Course: “Basics of soft computing theory”

Laboratory Work №4

Construction of an elementary fuzzy expert system

Objective: master the technique of constructing a fuzzy expert system.

Task: construct an elementary fuzzy expert system with the help of the interface program of the fuzzy logic package of the MATLAB software environment (according to the problem from the lab.work 3).

Example:

Task. Assessment of the financial condition of a potential client by the bank when granting long-term loans for real estate construction. The fuzzy model is proposed to use 4 input variables and 1 output variable.

An estimate of the location of the building under construction is used as the first input variable. It estimates the design of the building under construction. The higher this estimate is, the more liquid the project appears to be if it is implemented on the real estate market.

As the second input variable, the quality of the expected execution of the finishing works according to the architectural design of the building under construction is used.

As the third input variable, the asset valuation is used, that is used to estimate the property in case of insolvency of a potential client if he does not return the loan since the amount of the provided loan should be based not only on the cost of the building under construction but also on the client's capitalization.

As the fourth input variable, an estimate of the potential clients income minus fixed spending. The higher the value of this variable is, the loan is more likely to be provided to the client.

As an output variable, the creditworthiness assessment is used. It is the foundation for deciding by the bank management to grant a loan to potential customers. At the same time, the decision to grant a loan is made only if this variable is highly valued. The knowledgebase consists of the following heuristic rules:

1. If the assets are low, then the creditworthiness is very low.
2. If the income is low, then the creditworthiness is very low.
3. If the location is not prestigious, the quality of the finishes is excellent, the assets are low and the income is high, then the creditworthiness is average.
4. If the location is prestigious, the quality of finishing is good, the assets are low and the income is high, then the creditworthiness is average.
5. If the location is prestigious, the quality of finishing is good, the assets are low and the income is high, then the creditworthiness is average.
6. If the location is very prestigious, the quality of finishing is good, the assets are average and the income is high, then the creditworthiness is average.
7. If the location is not prestigious, the quality of the finishing is excellent, the assets are high and the income is low, then the creditworthiness is average.
8. If the location is prestigious, the quality of the finishes is excellent, the assets are average and the income is high, then the creditworthiness is very high.

9. If the location is prestigious, the quality of the finishes is excellent, the assets are average and the income is high, then the creditworthiness is very high.

10. If the location is not prestigious, the quality of the finishing is excellent, the assets are average and the income is high, then the creditworthiness is high.

11. If the location is not prestigious, the quality of the finishing is good, the assets are average and the income is high, then the creditworthiness is high.

12. If the location is very prestigious, the quality of finishing is excellent, then the creditworthiness is high.

This knowledgebase can be expanded due to including new rules.

In the MATLAB environment, on the command line, type the **fuzzy** keyword to invoke the fuzzy system editor.

