Computational Model of Student Competency Analysis in Fuzzy Topsis Method

by Agus Nursikuwagus

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A Nursikuwagus1, L Melian2, and D Permatasari3
1,2,3Information System Dept., Indonesia Computer University, Bandung-Indonesia

Abstract. In this research is proposed predicting student level competence in sustainability learning through vocational schools. Measuring student competence can use statistical method or intelligent computing process. One method in intelligent computing process is Fuzzy Topsis. Existing problem in this research is every process on evaluation student competence is calculated by average measure or mean measure. In enrolment Fuzzy Topsis, some variables are needed such as report, psycho-test, and teacher recommendations. Result of this research is level of student competency majors in vocational schools. Using the data for 270 students, precision test has calculated 75.60% and recall test has 96%. This percentage is gained by calculate confusion matrix that differentiate between competence and not competence students. Impact of this research is competency process will be efficient and effective if the process using Fuzzy Topsis or other Fuzzy method. Besides that, measuring competency can be simple and dynamic than conventional method that used only averaging value.

Introduction

In intelligence process, process is divided into two computing process that there are hard computing and soft computing method. Forming method in intelligence process is method dominantly by soft computing process. Hence, using of soft computing method is the direct to solve problem in Data Mining concept. Processing data in intelligence process is making precision and valid to interpret pattern of context. It is hard to solve the problem using hard computing. It caused by hard computing is using traversal method and fire match one by one to gain the solution. It is one reason why hard computing is rarely used in many research.

Challenging application in data mining process is measure student competency level at Vocational School. It is activity to separate student who has competency in appropriate skill. Many processes have succeeded to make decisions using Data Mining method. One of challenging process in data mining is mining information from collecting student information about competency. Predicting student competency is to be important to prepare alignment between student and major.

Many papers have revealed from many researcher about Fuzzy Topsis. They are explaining about Fuzzy Topsis in several activities. Concept mining in Fuzzy Topsis has proposed by [1-7]. However, Mahmud Yavuz [8] has explained about applying Fuzzy Topsis in selection equipment problem. This research has been completed by Fuzzy Topsis in measuring student competence level that is competence for registering at Vocational School. This research is accomplished at one Vocational School in Indonesia.

2. Methodology

2.1. Fuzzy Topsis Method

Fuzzy Topsis method has proposed by Hwan and Yoon [] to solve problem in MCDM (Multiple Objective Decision Making) process. Fuzzy Topsis is the ideal choice solution. Fuzzy Topsis has had simple formal mathematics concepts, and strategy to accomplish their process. This strategy is directed to step forward as follows normalized matrix decision, weighted normalized matrix, gain positive and negative solution matrix, distance between positive and negative solution, gain preference value for each alternative. Process in Fuzzy Topsis is needed a performance in rating for each alternative and criteria.

2.1.1. Created Normalized Matrix or Relation Matrix

Normalized Matrix is value that ordered in row and column. Normalized matrix is composed from relation between parameters therein. We have constructed normalize matrix by formula below.

$r_{ij}=x_{ij}\left[\sum_{i=1}^{m} x_{ij}^{2}\right]^{-\frac{1}{2}}$; i=1,2,…,m and j=1,2,…,n (1)

r is item in row i and column j ; x is every value in parameters that composed by rows 1 to i and columns 1 to j.

2.1.2. Gaining Weighted Normalized Matrix

Weighted normalized matrix is an integer value to give weight for each parameter. This design is tailored by human perception about concern for each parameter. An example, if the research design has five parameters, we can write value for five weighted and write as vector matrix as below:

$$w_{[ij]}=\left[x_{[ij]} \times r_{[ij]}\right] \qquad i = 1,2,\ldots,m \ ; j = 1,2,\ldots,n \tag{2}$$

2.1.3. Gaining Positive and Negative Solution Matrix

Step forward after obtain weighted value is enrolling positive and negative solution matrix. We have created a notation to separate value between positive solution (A +) and negative solution (A-). In this step Fuzzy Topsis used normalize weighted matrix to make rating (Yij). This formula can be written as follow:

$y_{ij}=w_i r_{ij}$ with i=1, 2, …, m; and j=1, 2, …, n (3)

$A^{+}=\left(y_1^{+}, y_2^{+}, \ldots, y_n^{+}\right)$ (4)

