

THE DECISION MAKING UNDER LAW UNCERTAINTY BY MEANS OF FUZZY LOGIC

Abstract: The article deals with the use of fuzzy logic at support of manager decision making. The brief description of fuzzy logic and the process of calculation are mentioned. The use is demonstrated on the example such as the decision making whether to accept, entertain or reject the client of law office. The scheme of models, rule blocks, attributes and their membership functions are mentioned. The use of fuzzy logic is the advantage especially at decision making processes at law uncertainty.

Keywords: Decision making, law, uncertainty, fuzzy logic, Matlab

1. Introduction

The use of fuzzy logic is the advantage especially at decision making processes where the description by algorithms is very difficult and criteria are multiplied. The advantage is that the linguistic variables are used. The fuzzy logic measures the certainty or uncertainty of membership of element of the set. Analogously the man makes decision during the mental and physical activities. The solution of certain case is found on the principle of rules that were defined by fuzzy logics for similar cases. The fuzzy logics belong among methods that are used in the area of decision making of firms and offices.

2. Fuzzy Logic

The calculation of fuzzy logics consists of three steps: fuzzification, fuzzy inference and defuzzification.

- The fuzzification means that the real variables are transferred on linguistic variables. The definition of linguistic variable goes out from basic linguistic variables, for example, at the variable profit is set up the following attributes: none, very low, low, medium, high, very high profit. Usually there are used from three to seven attributes of variable. The attributes are defined by the so called membership function, such as Λ , π Z, S and some others. The membership function is set up for input and output variables.

- The fuzzy inference defines the behavior of system by means of rules of type <When>, <Then> on linguistic level. The conditional clauses evaluate the state of input variables by the rules. The conditional clauses are in the form

<When> $Input_a$ <And> $Input_b$ $Input_x$ <Or> $Input_y$ <Then> $Output_1$, <With> x

it means, when (the state occurs) $Input_a$ and $Input_b$,, $Input_x$ or $Input_y$,, then (the situation is) $Output_1$ with x .

The fuzzy logic represents the expert systems. Each combination of attributes of variables, incoming into the system and occurring in condition <When>, <Then>, presents one rule. Every condition behind <When> has a corresponding result behind <Then>. It is necessary to determine every rule and its degree of supports (the weight of rule in the system). The rules are created by the expert himself.

- The defuzzification transfers the results of fuzzy inference on the output variables, that describe the results verbally (for example, whether to accept or reject the client).

The system with fuzzy logics can work as an automatic system with entering input data. The input data can be represented by many variables.

3. Case Study

Let us mention an example, when it will be evaluated whether the client of law office will be accepted – (Accept), entertained the acceptance – (Entertain) or rejected (Reject) on the basis of inputs. The input variables and their attributes are: Profit - low, medium and high profit from case, Time - low, medium and high of time costing ness, Professional - low, medium, high professional requirements, Value - small, medium high value of client, Justification - low, medium, high justification of claim. The task will be solved by means of MATLAB program using Fuzzy Logic Toolbox. It is suitable to set up an executable program to realize the mentioned task. The sequence of orders is as follows. See prog.1.

```
b2 = readfis('LO.fis');
Data = input('Set up the values in an order Profit; Time; Professional; Value; Justification
[Profit; Time; Professional; Value; Justification]: ');
result = evalfis(Data, b2);
fuzzy(b2)
mfedit(b2)
ruleedit(b2)
surfview(b2)
ruleview(b2)
result
if result<0.20 'Accept'
elseif result<0.50 'Entertain'
else 'Reject'
end
```

Prog. 1 File *LO.m*

The first row reads the parameters of fuzzy model into variable *b2* by order *readfis* from file *LO.fis*. The second row reads the five input variables such as Profit, Time, Professional, Value and Justification. The fourth row contains the order *evalfis*, that evaluates the input variables *Data* and *b2*. The output is in variable *result*. The following order *fuzzy(b2)* enables the set up of fuzzy model, the order *mfedit(b2)* enables the set up of membership functions, the order *ruleedit(b2)* enables the set up fuzzy rules, the order *surfview(b2)* enables the graphical search of dependence of input and output variables and order *ruleview(b2)* enables to evaluate the output on the basis of inputs. The order *result* writes off the final value. The following four rows make a vague result. If the output value *result* is in the range $R \in (0,20>$, the result is to Accept the client. If the output value *result* is in the range $R \in (20,50>$, the result is to Entertain the client. If the output value *result* is in the range $R \in (50,100)$, the result is to Reject the client.

