A Decision Support System using ANFIS to Determine the Major of Prospective Students in A Vocational School of Indonesia

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Abstract— *A decision support system (DSS) plays an important role in accurately determining optimal solutions or decisions in a variety of ways, including the activity of selecting most appropriate major for prospective students. This work aims to develop a computer-based DSS the most appropriate major using Adaptive Neuro-Fuzzy Inference System (ANFIS) based on the following determinant variables, the first is national exam scores (mathematics, Bahasa Indonesia, English, and Natural Science); the second, Interesting to the majors (prospective-students choice); and the third, test question scores. The results show that the computer-based DSS has worked properly, effective and accurate to determine major of the prospective student in a vocational school.*

Keywords— *Decision support system, ANFIS, prospective student, vocational school, Indonesia.*

I. INTRODUCTION

A decision support system (DSS) plays an important thing regarding to the accuracy in determining optimal solutions or decisions in a variety of ways, and also in decision making process which are uncertain and complex [1], including the activity of selecting the best prospective student of vocational school, especially to determine the appropriate major for prospective student. DSS have two majors types, it based on multi-criteria decision-making (MCDM) methods, and it aims to obtain a set of optimal solutions based on multi-objective programming (MOP) methods [2]. Furthermore, Several methods of DSS have been reported by researchers, including fuzzy reasoning and AHP–FPP for the eco-design of products [2]; Component Analysis (PCA), K-means, and AdaBoost classification [3]; Fuzzy Decision Support System (FDSS) that comparing with IRRINET [4]; Sustainable Choice of Remediation (SCORE) MCDA-method for market-driven product positioning and design [5]; Simple Additive Weighting [6], [7]; association rule mining classification [8]. Specifically, DSS by using ANFIS also have been published in several publications, there are hybrid ANFIS for business failure prediction [9]; ANFIS that integrating with fuzzy goal programming for the evaluation and selection of six sigma projects [10]; ANFIS and linear discriminant analysis (LDA) used for prediction of risk assessment of coronary heart disease [11], determination automatically of diseases related to lymph system [12]; weather prediction application [13]; recognition of outer membrane protein [14]; predict flight delays [15]. ANFIS can keeps the physical means of fuzzy model and improves the accuracy in simulation of training and adjusting the parameters of the fuzzy model through the existing dataset [16].

Research finding to comparison study of ANFIS and other methods has been done, it compared with fuzzy neural network, ANFIS for DSS gives better results according to MSEs [17], but in another study, comparison ANN, ANFIS, and Fuzzy Inference System (FIS) for the effectiveness of an indirect evaporative cooling for (IEC) system, the ANN model gives the most accurate results using the training algorithm Levenberg–Marquardt (LM) [18]. Among the tree models of ANN (back-propagation algorithm (BPA), radial basis function network (RBFN) and ANFIS), ANFIS is the best for mentioned problem of predict fetal delivery [19]. Therefore, we conclude that the ANFIS models suitable for solving problems in the field of DSS. This work aims to develop a computer-based DSS to determine the appropriate major for prospective student for vocational school using Adaptive Neuro-Fuzzy Inference System (ANFIS) based on the following determinant variables, the first is national exam scores (mathematics, Bahasa Indonesia, English, and Natural Science); the second, Interesting to the majors (prospective student choice); and the third, test question scores.

The paper is organized as follows: Section II reviews the methods. Section III results and discussion, and Section IV is Conclusions.

II. METHOD

This section describes the methods that used in the proposed DSS using ANFIS to determine the appropriate major for the prospective student in vocational school.

ANFIS is belonging to a class of neural networks, but based on the same function with fuzzy inference system, and also hybrid learning rule algorithm which integrates the gradient descent method and the least square methods to train parameters [17]. The Basic structure of ANFIS with a feed-forward process for Sugeno-type is illustrated in Fig. 1.

