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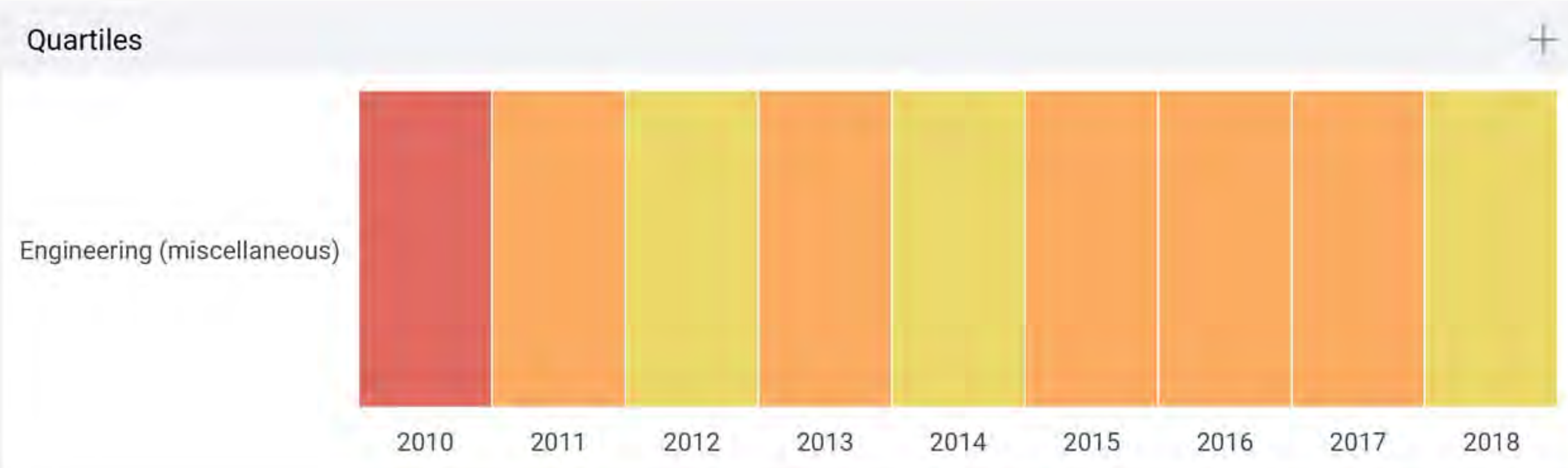
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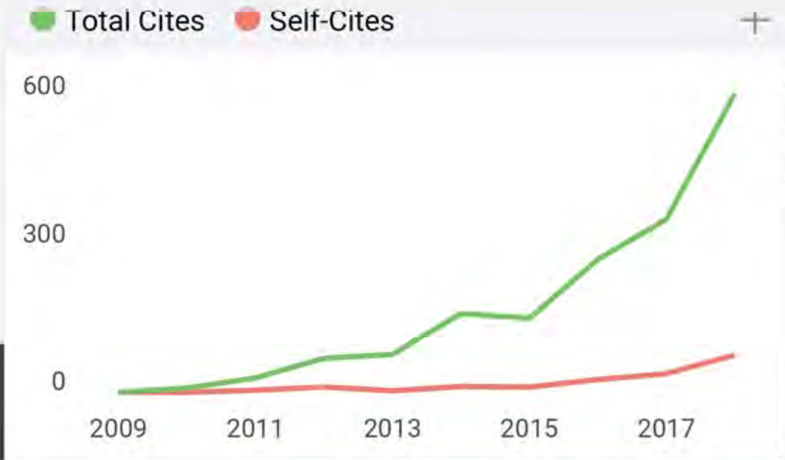
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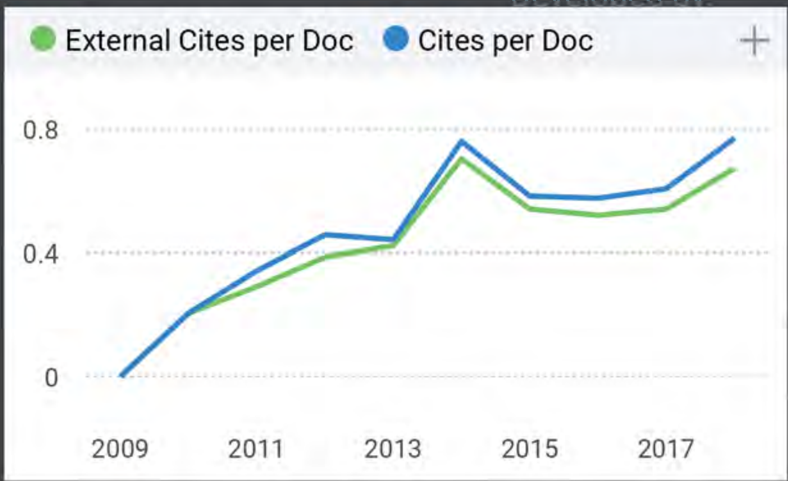
