensitivity of the system. A great contribution to the accuracy of the system renders the correct choice of the membership function.*
Keywords: *fuzzy logic, Mamdani algorithm, automatic control systems.*

ОЦЕНКА ПРАВИЛЬНОСТИ ВЫБОРА ПРАВИЛ НЕЧЕТКОЙ ЛОГИКИ И ФУНКЦИЙ ПРИНАДЛЕЖНОСТИ В АВТОМАТИЧЕСКИХ СИСТЕМАХ УПРАВЛЕНИЯ

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Аннотация: *в данной работе представлена возможность применения алгоритма Мамдани в системах автоматического управления, рассмотрен пример применения данного алгоритма и выполнены расчеты с использованием программы MATLAB R2014b. Проведен сравнительный анализ двух разработанных систем автоматического управления с различным подбором правил и разными функциями принадлежности. В ходе анализа установлено, что применение большого количества правил способствует повышению чувствительности системы. Большое влияние на точность системы оказывает правильный выбор функции принадлежности.*
Ключевые слова: *нечеткая логика, алгоритм Мамдани, системы автоматического управления.*

It is known that modern industry never stands still, it is constantly being improved and requires the application of new methods in the development of automatic control systems (ACS). The structure of the management object becomes more complicated with the years, the set of functions performed increases, and as a result, there is an increase in the uncertainty factors that must be taken into account in the design. At the same time, improving the quality of management should take place with minimal costs for the creation and operation of the systems being developed. The application of the Mamdani algorithm in automatic control systems makes it possible, with a relatively low level of spent resources, to manage objects in conditions of uncertainty [1].

Let us consider an example of the application of the Mamdani algorithm in the homing system. To do this, we assume that a missile with a homing system moves from point A to point B and encounters various obstacles along the route. To determine the direction of motion, three sensors are used: in the bow, on the left and right side of the rocket. Calculations will be performed in the program MATLAB R2014b.

The system contains three input blocks (1, 2 and 3 sensors), and one output block (solution). We define the membership functions for each of the blocks. The input block data definition area for simplicity of calculations is assumed to be from 0 to 10. This means that the data received from the sensors will produce a value close to 0 in the absence of an obstacle and a value close to 10 if an obstacle is detected.

For the first sensor, the S-shaped accessory function is used, for 2 and 3 sensors, a trapezoidal shape is used. The first membership function is capable of taking more values in the range from 0 to 1. The sensor located in the nose serves for the primary detection of the obstruction.

For the output block "solution" triangular membership functions are used.

After defining the membership functions, it is necessary to compose rules for the execution of the algorithm. In real conditions, more rules are given, but for a general understanding of the process we use the 6 rules, which are depicted in Figure 1.

1. If (1-й is Опасность) and (2-й is Низкий) and (3-й is Высокий) then (Решение is Лево) (1)
2. If (1-й is Опасность) and (2-й is Высокий) and (3-й is Низкий) then (Решение is Право) (1)
3. If (1-й is Нет_опасности) then (Решение is Прямо) (1)
4. If (1-й is Возможна_опасность) and (2-й is Низкий) and (3-й is Низкий) then (Решение is Право) (1)
5. If (1-й is Возможна_опасность) and (2-й is Низкий) and (3-й is Высокий) then (Решение is Лево) (1)
6. If (1-й is Возможна_опасность) and (2-й is Высокий) and (3-й is Низкий) then (Решение is Право) (1)

Fig. 1. Rules for the execution of the algorithm

The results of the calculations are shown in Figures 4-7. Note that for the output block "decision", a scale from 0 to 30 is used. We take the output value from 0 to 10, as the decision to fly to the left, from 10 to 20 - straight, from 20 to 30 - To the right.

