Identification of Gifted Students via ANFIS for a Purpose of their Inclusion into Special Educational Program

Introduction

If we try to define giftedness, it is most frequently described as an individual's ability in a particular area praised by the socio-cultural environment which is quantitatively and qualitatively more developed in comparison with their peers (Heward, 2013).

These characteristics include specificity in the cognitive area, such as high intelligence, intense curiosity, abstract thinking, ability to transfer knowledge, creativity, generating original ideas, excellent memory, interest in philosophical topics (Clark, 2013). Social-emotional characteristics which are described by T. L. Gross (2011) include for example asynchronous personality development (contradiction between the level of intelligence and aspects such as motoric, verbal, and socio-emotional development), perfectionism, emotional sensitivity, multipotentiality, intensity and depth of experience. Gifted students belong to specific group of students which have also the special educational needs (Heward 2013).

Gifted students must be identified for special educational program which develop their potential. For the purpose of respecting these specific educational needs of gifted students, it is usually recommended to modify educational program in its content, process, product, environment and evaluation (Riley, 2011).

Former studies on teacher´s identification criteria for giftedness show performance in school as a central factor for judging a pupil as gifted. But characteristics and behaviour, which can be subsumed under the term intelligence as well as features, which are to be classified into the ranges of creativity and achievement motivation, also seem to be relevant for the identification (Endepohls-Uple, Ruf, 2005).

Let´s focus on identification of gifted students during education. The gifted student must be evaluated (identified) in the context of the sign of his giftedness. The research problem is how to evaluate these criteria into one final outcome. The process of gifted student identification must be one of the most important parts of growing up gifted individuals because the outcome is inclusion into the special broad educational program in a form of special school for gifted students or another enriching curriculum. The process of identification must be an elaborate system of each school or institution in which they are addressed organizational, conceptual, and ethical and also the methodological issues in which we focus.

Related works and research problem

A lot of criteria of giftedness are taken into account during identification (Callahan 2004). These criteria come from their specific cognitive and no cognitive characteristic. We can evaluate their level of superior creativity, logical thinking and learning quality. These criteria are very different and vague and we need one final outcome. During evaluation of partial outputs (criteria) the broad model is suggested (Renzulli and Reis 2004). In the broad model the gifted individual must fulfil all or the most of evaluation criteria, so the methodological problem is how to combine these results.

The application of the additive model registered in praxis and theory (Callahan and Renzulli 2012). In this model the partial outcomes are easily added for each individual in evaluation process. These outputs in a form of some total points are compared. The advantage of additive model is quite easy evaluation, where we add each point together. On the other hand we add the criteria with different conditions and relevance, moreover the results from each different criteria could be inappropriately compensate and give mistaken results of evaluation process.

We must realize that different evaluation criteria cannot be added linearity. For example Hunsaker (2012) suggests addition of selected criteria which plays key role for evaluation of gifted students and other less important criteria which are used tentatively. To eliminate these disadvantages we suggest combining each result by using the fuzzy logic. The method allows to clear evaluation of larger number of data without compensation of variables. Its advantage comes from using of vague variables and in used evaluation method.

We found that there were no application of the ANFIS during evaluation process of gifted individuals according to analyse of available article database (EBSCO, XERXES and Proquest). There are no articles worldwide concerning evaluation of gifted student via computer aided processing. The build-up model enables evaluation of many students from databases and makes the evaluation objective and unified. The ANFIS method outperformed evaluation process of gifted people by other methods mentioned in (Callahan and Renzulli 2012; Renzulli and Reis 2004; Hunsaker 2012) from this point of view.

Case study

The case study represents process of identification of students in the school subject from school classes.

We used three most important criteria Superior creativity, Logical thinking and Learning quality which has 5 levels (normalized scale A=1, B=2, C=3, D=4, E=5), where A is extraordinary level and E is inadequate level. The output Rate of Talent (RT) has 4 levels (A=1, B=2, C=3, D=4), where A is extraordinary level and D is inadequate level. The Fuzzy Interface Model Sugeno type was set up. See Fig.1.