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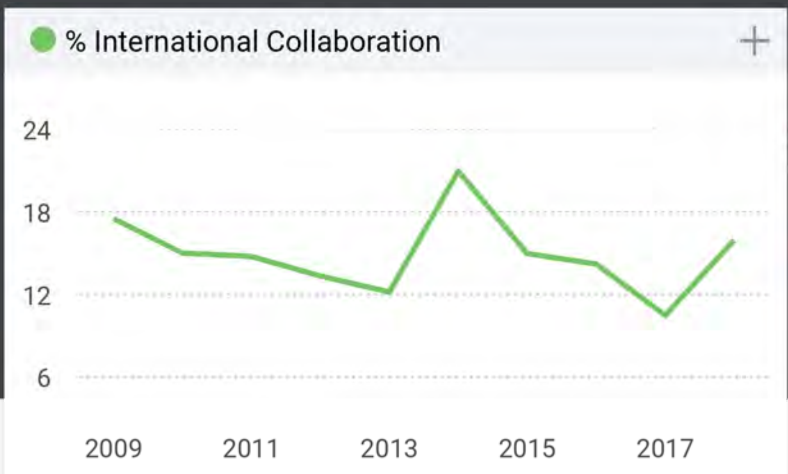
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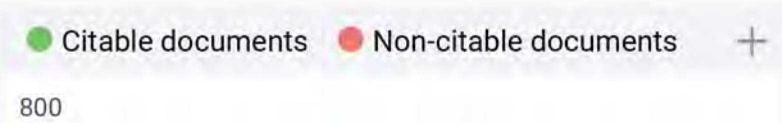
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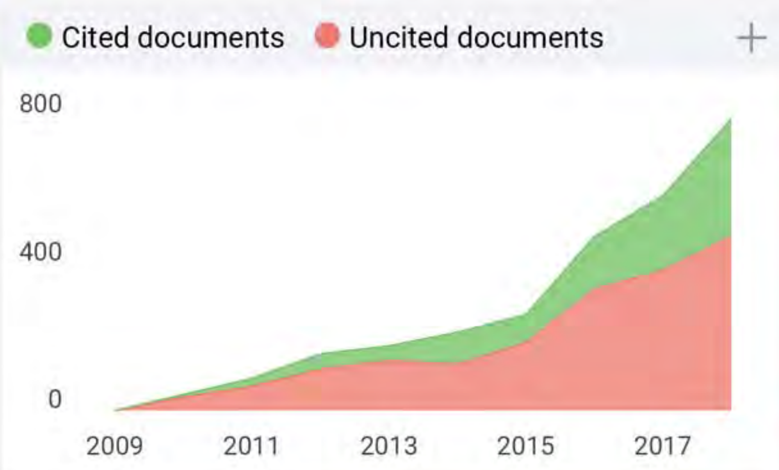