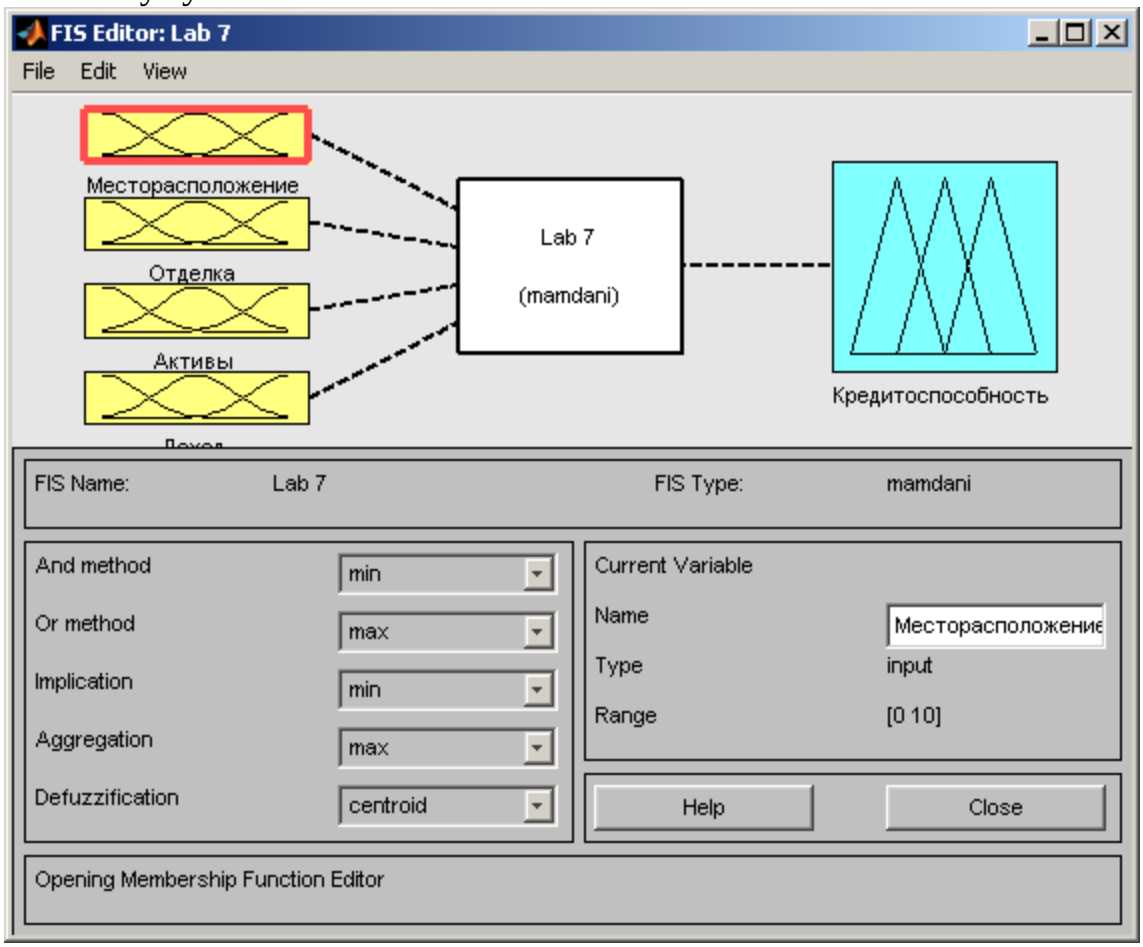

Figure 1 – Window of Mamdani fuzzy system type

The following data is set in the block of parameters of a fuzzy system of the Mamdani type:

• the **And method** menu allows you to set the implementation of logical operation AND: ***min*** – minimum and ***prod*** – algebraic product;

• The **Or method** menu allows you to set the implementation of logical operation OR: ***max*** – maximum, and ***probor*** –algebraic sum;

• the **Implication** menu allows you to set the following methods of implicating logical conclusions in each of the fuzzy rules: ***min*** – minimum and ***prod*** – algebraic product;

• the **Aggregation** menu allows you to set the following implementation of the operations of a union of membership functions of the output variable (aggregation): ***max*** – maximum, ***sum*** – limited sum, and ***probor*** – algebraic sum;

• the **Defuzzification** menu allows you to choose one of the defuzzification methods: ***centroid*** – centroid method, ***bisector*** – median method (the center of area method), ***lom*** – the largest of the maximums method, ***som*** – the smallest of maximums method, and ***mom*** – the center of maximums method.

Set 4 inputs and 1 output in our fuzzy system. Describe the membership functions for each of the inputs (fig. 2-5).