Learning in neural networks with a number of data pairs useful for updating parameters of fuzzy inference system. ANFIS can construct with form *if-then rules*

and stipulated input-output data pairs [20]. ANFIS architecture based on model of Sugeno's type can be presented by two input *x* and *y*, *Ai* and *Bi* are fuzzy sets, and the outputs are *fi* with specified by *pi*, *qi*, and *ri* considered:

Rule 1: if (*x* is *A1*) and (*y* is *B1*),
then *f1* = (*p1x* + *q1y* + *r1*);

Rule 2: if (*x* is *A2*) and (*y* is *B2*),
then *f2* = (*p2x* + *q2y* + *r2*);

These rules are used to implement the ANFIS architecture that shown in Fig.1.

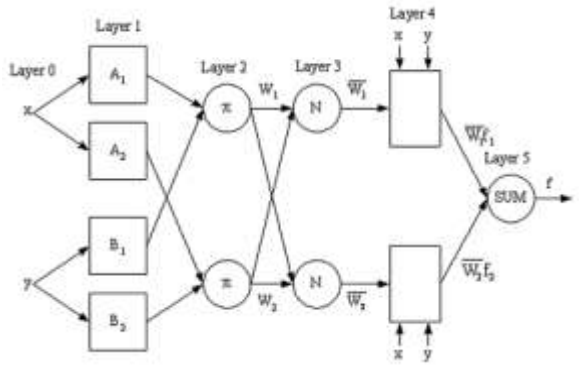


Figure-1. Basic ANFIS Structure [17]

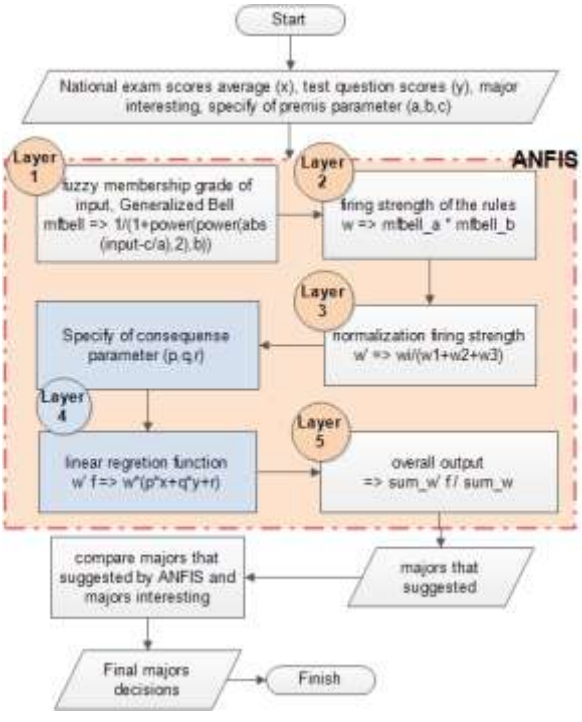


Figure-2. Flowchart DSS using ANFIS for vocational school selection

Some layers of ANFIS architecture can be combined, but the outputs that produced is same. The 1st Layer used for fuzzy membership grade of input, 2nd Layer has function for firing strength of the rules, 3rd layer normalization firing strength, 4th Layer consequent parameters, and 5th Layer used for overall output. All process to determine for the majors for prospective student are described by Fig. 2. 1st and 4th Layer are adaptive layers, and has three modifiable parameters [21].

III. RESULTS AND DISCUSSION

A. *Fuzzy membership grade of input*

To produce membership grade of input on 1st layer has given by (1) and (2). All the nodes are adaptive nodes.

$$O_{1,i} = \mu A_i(x), \quad i = 1,2, \tag{1}$$

$$O_{1,i} = \mu B_{i-2}(y), \quad i = 3,4, \tag{2}$$

Where $O_{1,i}$ is the membership degree of fuzzy set Ai or Bi and determine the degree of membership of the input x (or y). Membership function of the A parameters is given by bell shape (3).

$$\mu A_i(x) = \frac{1}{1+\{(\frac{x-ci}{ai})^2\}^{bi}} \tag{3}$$

In this work variable average of national exam scores and test questions scores are divided into three fuzzy sets (Fig. 3. and Fig. 4.)