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EXTENDED FUZZY TOPSIS TO IMPROVE PREDICTION STUDENT ON SELECTION PROPERLY MAJORS AT VOCATIONAL SCHOOL

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Abstract

This research aimed to predictability students on every test as a prerequisite to enter the major. Fuzzy Topsis, with the criteria and alternative approaches, can be determined according to the problems applied. The problem in fuzzy Topsis is not provided classification in the last step when we obtained many predictions classification. Fuzzy Topsis was executed only to get rank in a case. In order to solve that problem, we added a function in the last step fuzzy Topsis-like rule base. The rule base was divided into four majors, such as software engineering, animation, networking, and multimedia. To complete the prediction, we introduced some criteria that deployed some assessments, such as final examination, competency test, report, physical test, interview, and psychological tests. The results obtained for the process precision were 59.2%, and recall acquired 60%. The reason why the precision and recall were not got a high value because the dataset was very short (over fit), and only 270 to process in extended fuzzy Topsis. Another reason was the preference of function that was not proper for the dataset and imbalanced data, and dataset centered in one favorite major that was network and *S/W* engineering.

Keywords: Accuration, Decision, Fuzzy Topsis, Membership function, Prediction.

1. Introduction

Fuzzy has an improvement to help the decision-maker in a sophisticated domain. Many prototypes fuzzy have applied in many fields. We have known a fuzzy theory that applied to the continuous value domain to solve the continuous problem. One of the fuzzy systems that have been widely used is fuzzy Topsis. In computational intelligence, we get two definitions, like soft computing and hard computing [1]. The soft computing method has developed computation techniques with various approaches; one of the approaches is fuzzy Topsis. The use of fuzzy has the advantage of handling computations with incomplete data samples [2, 3].

Research on fuzzy MCDM had been first carried out by other researchers. This study addressed the problem of decisions that often constrained because of goals, consequences, and accuracy. The merging of the MCDM model with the fuzzy model made a new proposal known as fuzzy multi-decision decision making (FMCDM). The advantage of this new model was to handle decisions with incomplete and uncertain knowledge and information. Problems in decisions often judge by evaluating natural human language where human expressions are often unclear and uncertain in meaning. To overcome this, Bellman and Zadeh designed a decision with fuzzy to express subjective judgments from humans. This study also provided a way to convert values from actual values to fuzzy values using mapping techniques in trapezium diagrams, triangles, or gaussian diagrams [4].

Many approach systems help to justify solutions. The prediction can be a model for continuity and decision of work. Many models that have developed based on fuzzy Topsis. One of the models is prediction or classification. In this research, we did not make a trivial process, but we applied the fuzzy Topsis on the real problem. We used the dataset taken from a survey on the school and collected its value to predict one student with their properties that probably accepted on their ability. After the fuzzy Topsis inference, we knew the candidate student was accepted or not. This works to support the decision-maker, and it made the process efficient in determining students who enter vocational schools. The study used several variables and weighted based on the level of importance for the selection needs. The final results in a study conducted by other researchers that were predictions of students who could enter vocational schools. With the use of a dataset of 270, obtained 75.60% of precision results and 96% of recall [5].

Adding functions to fuzzy Topsis is a tool to solve cases of classification or prediction. Normally, fuzzy Topsis has given results in the form of preference values or ranking of a sample [3]. When the rating value wants to upgrade to a classification of certain values, fuzzy Topsis cannot handle this. Some research proposed function to improve the Topsis [5, 6]. The problem in this research was the classification or prediction of vocational students for majors that match the background of their values. The contribution was given in this study was to add a function to the fuzzy Topsis method to obtain a classification or prediction on the sample being tested, while the purpose of this study was, to get predictions or classifications from vocational students to be included in the fields of interest that are in accordance with their values [6-8].

The problem was how the major process election in the school could be fair and efficient to obtain the student who wanted to enter one major. We proposed one model is fuzzy Topsis. We designed a model to be a compact system to answer the problem. On the predicted process, we used fuzzy Topsis inference to get the prediction. For the input variable, we designed all the input as a real value and for output as a discrete value.

The purpose of this research provided the analytical process of prediction for properly major in school. We proposed combine methods between fuzzy Topsis and rule base system. On the analytical processing in fuzzy Topsis and rule base, we acquired the results that accuracy was overcome 59.2% for the whole method. If we divided into part of the major, we got accuracy for *S/W* Eng that was 86%, the animation was 6%, multimedia was 37.2%, and networking was 52.2%. The results obtained did not support objectively because supported data had a constraint in amount. As the impact, we acquired the assessment from 270 samples were 59.2% inaccuracy. We had another challenge for improving the method that was not suitable in the case.