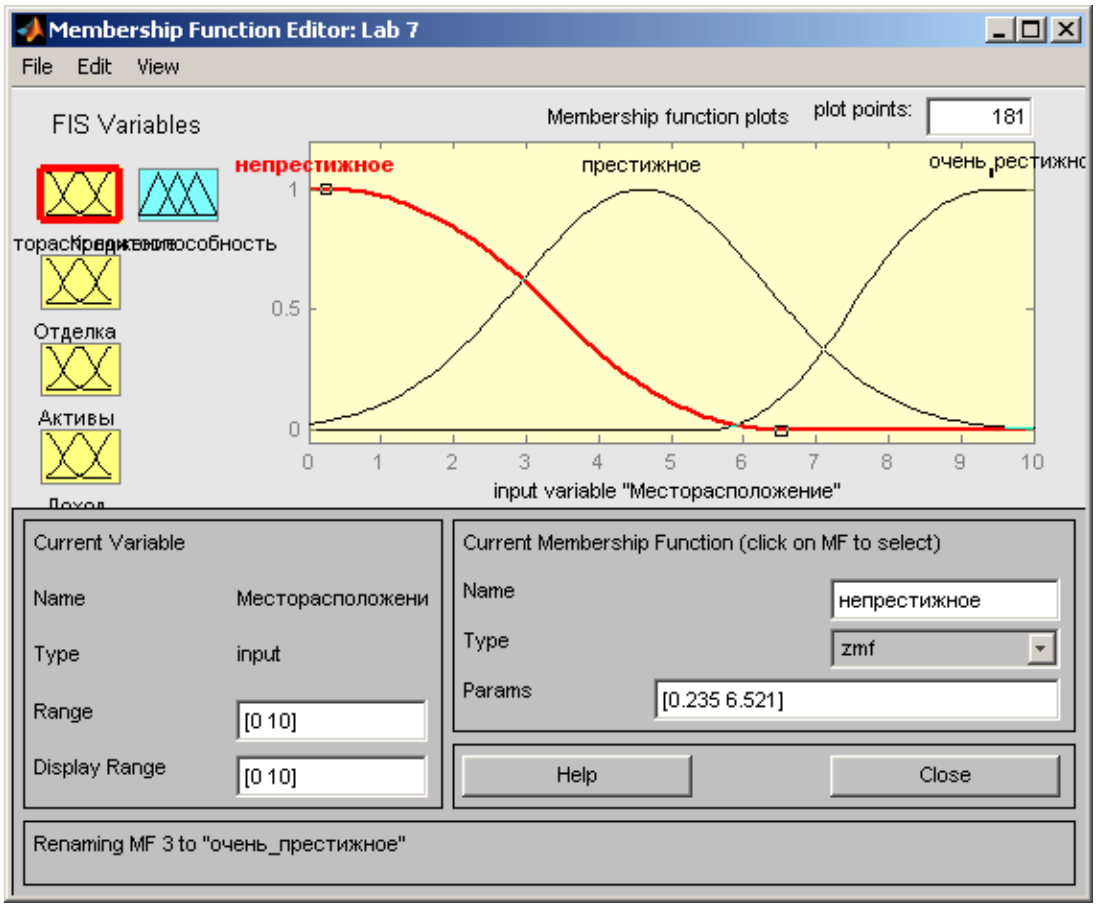

Figure 2 – Membership functions «Location» input

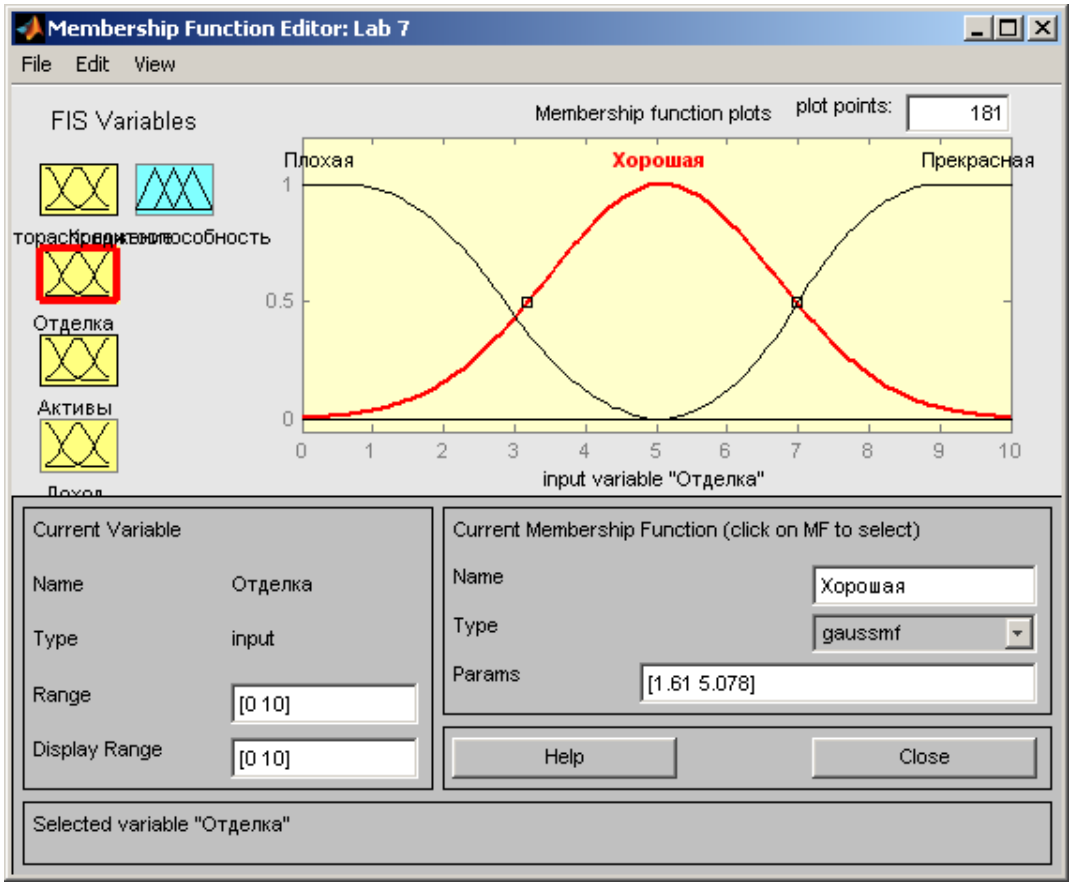

Figure 3 – Membership functions