The order *fuzzy(b2)* enables the set up of fuzzy model. See fig.1. The order *mfedit(b2)* enables the set up the membership functions of variables Profit, Time, Professional, Value, Justification and Result.

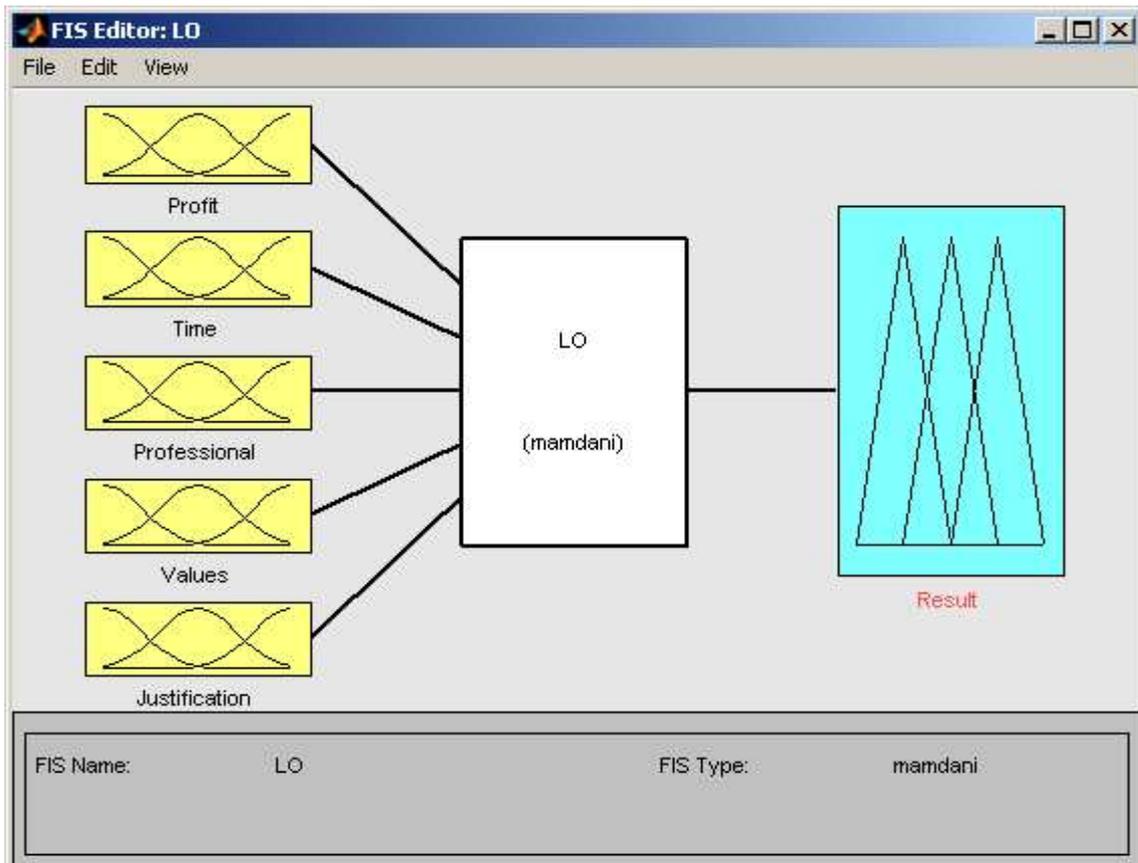


Fig. 1 Order *mfedit(b2)* – AK

The order *mfedit(b2)* enables the set up of membership functions. Fig.2 defines the attributes and membership functions for Profit - low (LP), medium (MP) and high (HP) profit from case. Fig.3 defines the attributes and membership functions for Time - low (LT), medium (MT) and (HT) high of time costing ness. Fig.4 defines the attributes and membership functions for Professional - low (LR), medium (MR), high (HR) Professional requirements. Fig.5 defines the attributes and membership functions for Value low (LV), medium (MV) high (HV) value of a client. Fig.6 defines the attributes and membership functions for Justification - low (LJ), medium (MJ) and high (HJ) justification of claim.