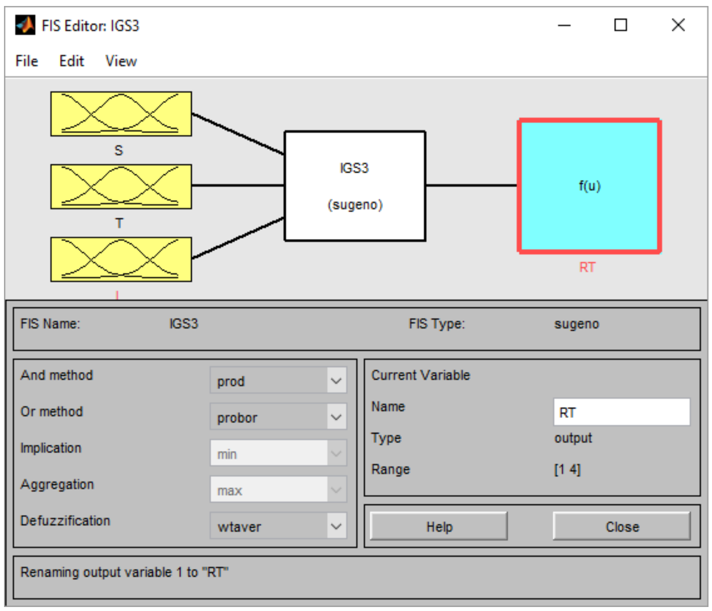


Fig 1. IGS Model

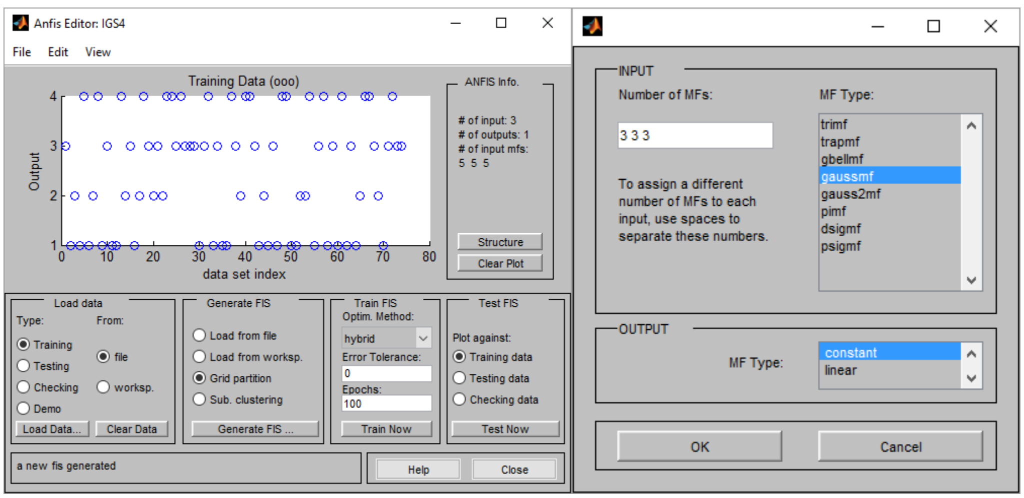
The data from research were used. See Table 1.

Table 1: Source data

No.	S	T	L	RT	No.	S	T	L	RT
1	3	3	3	3	38	3	3	3	3
2	2	2	2	1	39	2	2	3	3
3	2	2	3	2	40	4	4	3	1
4	2	2	2	1	41	4	4	4	3
5	4	4	4	4	42	3	3	3	4
6	2	2	2	1	43	2	2	2	1
7	3	2	3	2	44	2	2	3	3
8	4	4	4	4	45	2	1	1	1
9	2	2	2	1	46	3	3	3	1
10	3	3	4	3	47	2	2	2	4
11	2	2	1	1	48	4	4	3	3
12	2	2	2	1	49	4	5	4	2
13	4	4	4	4	50	3	3	1	4
14	2	2	3	2	51	1	2	2	4
15	3	2	4	3	52	2	3	3	3
16	2	3	2	1	53	1	2	3	1
17	2	2	3	2	54	4	4	3	2
18	5	5	3	4	55	1	1	1	1
19	4	3	3	3	56	4	3	4	3
20	3	2	3	2	57	4	4	3	1