$A^{-}=\left(y_1^{-}, y_2^{-}, \ldots, y_n^{-}\right)$ (5)

$$y_j^{+}=\begin{cases}\max_i y_{ij} & \text{;if j is beneficiary attribute}\\ \min_i y_{ij}; & \text{if i is cost attribute}\end{cases} \tag{6}$$

$$y_j^{-}=\begin{cases}\max_i y_{ij} & \text{;if j is beneficiary attribute}\\ \min_i y_{ij} & \text{; if i is cost attribute}\end{cases} \tag{7}$$

2.1.4. Distance between Positive and Negative Solution

Solution for each rating can be stated between alternative and ideal solution. Formulating the distance can be written as below:

Distance between Ai and positive ideal solution D_i^{+} :

$$D_i^{+}=\left[\sum_{j=1}^{n} y_i^{+}-y_{ij}\right]^{\frac{1}{2}};\ i=1,2,\ldots,m. \tag{8}$$

Distance between Ai and negative ideal solution D_i^{-} :

$$D_i^{-}=\left[\sum_{j=1}^{n} y_i^{+}-y_{ij}\right]^{\frac{1}{2}};\ i=1,2,\ldots,m \tag{9}$$

2.1.5. Gaining preference value for each alternative

In step forward after distance measuring, we calculate preference value for each (Vi). Formulating preference can be written as follow:

$V_i=D_i^{-}\left[D_i^{-}+D_i^{+}\right]^{-1}$; i=1,2,…,m. (10)

Rating (Vi) will be shown as high competency in major alternative selected (Ai) that have higher preference than the other.

2.2. Precision and Recall

Step forward from gaining rating is the validation of the formula that is suitable for that case. We used precision and recall that method has significant to problem. Precision and recall that have used are defined from []. We used a formula that can be seen at below:

$$\text{Recall}=\text{TP}\,[\text{TP}+\text{FN}]^{-1} \tag{11}$$

$$\text{Precision}=\text{TP}\,[\text{TP}+\text{FP}]^{-1} \tag{12}$$

Calculating precision and recall can be composed by confusion matrix. Confusion matrix is composing value gained from how many result is corrected with real condition. We can construct confusion matrix at table 1.

Table 1. Composition Confusion Matrix

	Condition : A	Not A
Test says accepted A	True positive (TP)	False positive (FP)
Test says accepted not A	False negative (FN)	True negative (TN)

3. Result and Discussion

3.1. Result

In this research, we have used 270 rows of data. We have from observed to the field. At vocational school in Indonesia, every school has regulation to accept their student. Prerequisite has to be achieving from every student and accepting students have to pass examine. There are several parameters that have fulfilled by candidate. These parameters are obtained from the school regulation such as national exam, psychology test, interview, grade report, body test, competency test. These parameters that have been calculated are processing by Fuzzy Topsis.

3.1.1. *Examples*. The Following example is showing data rows that have taken from observation. Showing the process, we only show 5 data rows as sample. At Table 2, an example data rows with parameters therein.

Table 2. An Example 10 data rows that have gained from survey at Vocational School

No	Name	National Exam	Competency	Grade Report	Body Test	Interview	Psychology Test
		(x1)	(x2)	(x3)	(x4)	(x5)	(x6)
1	Dadang Wasisto	30.74	83.33	79.84	80.00	85.00	50.00
2	Tri Andi Kusumah	28.21	73.33	79.52	80.00	85.00	80.00
`3	Ani Suryani	31.66	83.33	79.16	70.00	65.00	80.00
4	Winny Fitriani	25.62	63.33	79.04	70.00	65.00	50.00
5	Rika Silvia	27.67	66.67	77.68	70.00	65.00	80.00

3.1.2. *Normalized Matrix*. Step first in Fuzzy Topsis is gaining normalized matrix. We will showing result after calculated every value at Table 2. Look at Table 3, we used formula (1) to gain relation matrix or normalized matrix.

Table 3. A result from calculating normalized matrix by formula (1) as relation matrix r_{ij}

No	Name	x1	x2	x3	x4	x5	x6
1	Dadang Wasisto	2.04	5.73	4.91	5.12	5.73	2.10
2	Tri Andi Kusumah	1.72	4.44	4.87	5.12	5.73	5.38
3	Ani Suryani	2.16	5.73	4.83	3.92	3.35	5.38
4	Winny Fitriani	1.41	3.31	4.81	3.92	3.35	2.10
5	Rika Silvia	1.65	3.67	4.65	3.92	3.35	5.38

At Table 3, acquisition of the test score is obtained from the use of formula (1). The value in column x1, obtained by calculating x[1,1] value at Table 2 divided by the root of the number of values in column x1. So the value obtained is for r[1,1] is 2.04. An example calculation is performed as follows:

$$r_{[1,1]} = x_{[1,1]} \left[\sum_{i=1}^{270} [x_{[i,1]}]^2 \right]^{\frac{1}{2}} = r_{[1,1]} = 30.74 \; [\,[30.74]^2 + [28.21]^2 + \ldots + [33.22]^2\,]^{\frac{1}{2}} = 2.04$$

3.1.2. *Gain Weighted Normalized matrix*. Every weight in [i,j] is got from times x[i,j] and r[i,j]. Following table 4 is an example determines weighted value. At Table 4 is resulted from executing formula (2).