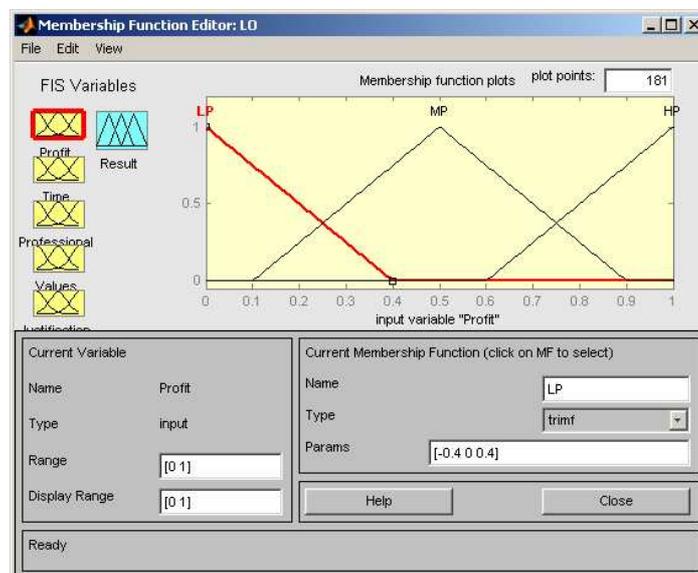


Fig. 2 Order *mfedit(b2)* – Profit

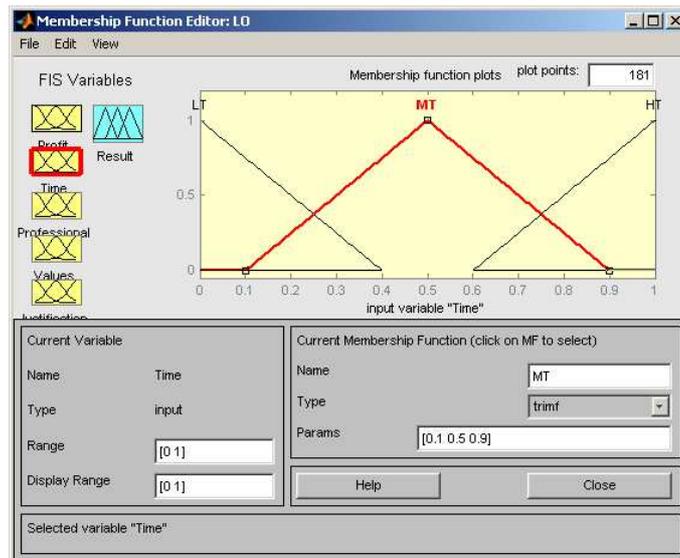


Fig. 3 Order *mfedit(b2) – Time*

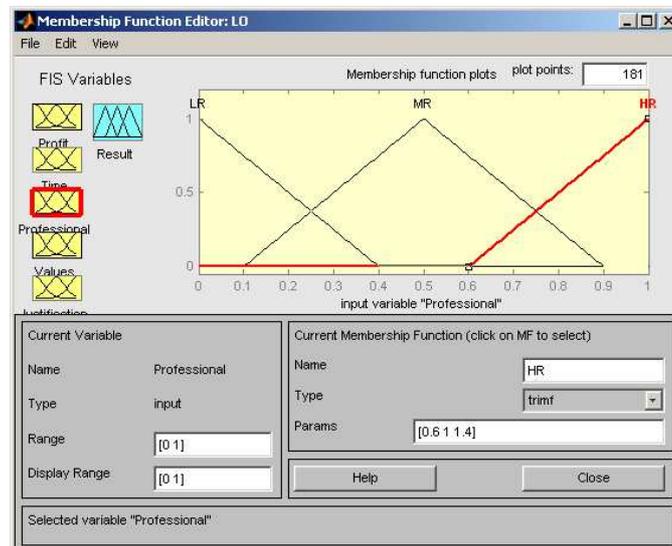


Fig. 4 Order *mfedit(b2) – Professional*

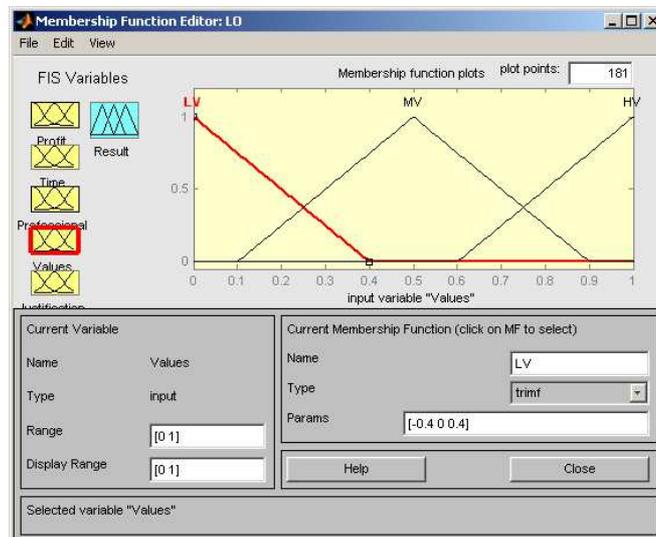