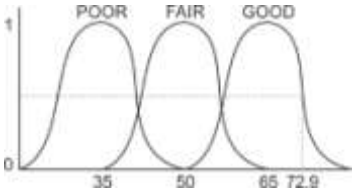


Figure-3. Fuzzy sets of national exam scores average

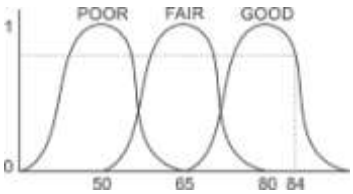


Figure-4. Fuzzy sets of test question scores

The fuzzification needed for the data before it process using neural models to ensure all input in fuzzy valuable. Fig. 5 shown that the syntax of bell function, it has four input parameters such as variable input values as well as a, b, and c as the parameter value premise on Bell function. Line 3 to 4 is a formula for calculating the membership functions using Bell.

```
1  function MFBell(input,a,b,c: real): real;
2  begin
3    Result:=1/(1+Power(Power(Abs(input-
4      c/a),2),b));
5  end;
```

Figure-5. Syntax of Bell function

B. Firing strength of the rules

For firing strength of the rules can be represented as (4). It process is done in second layer. The nodes are fixed, labeled with ∏, and perform as a simple multiplier to incoming signals and send the product out [12], and every node represents a linguistic label [16].

$$O_i^2 = w_i = \mu A_i(x)\mu B_i(Y), \quad i = 1,2 \tag{4}$$

Fig. 6. describes that the function have a parameter array type, that is *mf* as a membership value from the previous function results. Line 4 is the formula to calculate the firing strength.

```
1  function FiringStrength(mf: array[0..1] of
2     real): real;
3  begin
4    Result := mf[0] * mf[1];
5  end;
```

Figure-6. Syntax firing strength of the rules

C. Normalized firing strength

Normalized firing strength is processed on the third layer. Each node on this layer is labeled N, fixed nodes, indicating that it has the purpose of normalization for the firing strengths from a previous process (layer). Each node displays the normalized activation degree, given by (5).

$$O_i^3 = \bar{w}_i = \frac{w_i}{w_1 + w_2}, \quad i = 1,2 \tag{5}$$

The function in Fig.7. describes that the normalized firing strength has two parameters, namely *wx* as firing strength value on the specified index, and *w[i]* is an array variable as all of firing strength value. Line 4 is a formula for calculating the normalized firing strength.

```
1  function NormFiringStrength(wx: real, w:
2     array[0..1] of real): real;
3  begin
4    Result := wx / (w[0] + w[1]);
5  end;
```

Figure-7. Syntax of normalized firing strength

D. Consequent parameters

The consequent parameter is a process in the fourth layer. Each node in this layer are adaptive nodes. The output of this layer given by (6). Where *pi*, *qi* and *ri* are design parameter [21] .

$$O_i^4 = \bar{w}_i f_i = \bar{w}_i(p_i x + q_i y + r_i), \quad i = 1,2 \tag{6}$$

```
1  function LinierRegretion(w,x,y,p,q,r: real):
2     real;
3  begin
4    Result := w * (p*x + q*y + r);
5  end;
```

Figure-8. Syntax of linear regression function

The function (Fig. 8.) has six parameters, there are, where *w* is firing strength values of the normalized results in previous function, *x* and y are the variable input, and also *p*, *q*, and *r* are the consequent parameter values. Line 4 is the formula to calculate the linear regression