Table 4. An example result is calculated weighted normalized matrix. Y symbol is parameter that has calculated to weighted normalized matrix.

No	Name	(Y1)	(Y2)	(Y3)	(Y4)	(Y5)	(Y6)
1	Dadang Wasisto	62.60	477.51	392.10	409.53	487.10	105.05
2	Tri Andi Kusumah	48.39	325.41	387.40	409.53	487.10	430.27
3	Ani Suryani	68.45	477.51	382.16	274.36	217.82	430.27
4	Winny Fitriani	36.24	209.62	380.43	274.36	217.82	105.05
5	Rika Silvia	45.68	244.49	361.13	274.36	217.82	430.27

At Table 4, the result is gained from calculating weighted with formula (2). As an execution, process is following like:

$$w_{[1,1]} = x_{[1,1]} \times r_{[1,1]} = 30.74 \times 2.04 = 62.60 \; ; \text{For column Y1}$$

We are going to end of row until 270 in column Y1. For Y2 until Y6 is same process like Y1.

3.1.3. *Gaining Positive and Negative Solution Matrix*. Step forward after receive weighted normalize matrix is calculating solution in positive and negative respectively. We have use formula (3) to collect be A+ (alternative positive) and A- (alternative negative). A+ and A- are collecting in one matrix is called $y^+_{[j]}$ and $y^-_{[j]}$. A result for A+ and A- can be seen as follow:

$$y^+_1 = \max[\text{column(Y1)}] \; ; y^+_2 = \max[\text{column(Y2)}]$$
$$y^+_3 = \max[\text{column(Y3)}] \; ; y^+_4 = \max[\text{column(Y4)}]$$
$$y^+_5 = \max[\text{column(Y5)}] \; ; y^+_6 = \max[\text{column(Y6)}]$$

$$A^+ = \left[y^+_{[1]} ; y^+_{[2]} ; \ldots ; y^+_{[6]} \right] = [79.01 ; 784.57 ; 549.01 ; 583.11 ; 487.10 ; 430.27]$$

$$y^-_1 = \min[\text{column(Y1)}] \; ; y^-_2 = \min[\text{column(Y2)}]$$
$$y^-_3 = \min[\text{column(Y3)}] \; ; y^-_4 = \min[\text{column(Y4)}]$$
$$y^-_5 = \min[\text{column(Y5)}] \; ; y^-_6 = \min[\text{column(Y6)}]$$

$$A^- = \left[y^-_{[1]} ; y^-_{[2]} ; \ldots ; y^-_{[6]} \right] = [13.84 ; 22.28 ; 157.91 ; 99.98 ; 217.82 ; 105.05]$$

3.1.4. *Distance between Positive and Negative Solution.* Distance is counting how far differ between positive and negative solution. Computing distance is used formula (8) and (9). We used D symbol for symbolizing distance. D^+ for solution distance + and D^- for solution distance negative. At below shows an example execution from formula (8) and (9).

$$D_i^+ = \left[\sum_{j=1}^{6} y_j^+ - y_{[i,j]}\right]^{\frac{1}{2}} \quad ; \quad D_i^- = \left[\sum_{j=1}^{6} y_{[i,j]} - y_j^+\right]^{\frac{1}{2}}$$

$$D_1^+ = \left[\left(y_1^+ - y_{[1,1]}\right) + \left(y_2^+ - y_{[1,2]}\right) + \ldots + \left(y_1^+ - y_{[1,6]}\right)\right]^{\frac{1}{2}} = [(79.01-62.60)+(784.57-477.51)+\ldots+(430.27-105.05)]^{\frac{1}{2}} = 31.29$$

$$D_1^- = \left[\left(y_{[1,1]} - y_1^-\right) + \left(y_{[1,2]} - y_2^-\right) + \ldots + \left(y_{[1,6]} - y_6^-\right)\right]^{\frac{1}{2}} = [(62.60-13.84)+(477.51-22.28)+\ldots+(105.05-105.05)]^{\frac{1}{2}} = 8.81$$