21	3	3	4	3	58	2	2	2	4
22	3	2	3	2	59	3	3	4	4
23	4	4	3	4	60	1	2	1	1
24	5	5	5	4	61	4	4	4	1
25	3	3	3	3	62	2	2	2	2
26	4	4	4	4	63	3	3	4	2
27	3	4	3	3	64	2	2	2	4
28	3	3	4	3	65	2	2	3	1
29	4	3	3	1	66	5	5	3	3
30	2	2	2	2	67	4	4	3	4
31	3	3	4	1	68	3	3	3	1
32	5	5	5	4	69	3	2	3	3
33	2	2	2	1	70	2	2	2	1
34	4	3	3	2	71	3	3	2	4
35	1	2	2	4	72	5	5	5	1
36	2	2	2	1	73	3	3	3	3
37	4	4	3	3	74	3	3	3	1

The parameters of model was setup: Gauss membership fuctions, three terms and 100 training epochs. See Fig.2.



a) b)

Fig 2. Parameters of model

The calculation leads to following results. The training error is equal to zero after 100 epoch of training, which means good fitted neural network. See Fig.3. The structure of ANFIS model is presented on Fig.4.

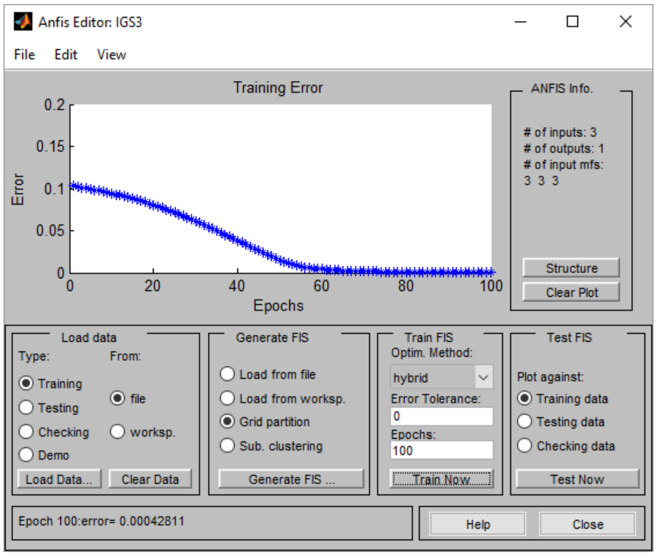


Fig.3. ANFIS Editor

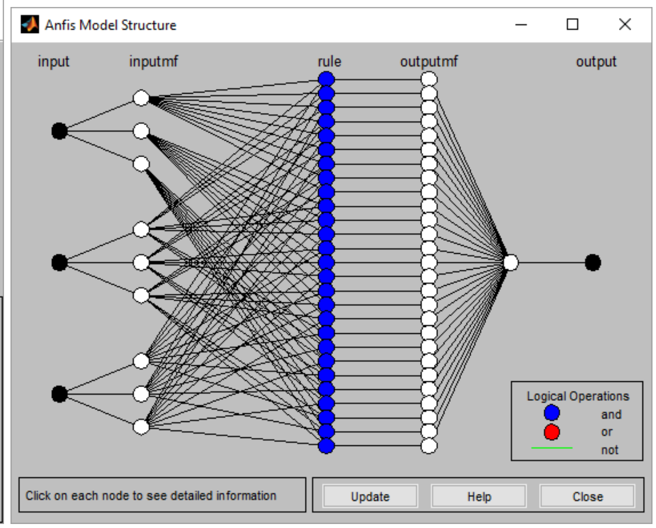
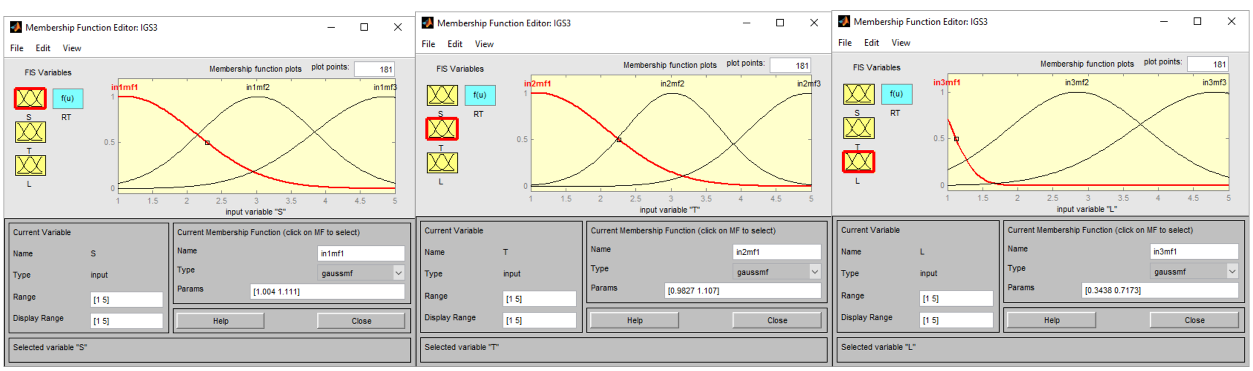