2. Related Works

Technique for Order Preference by Similarity to Ideal Solution (Topsis) is a very simple decision-making technique. The technique employed is to give weight to each fuzzy variable in doing its calculations [2]. For example, the first fuzzy Topsis [9] showed that the best results were the results closest to the specified criteria. This criterion calculated based on positive solutions and negative solutions using the most distance with the solution to be achieved [1]. A positive ideal solution was a solution that maximizes the benefit criteria and minimizes the cost criteria. Other reports described a technique to determine the final ranking of the system being operated [9].

Other studies, like weighting techniques, reported on Topsis that was prepared by considering the most important weights in decision-making. The variable nomination given was to define criteria and alternatives. Thus, decisions were more accurate. MCDM provided good techniques by giving weights as computable alternatives. The proposed method was to determine internal and external weights using mathematical modelling [6]. Another use of Fuzzy Topsis was decision making for alternative stock investments. Fuzzy Topsis used to check stocks to get optimal selection. Fuzzy Topsis showed positive work results in terms of performance, income, and risk for the selection of company fort polio [8]. The use of fuzzy Topsis for determining supply chains is by utilizing several variables such as logistics, transportation, turnaround time, and sales. Fuzzy Topsis used to handle efficient chains for the distribution of agricultural products. The results of using Fuzzy Topsis had successfully determined the supply chain of agricultural products [10].

3.Methods

In the research, we used a method that described the flow of the process. This method was a guideline for conducting the research to support a problem context. We arranged the stages from the initial process until the end of the process. We designed the flow of process like collecting the needs and aim the target, collecting and processing the data, designing the datasets, normalizing values, fuzzy Topsis process, rule base context, validation, and summarization. The method sequence can be seen in Fig. 1. We justified a limit of validation were 50% as a looping process until the process meets with the target [6].

Figure 1 is the research method followed to run out our step research from the requirement until summarization. We divided the diagram into three parts, and each part consisted of a subpart to handle the fuzzy domain. In the first part, we created the phase such as requirement, collect the data, making data structures, and normalization. In the second part, we deployed the main function like fuzzy Topsis inference, fuzzy rule base, and validation. The third part was summarization; we designed for the solution of the problem and gave the predicting class for the student. Following the fuzzy Topsis in the research [11], we designed some steps to deploy a prediction system. Fuzzy Topsis had several steps to justify the conclusion and a prominent step to answer the problem.

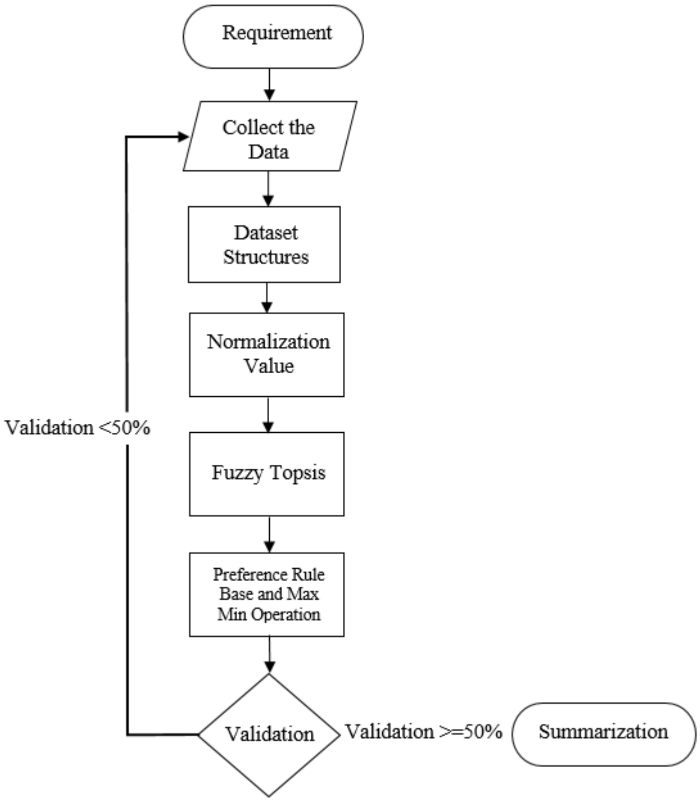

Fig. 1. The flow of research method.