of the "Finishing" input

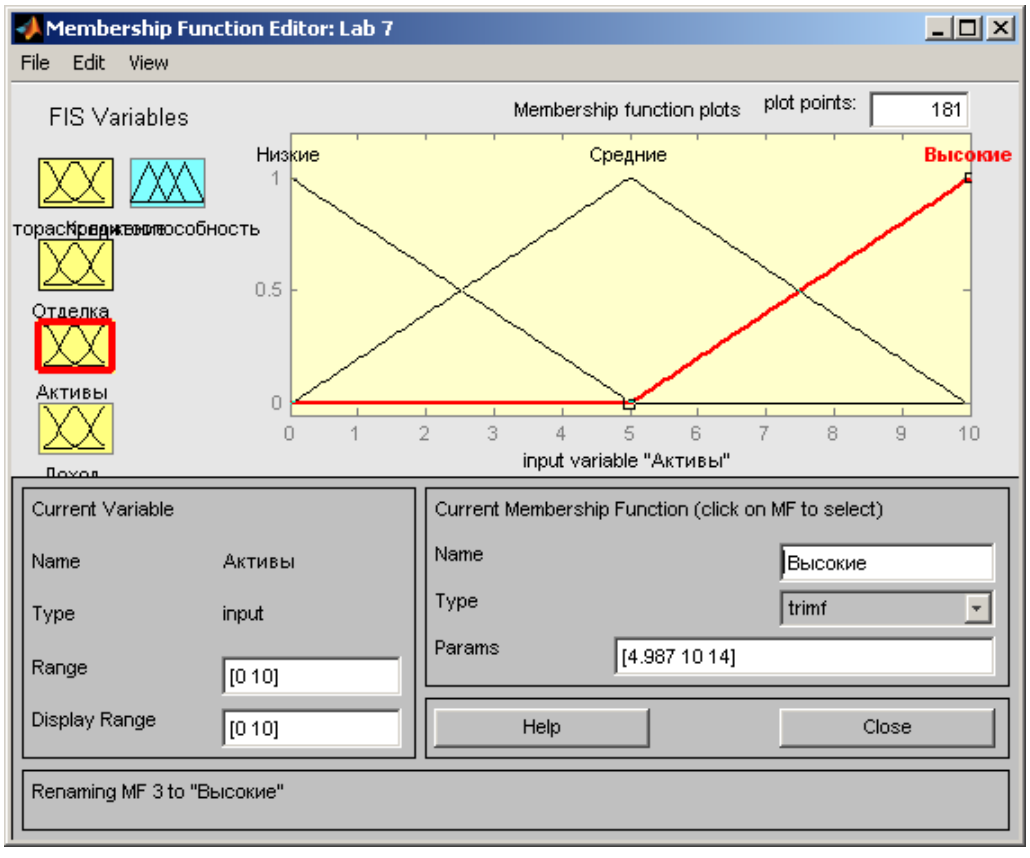

Figure 4 – Membership functions of the "Assets" input

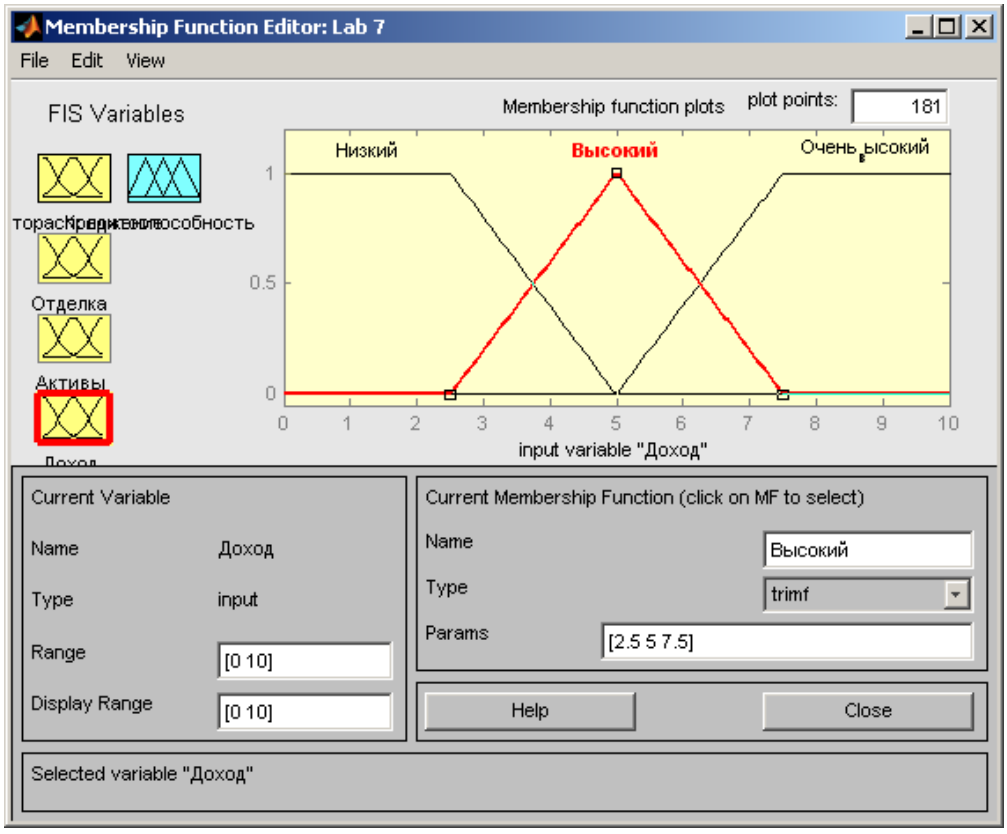

Figure 5 – Membership functions of the "Income" input

Set the membership functions of the output in accordance with the decided price level. (fig. 6).