Fig.4. ANFIS Model Structure

The shape and position of membership functions were set up during the calculation for input S,T,L. See Fig.5a,b,c.



a) S b) T c) L

Fig 5. Membership functions

The otput is presented on Fig.6.

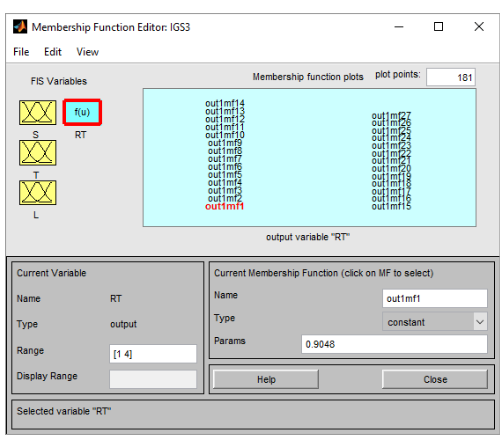


Fig 6. The output RT

The rules were set up during calculation such as:

If (S is in1mf1) and (T is in2mf1) and (L is in3mf1) Then (RT is out1mf1)

If (S is in1mf1) and (T is in2mf1) and (L is in3mf2) Then (RT is out1mf2)

If (S is in1mf1) and (T is in2mf1) and (L is in3mf3) Then (RT is out1mf3)
If (S is in1mf1) and (T is in2mf2) and (L is in3mf1) Then (RT is out1mf4)

and some others. See Fig 7.