3.1. Normalized matrix or relation matrix.

Normalized Matrix is a temporary dataset structure that composes in row and column by formula (1) [5, 7]. Normalize matrix was created by data definition on the dataset. Every value on the dataset transformed into a feature vector which predefined. The content of value was a numerical value that could be operated in the arithmetic model. The formula of normalize matrix can be written as below:

$$r_{ij} = x_{ij}\left[\sum_{i=1}^{m} x_{ij}^{2}\right]^{-\frac{1}{2}} \quad ; i = 1,2,\ldots, m \text{ and } j = 1, 2, \ldots, n \tag{1}$$

3.2. Weighted normalized matrix.

After being completed in normalized matrix, the continuous process was obtaining the weighted. The weighted matrix is a multiple of two values between the original value "*x*", the normalized value "*r*", and weighted value "*w*". The process runs every row, and the column starts from index *i* = 1 until m for rows and index *j* = 1 until *n* for column [6]. We have written for weighted at formula (2) below [7].

$$w_{[ij]} = \left[x_{[ij]} \ x \ r_{[ij]}\right] \qquad (2)$$

where *i* = 1, 2, …, *m*; and *j* = 1, 2, …, *n*.

3.3. Positive and negative solution matrix.

The forward process from section 3.2 is a given deal for positive and negative solutions. The step has also shown a matrix form. We gave a sign "+" for a positive solution and "-" for a negative solution. The positive and negative solution Positive is a different value among benefits and cost. The positive symbol solution is symbolized "*A+*" and negative solution "*A-*". The formula has written by [7].

$$y_{ij} = w_i r_{ij} \ ; \qquad (3)$$

where *i = 1, 2, …, m;* and *j = 1, 2, …, n*

$$A^{+} = (y_1^{+}, y_2^{+}, \dots, y_n^{+}) \qquad (4)$$

$$A^{-} = (y_1^{-}, y_2^{-}, \dots, y_n^{-}) \qquad (5)$$

$$y_j^{+} = max_i \ y_{ij} \qquad (6)$$

where if *j* is the beneficiary attribute

$$y_j^{-} = min_i y_{ij} \qquad (7)$$

where if *i* is the cost attribute.

3.4. Distance between positive and negative solution.

This step was to the calculated distance between alternative and another alternative on formula (8) and (9) [7]. This distance ideal positive ad ideal negative explains how far the distance between alternative and solution. We focused on count on the benefit and cost. Distance between *Ai* and positive ideal solution can be written as

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

while distance between *Ai* and negative ideal solution was

$$D_i^{-} : D_i^{-} = \left[\sum_{j=1}^{n} \ y_i^{-} - y_{\ ij}\right]^{\frac{1}{2}}; \ \ i = 1,2, \dots, m \qquad (9)$$

3.5. Preference value for each alternative.

In this section, this was the last procedure in the fuzzy Topsis algorithm. We selected one of considering cost and benefit. If the goal is cost, we could choose the (10) formula. In contrast, if we needed a benefit, we could use formula (11).

Ranked for every value in preference V_i. We used formula (10) for a cost manner [7].

$$V_i = D_i^- / [D_i^- + D_i^+]^{-1}; \qquad i = 1,2, \dots, m. \tag{10}$$

$$V_i = D_i^+ / [D_i^- + D_i^+]^{-1}; \qquad i = 1,2, \dots, m. \tag{11}$$

3.6. Rule base form

In this step, we added some rules base in the *If-Then* form. Construction of *If-Then* rules derived from an area in the graphic used in a triangular shape. We added some rules base to obtain the class of prediction. In Fig. 2, the graphics divided into four majors to classify. There were multimedia, animation, networking, and software engineering [12]. We explored some rules that were captioning in Fig. 2. For some functions, we constructed based on Fig. 2. We designed the rule base on the *If-then* form.