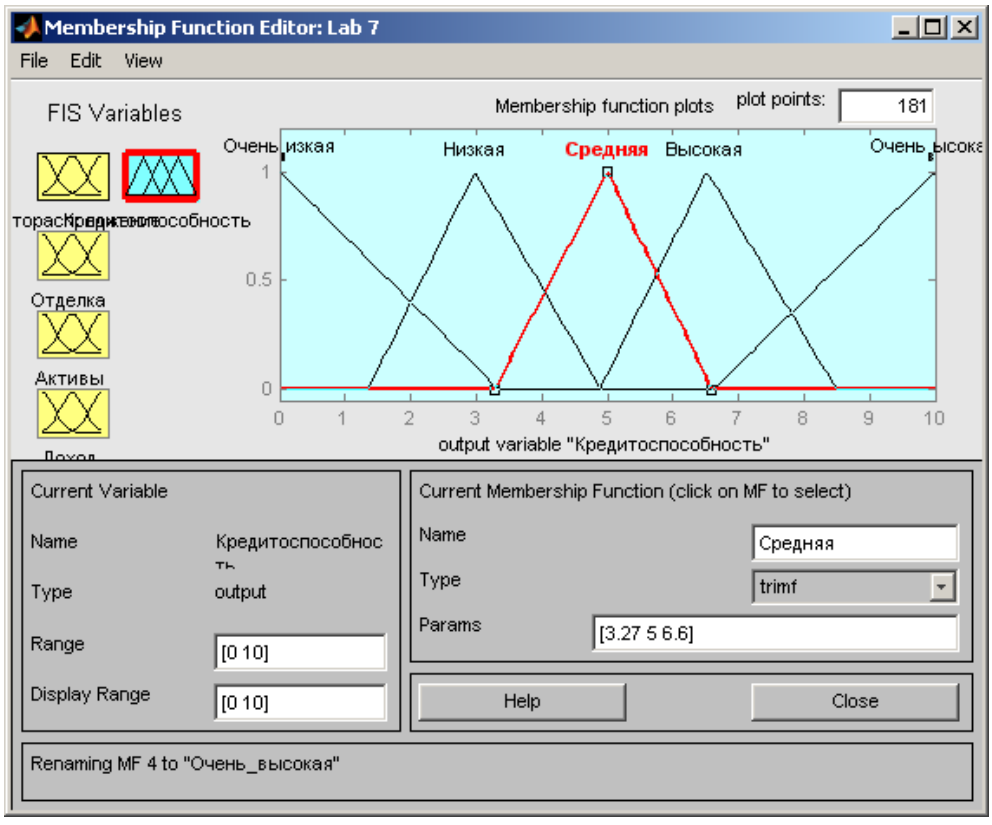

Figure 6 – Membership functions output

Move on to constructing rules. To do this, select the **View/Edit rules** menu. Then input the rules (fig. 7).