Fig. 5 Order *mfedit(b2) – Value*

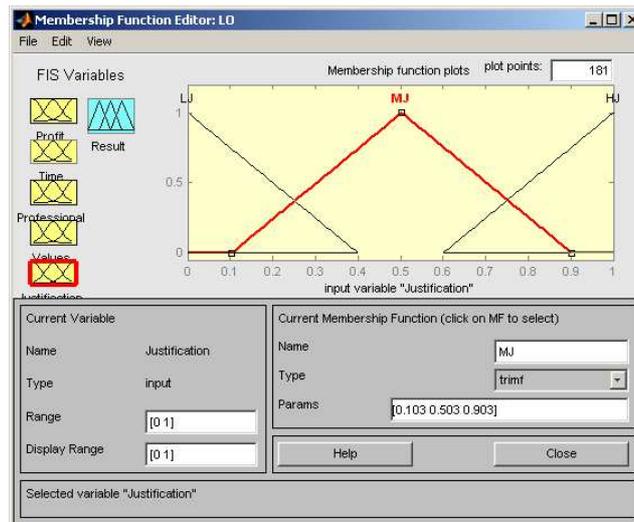


Fig. 6 Order *mfedit(b2)* – *Justification*

Fig.7 defines the attributes and membership functions for *Result* Accept (RA), Entertain (RE) or Rejected (RR) the client