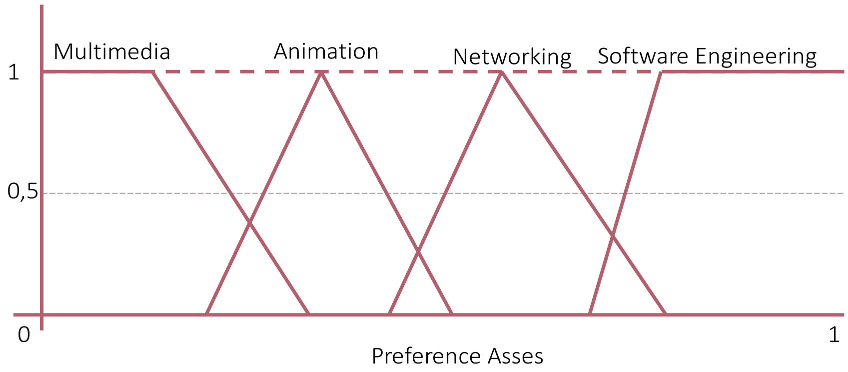

Fig. 2. Membership function graphic.

Rule 1 (multimedia):

IF V < 0.15 THEN major = 1 OR

IF V >= 0.15 AND V <= 0.25 THEN major = (0.25-V) / (0.25-0.15) OR

IF V > 0.25 THEN major = 0

Rule 2 (animation):

IF V < 0.2 THEN major = 0 OR

IF V >= 0.2 AND V < (0.2+0.3)/2 THEN major = (V-0.2) / (0.2+0.3)/2)-0.2) OR

IF V >= (0.2 + 0.3)/2) AND V < 0.3 THEN major = (0.3-V) / (0.3 -(0.2+0.3)/2) OR

IF V > 0.3 THEN major = 0

Rule 3 (networking):

IF V < 0.3 THEN major = 0 OR

IF V >= 0.3 AND V < (0.45+0.3)/2) THEN major = (V-0.3) / ((0.45-0.3)/2) OR

IF V >= ((0.45+0.3)/2) AND V <= 0.45) THEN major = (0.45-V) / (0.45-0.3) OR

IF V > 0.45 THEN major = 0

Rule 4 (software engineering):

IF V < 0.4 THE major = 0 OR

IF V >= 0.4 AND V <= 0.75 THEN major = (V-0.4) / (0.75-0.4) OR

IF V >= 0.6 THEN major = 1

3.7. Max-min function.

The max-min function is one of the fuzzy operations that the count minimum value or maximum value. This operator compares the value from the rule results; we selected only one value that the bigger ones or the smallest ones. For example, from the fuzzy rules, we got a value like 0.2, 0.6, and 0.3. If we applied the min operation *MIN* [0.2, 0.6, 0.3], then the results were 0.2. This behavior the same for *MAX* operation; we chose the highest value from the set.

3.8. Precision and recall.

This section measures the model we had. How far the model extended fuzzy is suitable for this case. Is there any other improvement for the model? This question answered after we knew about the precision and recall. Preference values that resulted from rule base functions are tested by accuracy [8]. We presented the precision and recall at formula (11) and (12), respectively.

$$Recall = TP / [TP + FN]^{-1} \tag{12}$$

$$Precision = TP / [TP + FP]^{-1} \tag{13}$$

where Precision and Recall can be composed by a confusion matrix (see Table 1).

Table 1. Confusion matrix.

	Predict: A	**Not A**
Actual accepted A	True positive (*TP*)	False positive (*FP*)
Actual accepted not A	False negative (*FN*)	True negative (*TN*)

4. Results

The dataset used directly collected from a vocational school. The number of instances were 270. Following the classification designation, we used variables as dataset features. These features consisted of a national exam, psychology test, interview, grade report, physics test, and competency test [7]. Following the methods, we started collecting data directly from the school by interviewing vice headmaster. We got 270 samples that contained a sample with various features like the national exam, competency, grade report, body test, interview, and psychology test [13] (see Table 2).