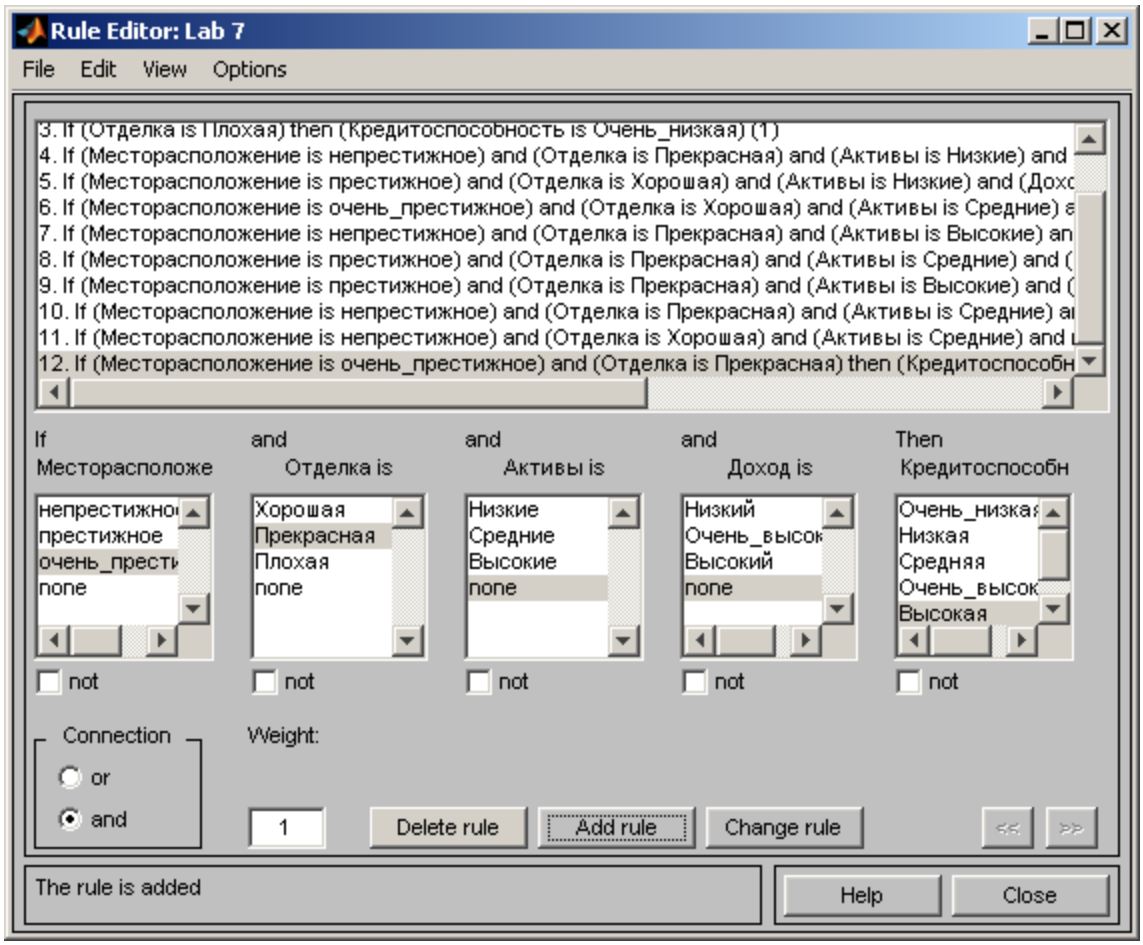

Figure 7 – Set of knowledgebase rules

Checking the system in action. Open (through the **View\View rules** menu item) the rules view window and put the following values of the variables: the value of the input variable “location” at 3 points, the value of the variable “finishing” at 5 points, the value of the variables “assets” and “income” at 4 points (fig. 8).