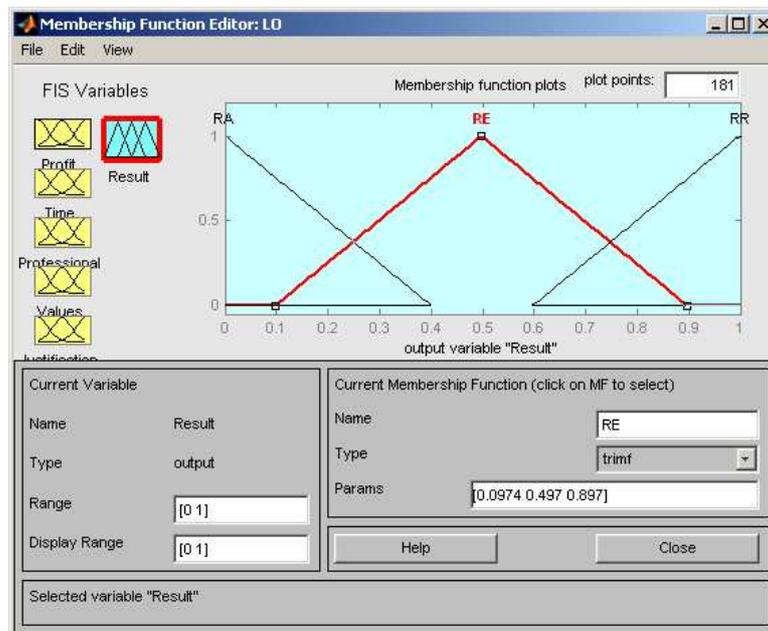


Fig. 7 Order *mfedit(b2)* – *Result*

The way of set up of the first rule is on the fig.8 and its verbal interpretation is as follows: If the profit is low (Profit = LP) and together the time costing ness is high (Time = HT) and together professional requirements is high (Professional = HR) and together the value of an client is low (Value = LV) and together the justification of a claim is low (Justification = LJ), then the result of an client is its rejection (Result = RR) with weight 1.

The other rules are set up accordingly. The created rules are possible to check in the table of rules at upper part of display. It is necessary to set up such number of rules that describe the solved task. The order *surfview(b2)* enables the graphical search of dependence of input and output variables, for example the dependence of *Result* on *Profit* and *Justification*. See fig.9.

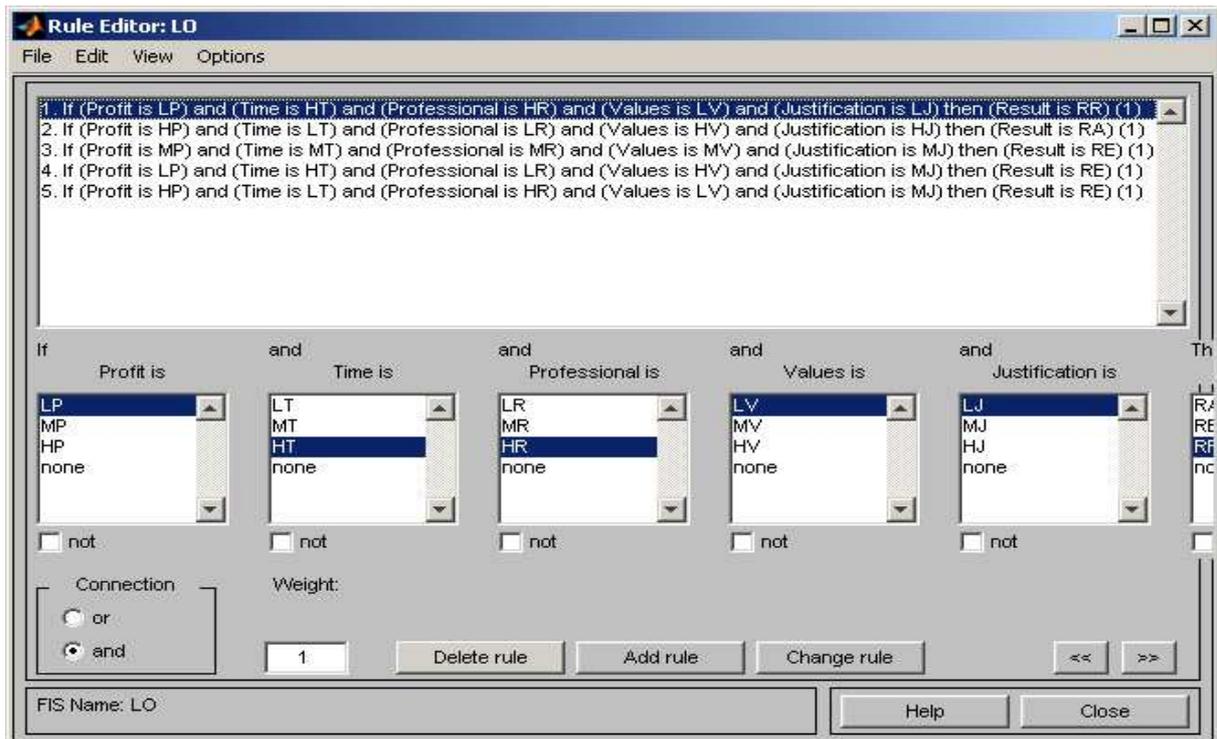


Fig. 8 Order ruleedit(b2)