In the first step of the extended fuzzy process, we started from the normalization of the data. The normalization process was one activity to get the relation value by formula (1), which transformed to be a single relation value and place on the relation matrix. We follow the formula (10 and an example of results can be seen in Table 3. $r_{[1,1]} = x_{[1,1]} \left[\sum_{i=1}^{270} \left[x_{[i,1]}\right]^2\right]^{-\frac{1}{2}} = r_{[1,1]} = 30.74\,[[30.74]^2 + [28.21]^2 + \cdots + [33.22]^2\,]^{-\frac{1}{2}} = 2.04.$

Table 2. An example dataset.

No.	Name	National Exam	Compe-tency	Grade Report	Body Test	Inter-view	Psycho-logy Test
		(x1)	*(x2)*	*(x3)*	*(x4)*	*(x5)*	*(x6)*
1	Student 1	30.74	83.33	79.84	80.00	85.00	50.00
2	Student 2	28.21	73.33	79.52	80.00	85.00	80.00
3	Student 3	31.66	83.33	79.16	70.00	65.00	80.00

Table 3. An example relation matrix *rij.* by formula (1).

No	Name	*x1*	*x2*	*x3*	*x4*	*x5*	*x6*
1	Student 1	2.04	5.73	4.91	5.12	5.73	2.10
2	Student 2	1.72	4.44	4.87	5.12	5.73	5.38
3	Student 3	2.16	5.73	4.83	3.92	3.35	5.38

Next process after obtaining the relation value, we calculated for weighting every single relation value with the dataset value. This operation to fill the weighted value on the weighted matrix. Table 4 shows the results from the formula (2) with the following instruction like $w_{[1,1]} = x_{[1,1]}$ x $r_{[1,1]}$ = 30.74 x 2.04 = 62.60 .

The next process in the fuzzy Topsis after built the weighted value was a calculation of alternative positive and negative. We symbolized the alternative positive and negative to be $A+$ and $A-$ on the formula (4) and (5).

Table 4. An example results by operating the formula (2).

No.	Name	*(Y1)*	*(Y2)*	*(Y3)*	*(Y4)*	*(Y5)*	*(Y6)*
1	Student 1	62.60	477.51	392.10	409.53	487.10	105.05
2	Student 2	48.39	325.41	387.40	409.53	487.10	430.27
3	Student 3	68.45	477.51	382.16	274.36	217.82	430.27

A+ and A- are collecting to be one matrix (called as $y^+_{[j]}$ and $y^-_{[j]}$, respectively). The execution follows the formula (6) and (7), respectively. For the instruction, we used $y^+_1 = max[column(Y1)]$; $y^+_2 = max[column(Y2)]$; $y^+_3 = max[column(Y3)]$.

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

$y^-_1 = min[column(Y1)]\,; y^-_2 = min[column(Y2)]\,;\, y^-_3 = min[column(Y3)]$

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

The forward process after $y^{+}_{[j]}$ and $y^{-}_{[j]}$, we continued to calculate for distance using formula (8) and (9), respectively [1]. Similar to an alternative process, we deployed for distance "*D*" and symbolize with "+" and "-". This is the same meaning as *A*+ and *A*- that focused on benefit and cost. This illustration was the process of calculated distance using formula (8) and formula (9). D^{+} for solution distance positive, and D^{-} for solution distance negative. $D^{+}_{i} = [\sum_{j=1}^{6} y^{+}_{j} - y_{[i,j]}]^{\frac{1}{2}}$; $D^{-}_{i} = [\sum_{j=1}^{6} y_{[i,j]} - y^{-}_{j}]^{\frac{1}{2}}$

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

$$D^{-}_{1} = \left[\left(y_{[1,1]} - y^{-}_{1}\right) + \left(y_{[1,2]} - y^{-}_{2}\right) + \ldots + \left(y_{[1,6]} - y^{-}_{6}\right)\right]^{\frac{1}{2}} = [(62.60-13.84)+(477.51-22.28)+\ldots+(105.05-105.05)]^{\frac{1}{2}} = 8.81$$

The last process of fuzzy Topsis was to build the preference value by following formula (10). The preference value was processed to sort the value from maximum until minimum. The highest value selected as the number one alternative that informs decision-makers to choose. Table 5 presents about proceeds of formula (10), we deployed the operation like $V_1 = D^{-}_{1} / [D^{-}_{1} + D^{+}_{1}]^{-1} = 8.81 / [8.81+31.29]^{-1} = 0.220$ [1].