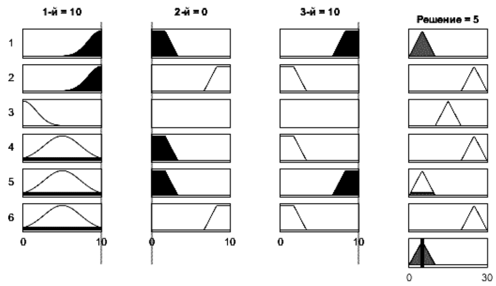

Fig. 2. Obstruction right and right

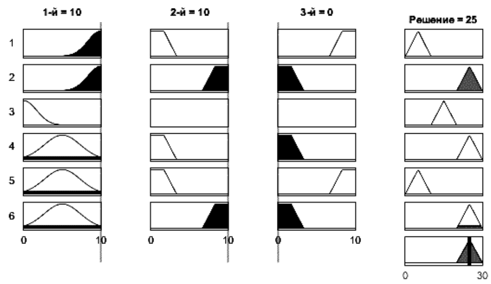

Fig. 3. Obstruction right and left

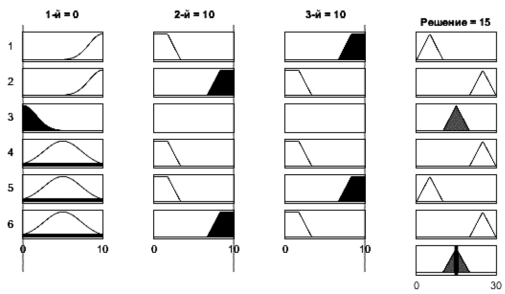

Fig. 4. Obstruction left and right

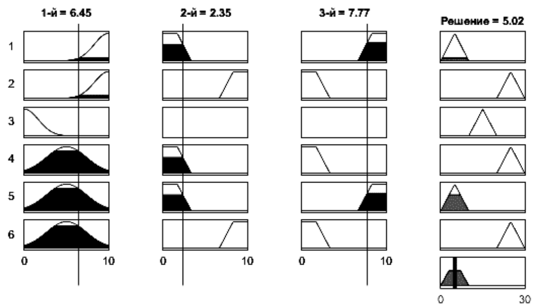

Fig. 5. Possible obstacle right and right

Figure 2 shows a situation where the obstacle is directly at the path and to the right of the path, so the system decides to turn to the left.

Figure 3 shows the situation where the obstacle is directly at the path and to the left of the path, so the system decides to turn to the right.

Figure 4 shows the situation where the obstacle is on the right and left of the path, so the system decides to fly straight.

Figure 5 shows a situation where a possible obstacle is directly at the path and to the right of the path, so the system decides to turn to the left. However, since the obstacle is not explicit, then the decision is made to fly to one side or another with some probability.

Analyzing the obtained data, it can be concluded that the application of this algorithm will allow the system to make independent decisions with great accuracy.

In real conditions, to achieve greater accuracy, it is necessary to specify more rules, use more sensors and perform calculations on real data.

We use the S-shaped accessory function for the second and third sensor, as for the first one. As mentioned, this function is able to take a greater number of values in the range from 0 to 1. Also, for example, we will increase the number of rules. Since the model is not real, but only demonstrates the possibility of applying this algorithm, ten rules with three used sensors will suffice.

Suppose that the probability of finding the obstacle right and left is 0.2. The probability of finding the obstacle on the right is 0.7. In this case, the system decides to move directly.

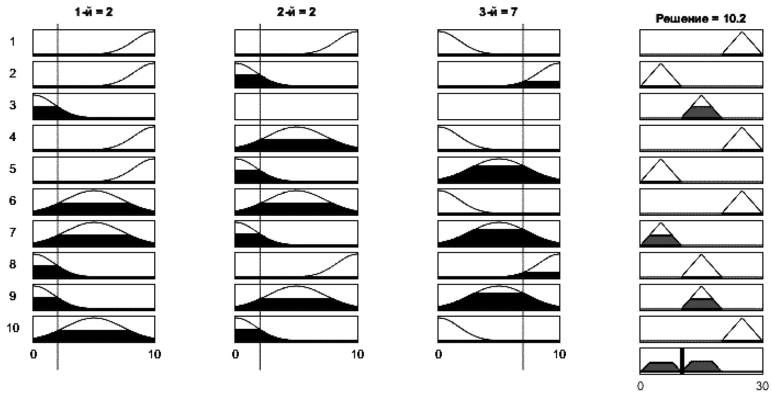

Fig. 6. Possible obstacle right and left, obstacle on the right

Let's change the probability of finding an obstacle right up to 0.21. The remaining parameters remain the same. The system decides to fly to the left. In other words, with a slight change in the input parameters, the system changes its output values.