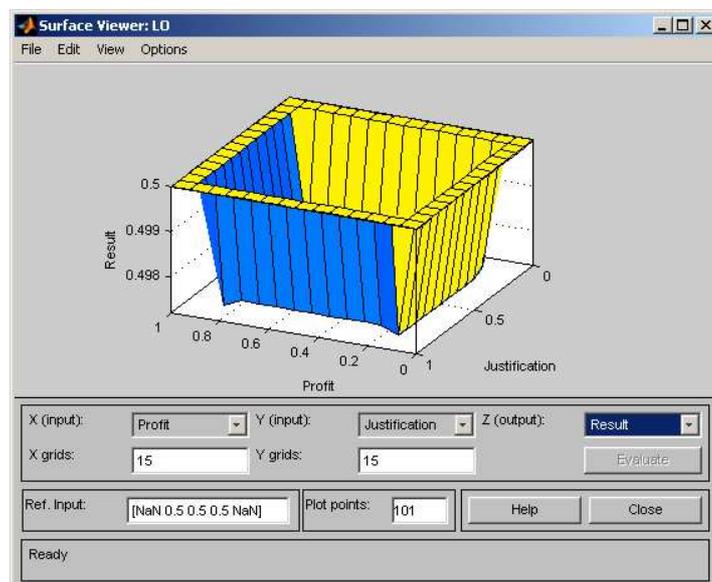


Fig. 9 Order surfview(b2) – $Result = f(Profit, Justification)$

The order *ruleview(b2)* enables to evaluate output *Result* on the basis of inputs Profit, Time, Professional, Value and Justification. The following cases represent two set up rules. The ranges of variables are normalized in range $<0,1>$. Fig.10 presents the input variables with values Profit =1.0, Time = 0.0, Professional = 0.0, Value = 1.0, Justification = 1.0, that results in this case to value Result = 0.13, it means to reject the client. Fig.11 presents the input variables with values Profit =0.0, Time = 1.0, Professional = 1.0, Value = 0.0, Justification = 0.0, that results in this case to value Result = 0.87, it means to accept the client. The ranges and abbreviation of attributes of variables is as follows: Profit $<0-1>$ $<LP,MP,HP>$; Time $<0-1>$ $<LT,MT,HT>$; Professional $<0-1>$ $<LR,MR,HR>$; Value $<0-1>$ $<LV,MV,HV>$; Justification $<0-1>$ $<LJ,MJ, HJ>$ and Result $<0-1>$ $<RA,RE,RR>$.