Table 5. An example of proceeds of preference value.

No.	Name	*Y1*	*Y2*	*Y3*	*Y4*	*Y5*	*Y6*	D^{+}_{i}	D^{-}_{i}	V_i
1	Student 1	16.41	307.06	156.91	173.57	0.00	325.22	31.29	8.81	0.220
2	Student 2	30.62	21.43	161.61	173.57	0.00	0.00	19.68	9.51	0.326
3	Student 3	10.57	17.52	166.84	308.75	269.28	0.00	27.80	8.66	0.237

We added some rules to apply in Table 5. We made the preference value to infer based on section 3.6. As proceeds from inferring the rules, Table 6 shows every major that has been chosen. We chose the highest value in Table 6 to be a preferencence for the student. On the column *Max-Min*, we operated the *Max-Min* function to select where the *Max* or *Min* value. We deployed operations like *Max* [0; 0; 0; 0.312595] and placed into *S/W* eng. We provided four major in this case, such as multimedia, animation, network, and software engineering.

Table 6. An Example classification in major.

No	Name	Multi-media	Anima-tion	Net-work	*S/W* Eng.	*Max-Min*	Major
1	Student 1	0	0	0	0.312595	0.312595	*RPL*
2	Student 2	0	0	0	0.218959	0.218959	*RPL*
3	Student 3	0	0	0	0.175843	0.175843	*RPL*

5. Discussion

The ordinary fuzzy Topsis model was just an enumeration from calculated relation value until preference value. In the last operation, we added some rules to detect where the highest value to address the major for the student. The rules have defined in section 3.6; we just operated to preference value to achieve the major. This step has managed to support the final aims. It was a measure of the model, which was the model fine to the problem [11-13]. We presented a confusion matrix to give an illustration of the comparison between actual and predicted. Table 7 is the results form every major in our case [14]. We found small accuracy after the execution of fuzzy because the major was still found imbalance class on the results [15-18].

Based on Table 7, we built some measurements like precision and recall. Table 8 shows the precision and recall that used a formula (11) and formula (12). In Table 9, the extent of fuzzy Topsis is as an inadequate method. Adding some rules cannot increase accuracy. Several hypotheses become a challenge for future works; we found the data was not at balance class, and the second when created the rules were not considered about the range of value and distribution for every class, for instance, third justify of the boundary value from every rule were not using properly method. Table 9 shows about comparison among methods in the fuzzy series. Even the results were the smallest method, and extended fuzzy Topsis has still an improvement process for the next research.

Table 7. Confusion matrix.

Features		**Predict**			
		Multimedia	**Animation**	**Network**	***S/W* Eng.**
Actual	**Multimedia**	22	8	23	6
	Animation	25	3	11	8
	Network	20	20	45	1
	***S/W* Eng.**	4	7	0	67

Table 8. Precision and recall.

Features	**Precision**	**Recall**
Multimedia	0.309859	0.372881
Animation	0.078947	0.06383
Network	0.56962	0.523256
S/W Eng.	0.817073	0.858974

Table 9. Comparison among fuzzy methods.

Method	***Precision***	***Recall***
Fuzzy Mamdani [1]	75.63%	90%
Fuzzy Topsis [2]	75.60%	96%
Extended Fuzzy Topsis	59,2%	60%

6. Conclusion

Implementation Extended fuzzy Topsis had not reached on high precision and recall. The research obtained 59.20% in precision and 60% in the recall. The achievement happened because of the obstacle in the dataset sample. 270 exemplars had caused the fuzzy Topsis did not process in suitable methods. Adding some rules did not increase the accuracy and impact their case. Several hypotheses become a challenge for future works.

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EXTENDED FUZZY TOPSIS TO IMPROVE PREDICTION STUDENT ON SELECTION PROPERLY MAJORS AT VOCATIONAL SCHOOL

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