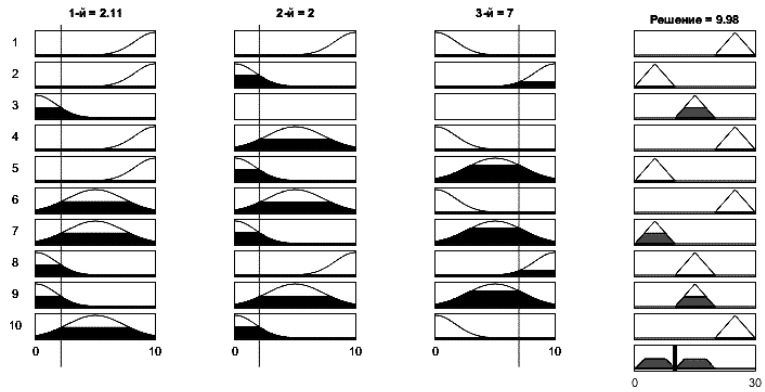

Fig. 7. Possible obstacle right and left, obstacle on the right

Substitute the probability data in the original program with fewer rules and other membership functions. We observe that under initial conditions the system decides to move directly with a sufficiently high probability.

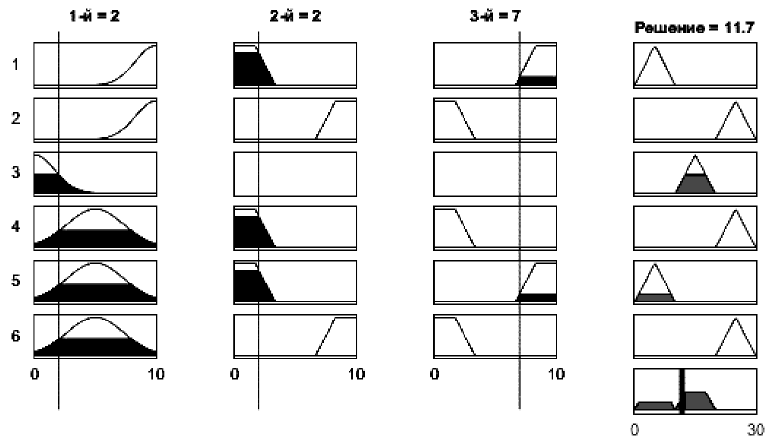

Fig. 8. Possible obstacle right and left, obstacle on the right

With increasing probability of finding an obstacle directly and the same other parameters, the system changes its decision only with a significant increase in the first parameter.

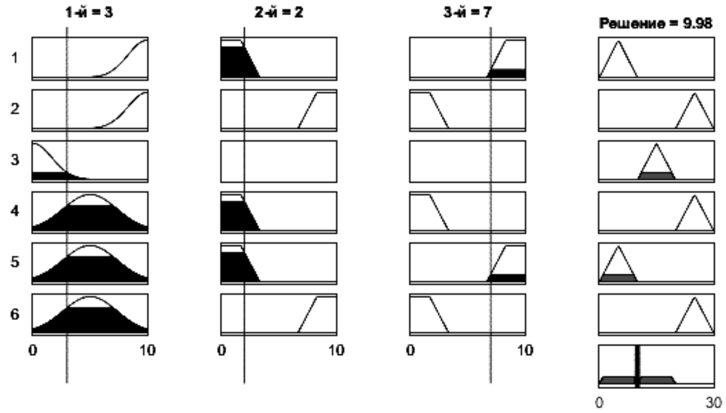

Fig. 9. Possible obstacle right and left, obstacle on the right

This indicates a low sensitivity of the system. Thus, we can conclude that an increase in the number of rules and the correct choice of the membership function do affect the quality of the decisions made. Using high-quality measuring equipment will increase the accuracy of the decision, which will also affect the correctness of the decisions made.

The modern element base and computer systems allow to receive and process data in real time with a delay tending to zero. All this in aggregate will allow creating a high-precision automatic control system.

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