Table 4. An Example result positive solution

A	Name	Y1	Y2	Y3	Y4	Y5	Y6	D_i^+
1	Dadang Wasisto	16.41	307.06	156.91	173.57	0.00	325.22	31.29
2	Tri Andi Kusumah	30.62	21.43	161.61	173.57	0.00	0.00	19.68
3	Ani Suryani	10.57	17.52	166.84	308.75	269.28	0.00	27.80
4	Winny Fitriani	42.77	23.98	168.58	308.75	269.28	325.22	33.74
5	Rika Silvia	33.33	23.24	187.88	308.75	269.28	0.00	28.68

Table 5. An Example result negative solution

A	Name	Y1	Y2	Y3	Y4	Y5	Y6	D_i^-
1	Dadang Wasisto	6.98	21.34	15.30	17.59	16.41	0.00	8.81
2	Tri Andi Kusumah	5.88	17.41	15.15	17.59	16.41	18.03	9.51
3	Ani Suryani	7.39	21.34	14.98	13.21	0.00	18.03	8.66
4	Winny Fitriani	4.73	13.69	14.92	13.21	0.00	0.00	6.82
5	Rika Silvia	5.64	14.91	14.26	13.21	0.00	18.03	8.13

3.1.5. *Gaining preference value for each alternative.* Finalization process is determining preference value for each alternative. Preference is gained from formula (10). We count every alternative from A1 until A270. An example execution formula (10) can be seen as follow:

$$V_1 = D_1^- [D_1^- + D_1^+]^{-1} = 8.81\ [8.81 + 31.29]^{-1} = 0.220 \ ; \text{Preference for alternative A1}$$

Table 6. An Example preference in every alternative A

A	Name	D_i^+	D_i^-	V_i
1	Dadang Wasisto	31.29	8.81	0.220
2	Tri Andi Kusumah	19.68	9.51	0.326
3	Ani Suryani	27.80	8.66	0.237
4	Winny Fitriani	33.74	6.82	0.168
5	Rika Silvia	28.68	8.13	0.221

3.2. *Discussion*

Fuzzy Topsis has a simple execution in process. Every step is only execution following the formula. Subsection before, has proven that Fuzzy Topsis has given simplicity calculation. Values at the table have shown strictly computation with numeric manner. At table 4, information that content at the table 4 is real value. We have taken from survey at Vocational School in Indonesia. Not all data we are taking, because of limitation in time. We are just to prove steps in Fuzzy Topsis. We are thinking is the same in process. 270 data rows or more is the same of process. We are just considering effective algorithm to process bulk of data.

Measurement effectively process, we used precision and recall. In formula (11), we wrote formulation from []. At Table 7 shows a result from separation result in the context manner and result manner. We used confusion matrix to measure precision and recall.

Table 7. Confusion matrix from result

	Condition : Accepted	Not Accepted
Result accepted	TP = 192	FP = 8
Result Not accepted	FN = 62	TN = 8

$$Precision = TP\ [TP + FN]^{-1} = 192\ [192+62]^{-1} = 0.756$$
$$Recall = TP\ [TP + FP]^{-1} = 192\ [192+8]^{-1} = 0.96$$

In information retrieval, recall in the process is 0.96. It means that document we are used to have relevant 96% in Fuzzy Topsis. On the other hand, precision is 0.756 that is data rows only 75.6% alignment within the context.

Table 8. Result Comparation in Fuzzy Method within Precision and Recall as much as 270 data rows

Method	Precision	Recall
Fuzzy Mamdani []	75.63%	90%
Fuzzy Topsis	75.60%	96%

4. *Conclusion*

Implementation Fuzzy Topsis in measuring student competency is effective process. Simplicity in execution is making Fuzzy Topsis suitable for data rows that contents numeric values. In parameters therein such as national exam, competency, grade report, body test, interview, and psychology test are made success in predicting student competency. In 270 data rows, we conclude that fuzzy Topsis is able reach 75.60% in precision. In recall, Fuzzy Topsis reach almost 96%. Meaning of precision that Fuzzy Topsis can be executed and resulted 75.60% valid data, and meaning of recall that Fuzzy Topsis is able process in document as much as 96% significant document. Comparing with other Fuzzy Method, we have concluded that in Fuzzy term almost the same values in ranging 90% - 96% in Recall. Likewise in precision, the result has the same ranging between 75% - 77%. Overall, this research can be said that Fuzzy Topsis method can be executed with proper numeric value and parameter defines. Impact of this research is Fuzzy Topsis or other Fuzzy method. Besides that, measuring competency can be simple and dynamic than conventional method that used only averaging value.

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