TABLE I. THE DATA SET SAMPLE TEST

National exam scores		Interest to the majors (choice by prospective student)		Test questions score (number of correct answers)	
No. registration			***100***		
Mathematics	55	1st	Engineering	Accounting	40
Bahasa Indonesia	68	2nd	Accounting	Office adm.	100
English	71			Marketing	30
Natural science	60			Multimedia	95
Average	63.5			Engineering	70
No. registration			***101***		
Mathematics	62	1st	Engineering	Accounting	30
Bahasa Indonesia	73	2nd	Office Adm.	Office adm.	30
English	63			Marketing	60
Natural science	67			Multimedia	30
Average	66.25			Engineering	60
No. registration			***102***		
Mathematics	93	1st	Marketing	Accounting	40
Bahasa Indonesia	77	2nd	Multimedia	Office adm.	25
English	61			Marketing	70
Natural science	92			Multimedia	95
Average	80.75			Engineering	60
Etc.	*Etc.*	*Etc.*	*Etc.*	*Etc.*	*Etc.*

E. Overall output

The output function is only single layer on the fifth layer (labeled with SUM), which is the output as a summation of all incoming signals, the output is given by (7).

$$O_i^5 = \sum_{i=1}^{2} w_i f_i = \frac{\sum_{i=1}^{2} w_i f_i}{w_1 + w_2} \tag{7}$$

The function in Fig. 9. has two parameters, where *sum_wf* as linear regression values of previous

function results, and *sum_w* as the summation of the firing strength values. Line 3 is a formula to calculate the output.

```
1  function Output(sum_wf,sum_w: real): real;
2  begin
3    Result := sum_wf / sum_w;
4  end;
```

Figure-9. Syntax of output function

F. System testing results

The black box test used for testing the system functionality with input the following variables :

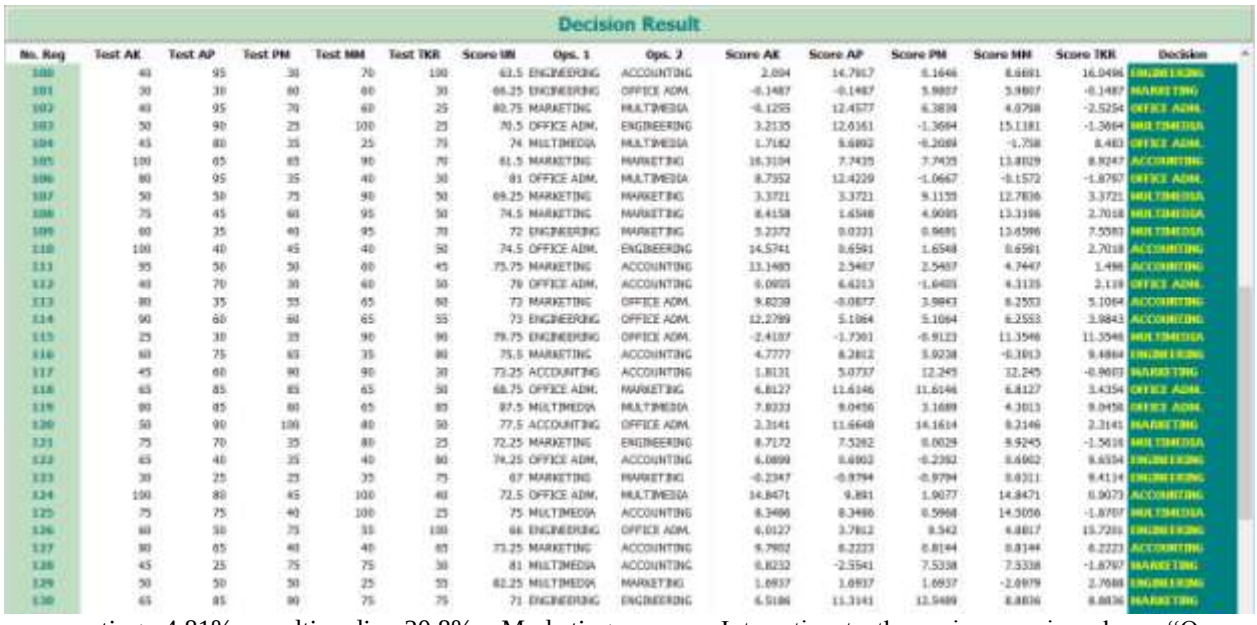
- National exam scores, consists of: mathematics, Bahasa Indonesia, English, and Natural Sciences;
- Interesting to the majors (example: 1st choice is Engineering, and 2nd Choice is Accounting); and
- Test questions scores, which consists of field: Accounting, Office Administration, Marketing, Multimedia, and Engineering.