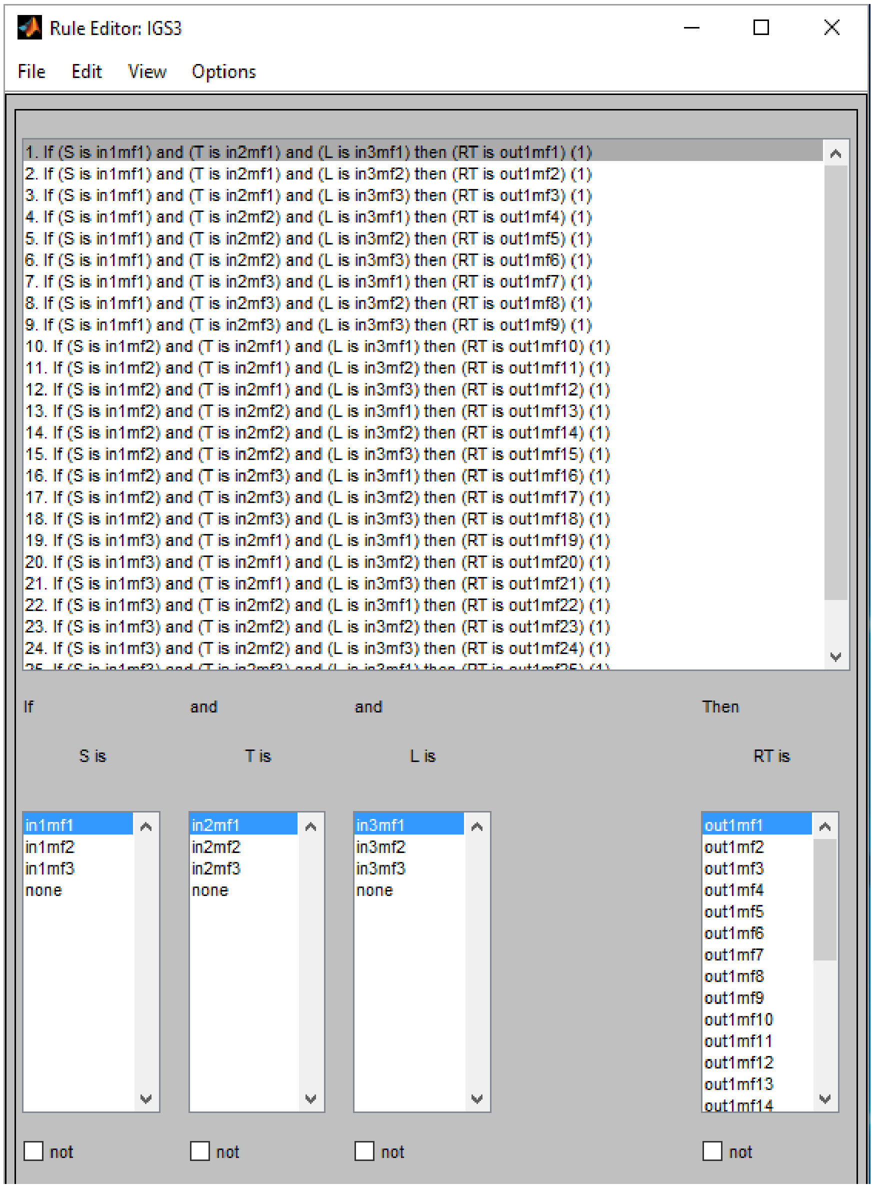
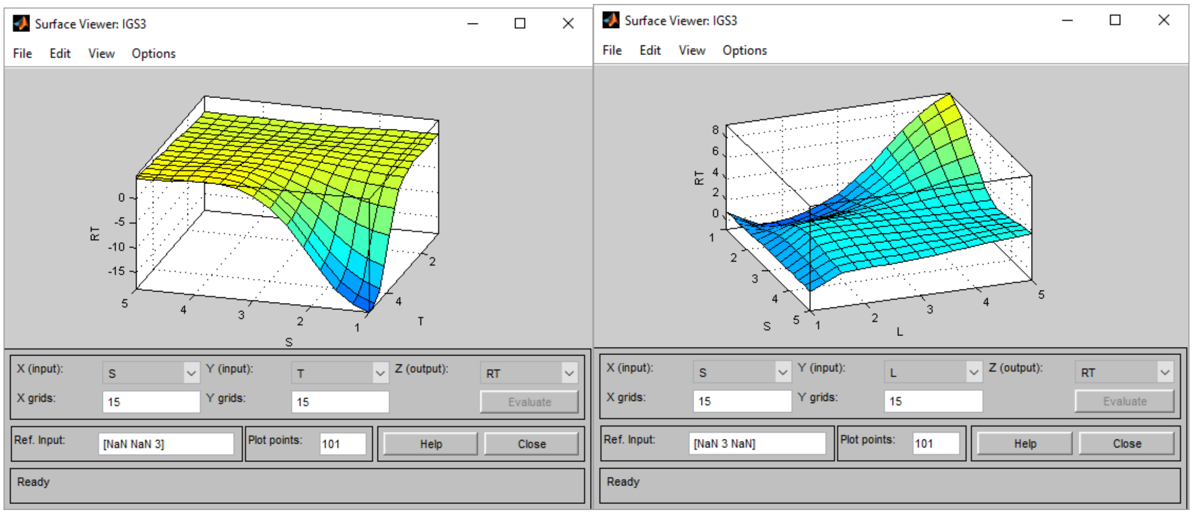