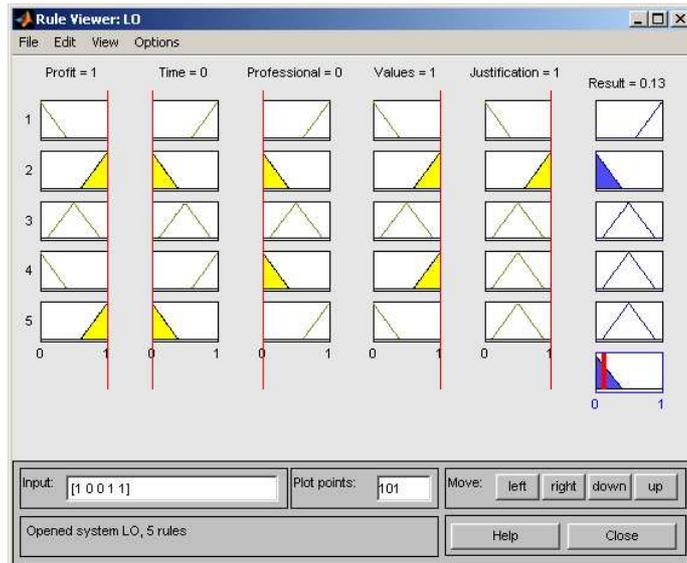


Fig. 10 Order $ruleview(b2)$ - Input $[1;0;0;1;1]$

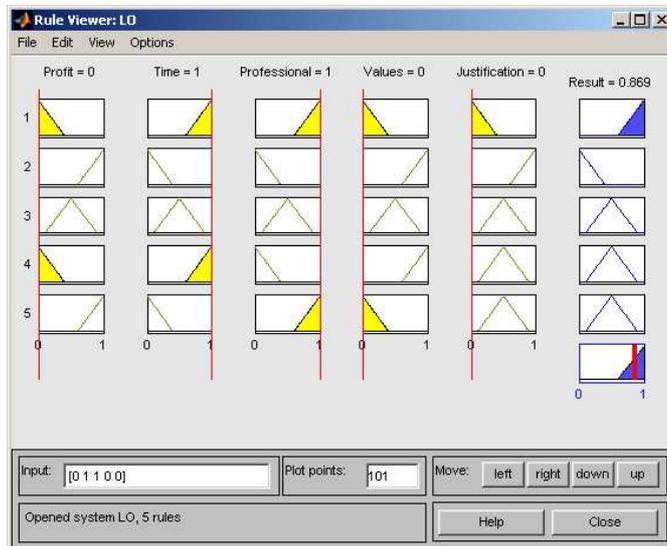


Fig. 11 Order $ruleview(b2)$ - Input $[0;1;1;0;0]$

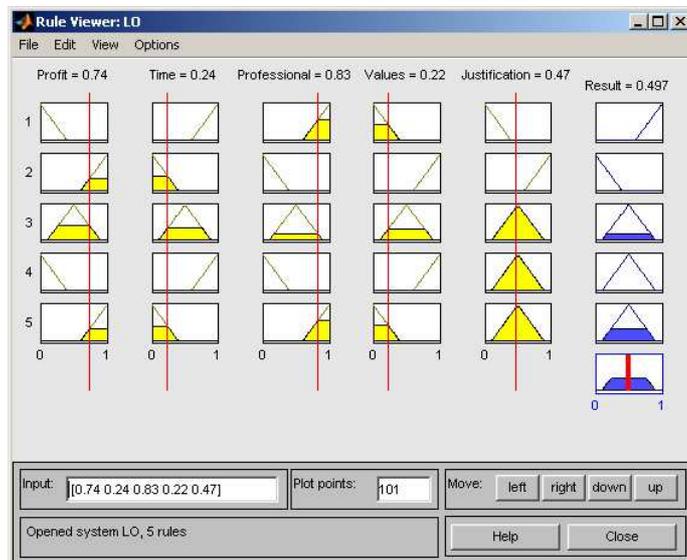


Fig. 12 Order $ruleview(b2)$ - Input $[0.74;0.24;0.83;0.22;0.47]$

It is possible to use the model in practice, when the build up model is verified and its result corresponds to the reality. In this case the values of input variables are set up on the basis of real client. The set up is done by movement of vertical lines. See fig.12 for values Profit = 0.74, Time = 0.24, Professional = 0.83, Value = 0.22 and Justification = 0.47.

When the program *LO.m* is started, the request for entering the input data is displayed in the form Profit, Time, Professional, Value, Justification. When the input values are written [0;1;1;0;0], the result is to Reject the client. When the input values are written [1;0;0;1;1], the result is to Accept the client. When the input values are written [0.74; 0.24; 0.83; 0.22; 0.47] the result is to Entertain the acceptance of client. See fig.13.

```
Set up the values in an order Profit; Time; Professional; Value; Justification [Profit; Time;
Professional; Value; Justification]: [0;1;1;0;0]
ans = Reject
Set up the values in an order Profit; Time; Professional; Value; Justification [Profit; Time;
Professional; Value; Justification]: [1;0;0;1;1]
ans = Accept
Set up the values in an order Profit; Time; Professional; Value; Justification [Profit; Time;
Professional; Value; Justification]: [0.74;0.24;0.83;0.22;0.47]
ans = Entertain
```

Fig. 13 Result of a client

The results correspond to reality therefore it is possible to consider the build up model to be functional. All graph generated by orders *fuzzy(b)*, *mfedit(b)*, *ruleedit(b)*, *surfview(b)* and *ruleview(b)* are at disposal after calculation. The parameters of the build up model are saved in a *LO.fis* file.

5. Conclusion

The fuzzy logic is used for the decision making process whether the client of law office will be accepted, entertained or rejected. The use of fuzzy logic is suitable in the cases when vague notes are used. The low profession belongs among these cases.