Tha sample dataset shown on Table 1, and a summary test of results for each prospective student is shown in Fig. 10., it describes the summary results test prospective student with register number 100. that describes the all percentage majors test results, accounting 4.81%, multimedia 20.8%, Marketing 0.39%, Office administration 35.49%, and engineering 38.51%. So, the major decision for prospective student who has registered no 100 is Engineering.

Figure-10. Pie chart of ANFIS

The Fig.11. is a sample dataset displayed by the system that given the information about:

- No. Reg.: Registration number of the prospective student.
- Test questions scores, which consists of field in column: 1) Test AK = Accounting, 2) Test AP = Office Administration, 3) Test PM = Marketing, 4) Test MM = Multimedia, and 5) Test TKR = Engineering.
- National exam score average by column "Score UN".



- Interesting to the majors are in column "Ops. 1" for 1st choice, and "Ops. 2" for 2nd Choice.
- Test questions scores are calculate by ANFIS, which consists of field in column: 1) Score AK = Accounting, 2) Score AP = Office Administration, 3) Score PM = Marketing, 4) Score MM = Multimedia, and 5) Score TKR = Engineering.

Figure-11. Screen shot of ANFIS test results by system

- Column decision is the results of determined majors by ANFIS based on highest score of results. The results can be:
    - Same with the prospective student choices (Ops. 1 or Ops. 2)
    - Alternative majors will be given by system, if no one of choices by prospective student have highest scores.

The Bar chart (Fig.12) shown the results summary of the determination by ANFIS. Each block of bar chart shown the summary of majors that choice by 130 of prospective student (PS), consists of 1st major interesting, 2nd major interesting, and major determine by ANFIS.

Engineering major has 1st choice by 12 prospective student, 2nd choice by 10 PS, and 9 PS is determined by ANFIS to choice engineering major. Marketing major has 1st choice by 11 PS, 2nd choice by 11 PS, and 9 PS is determined by ANFIS to choice Marketing major. Office Administration major has 1st choice by 8 PS, 2nd choice by 7 PS, and 9 PS is determined by ANFIS to choice Office Administration major. Multimedia major has 1st choice by 11 PS, 2nd choice by 11 PS, and 9 PS is determined by ANFIS to choice Multimedia major. Accounting major has 1st choice by 9 PS, 2nd choice by 12 PS, and 15 PS is determined by ANFIS to choice Accounting major.

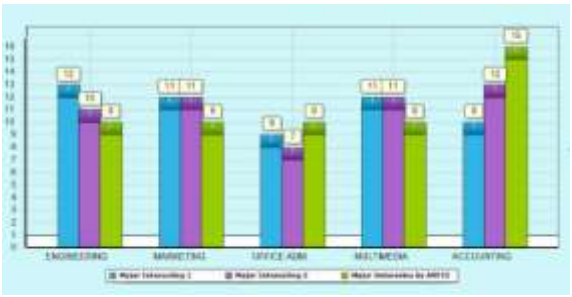


Figure-12. Screen shot of test results summary

IV. Conclusion

The conclusions of this work are as follows:

- ANFIS can used for Decision Support System (DSS) to determine major prospective student of vocational school. ANFIS function in this DSS system is to determine the ranking major that appropriate for prospective student
- The final result depends on weight that given to the national exam scores variable and weight of test question scores.

The major decision based on ANFIS highest score. The results of decision can be: a) Same with the prospective student choices (Ops. 1 or Ops. 2); b) Alternative majors will be given by system, if no one of choices by prospective student have highest scores

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