Fig. 7. Fuzzy rules

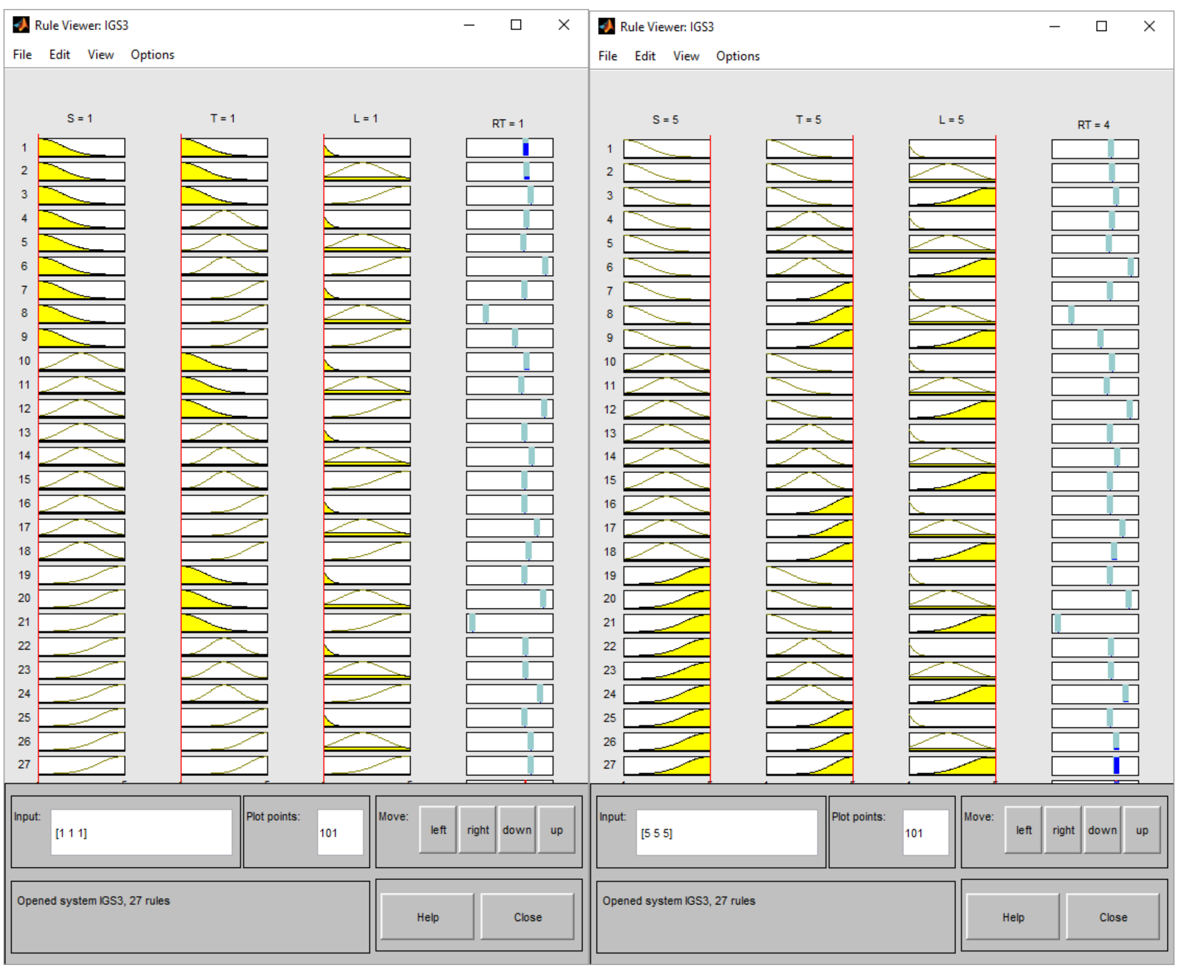
The dependence RT=f(S,T) and RT=f(S,L) makes good conformity with reality. See Fig.8a,b.



a) RT=f(S,T) b) RT=f(S,L)

Fig 8. Surface viewer graph

The rule viewer gives good match. If S, T, L = 1 then RT = 1, if If S, T, L = 5 then RT=4. See Fig.9.



a) b)

Fig 9. Rule viewer

The first example is represented by students from group with high level of talent demonstrated criteria of giftedness. They have an excellent Superior creativity, Logical thinking and Learning quality than their peers. The second example is represented by students from group with low level of talent demonstrated criteria of giftedness. They have bad Superior creativity, Logical thinking and Learning quality than their peers. The model will be spread for additional inputs in future.

It was evaluated many students and it results in following proportions: The Rate of Talent (RT) A level reaches 33.8%, B level reaches 16,2%, C level reaches 25,7% and D level reaches 24,3% students. The results serves to create the groups according their level of talented for their specific education.

Conclusion

In this article we presented the process of identification of gifted students in the school subject from ordinary school classes. Students were identified with three criteria via ANFIS model: Superior creativity, Logical thinking, Learning quality, in which the class teacher evaluated all students in three criteria, where A was extraordinary level and E inadequate level. We didn´t use "additive model", which is applied in many evaluation process, because of inappropriately compensation of each results of evaluation process. The model will be spread for additional inputs in future.

For evaluating results from three different criteria we used the ANFIS. The method allowed to clear identification of larger number of data without compensation of variables. This computing method is very suitable for mentioned purposes and it leads to higher quality of analyses and identification of students and educational process themselves. The model is used for routine identification.