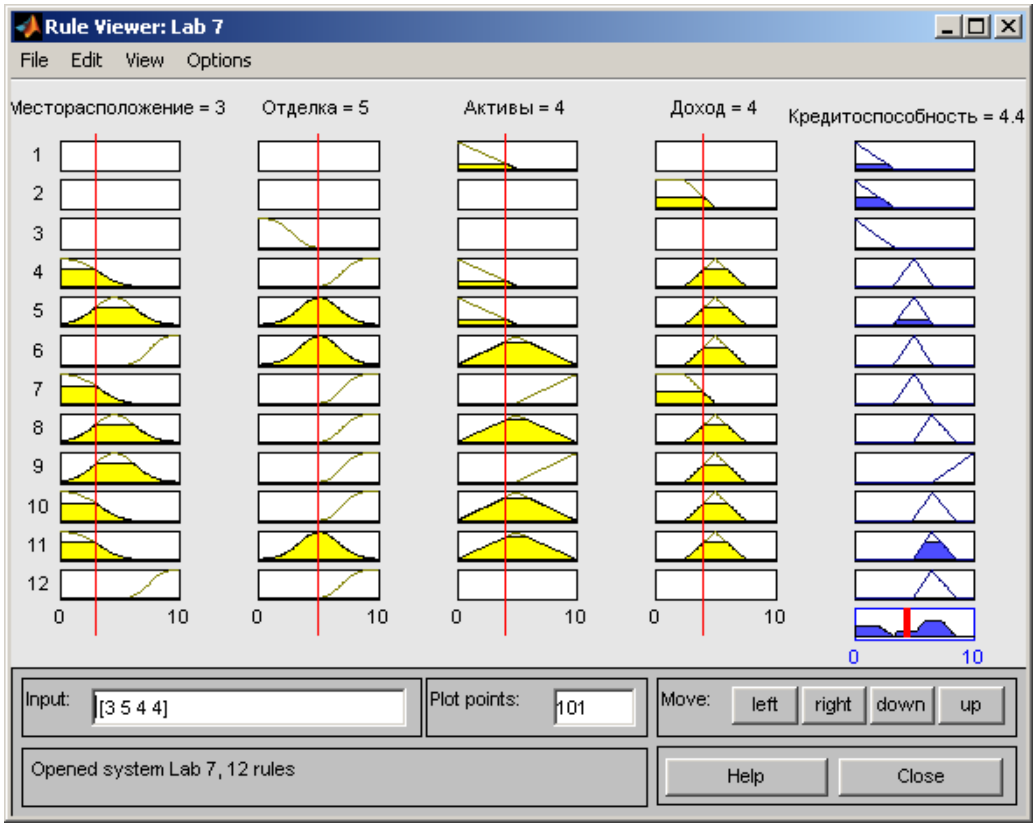

Figure 8 – Window of rules view

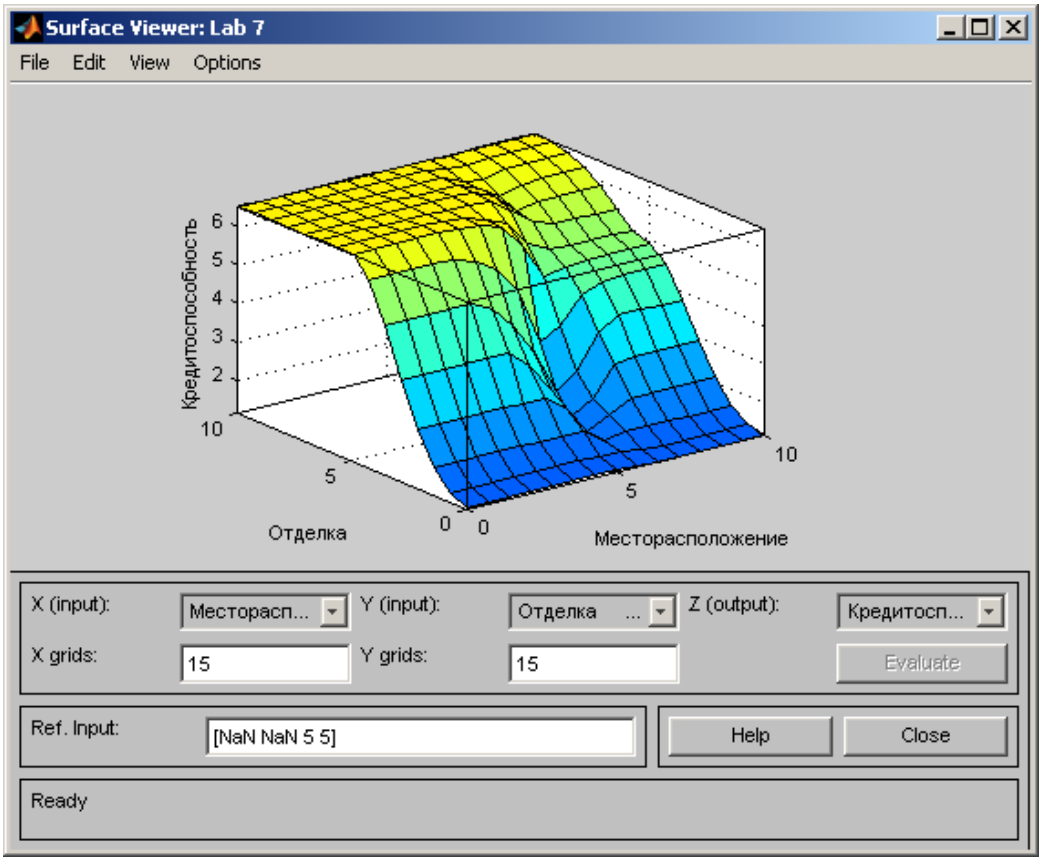

Figure 9 – Graphical view of the dependence of the system output from the inputs

The fuzzy inference procedure gives the value of the output variable "creditworthiness" equal to 4.4 points, which is a rather low estimate of the financial solvency of a potential client and can serve as a basis for a negative decision on the part of the bank to provide a secured loan.

The editor of fuzzy systems in the MATLAB environment also allows you to see the dependence of the output variable on its input in the graphical view (fig. 9).

Test questions.

1. What is an expert system?
2. What is knowledge and how is it different from data?
3. What is a knowledge base and how is it different from a database?
4. How many variables are in your fuzzy system and how many membership functions each of them have, and why?
5. What types of membership functions did you use in your laboratory work?
6. What types of membership functions were used in the laboratory, and why?
7. How is a set of rules set?
8. What is the difference between Mamdani fuzzy inference type and Sugeno inference type?
9. Describe the stages of fuzzy inference.
10. Describe the structure of the expert system.
11. List the main advantages and disadvantages of systems with fuzzy logic?