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TOPSIS Hybrid Methods Comparison, AHP-TOPSIS and SAW-TOPSIS

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Abstract:

TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is one method that is often used in decision support systems, TOPSIS has a weakness in weight calculations that can be overcome by combining other methods. The purpose of this study is to compare 2 TOPSIS hybrid methods namely AHP-TOPSIS and SAW-TOPSIS to determine the accuracy and calculation of the criteria weight, the data used in the calculation are lecturer data of 145 people with 8 criteria, while the accuracy calculation uses the Hamming Distance method. This research has succeeded in implementing the 2 hybrid TOPSIS on lecturer rankings with the same top-ranking results namely AL29 and AL90, the accuracy of AHP-TOPSIS is superior then SAW-TOPSIS when compared with manual calculations. The criteria weight for AHP-TOPSIS is obtained from the Pairwise matrix results and must meet the requirements that the CR value is below 0.1, while the criteria weight for the SAW-TOPSIS is only obtained from the decision-maker.

Keywords — **AHP-TOPSIS, Decision Support Systems, Hamming Distance, SAW-TOPSIS, TOPSIS Hybrid**

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I. INTRODUCTION

Decision support systems (DSS) provide knowledge, modeling forms, and data processing tools that can be used to support better decision-making in various situations [1] or semi-structured and unstructured situations where no one knows exactly how decisions should be made [2]. TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is one of the methods commonly used in decision support systems, but according to Abdulhadi TOPSIS has a weakness, namely problems with the weight of criteria, decision makers must assign weights to each criterion and this weight may not correct and will affect the final ranking. To overcome these weaknesses TOPSIS is combined with AHP, ANP, SAW, Entropy, and other methods proposed to calculate the weights [3].

Research [4] uses the TOPSIS method with 5 criteria in ranking lecturers, the weight of the criteria is determined directly by the decision maker, while in research [5] the use of the SAW method with 9 criteria and weights has been determined to provide the best employee recommendations for decision-makers [6] using the AHP method in determining the weight of the criteria and the TOPSIS method in the employee ranking process, the approach with the 2 methods is effective, compatible and reliable in the employee ranking study. The SAW and AHP methods are used in the search for the head of the student organization [7], the use of these 2 methods is intended so that the references given to decision makers are not only from 1 source so that decision-makers will be more confident in determining who will be the head of the student organization.

Previous research has succeeded in using DSS with TOPSIS, SAW, and AHP methods in the ranking process. In this study 2 TOPSIS hybrid methods were used namely AHP-TOPSIS and SAW-TOPSIS in ranking the best lecturers. The purpose of this study was to compare the results of the 2 methods with the results of manual calculations to determine the accuracy and determine the weight calculation on the 2 TOPSIS hybrid methods.

The writing in this article then includes research methods with sub-sections, namely AHP, SAW, TOPSIS, AHP-TOPSIS, and SAW-TOPSIS. Results and analysis section contain the calculation of the DSS with AHP-TOPSIS and SAW-TOPSIS, and in conclusion section contains the conclusions of 2 TOPSIS hybrid methods analysis along with suggestions for further research. The last section contains acknowledgments to those who contributed to this research and references to this research.

II. METHOD

The research method used by the researcher is a descriptive research method with a comparative approach, the data used is obtained from the SPM unit (Quality Assurance Unit) of the Institut Teknologi Telkom Purwokerto (ITTP) as the unit that becomes the decision maker which is secondary data. A case study in the form of ranking the best lecturers is used as an object of research, a research framework or design is needed so that research objectives can be achieved, and the research framework or design that becomes a reference is shown in Fig. 1.

The research framework starts by identifying the problems described in the introduction and then becomes the basis for formulating the problem formulation and research objectives. Concepts and references to decision support systems using the AHP, SAW, and TOPSIS methods as well as hybrid TOPSIS were obtained from literature reviews from various sources in the form of journals, articles, and books. Sources of data in the form of lecturer data amounting to 145 are described in Table 1 and 8 criteria data are described in Table 2 and lecturer score data against the criteria are described in Table 3, the data source is obtained from the results of interviews and observations in the unit. The next stage is the calculation process using AHP-TOPSIS and SAW-TOPSIS method to obtain the ranking results, and comparison using the Hamming Distance method.

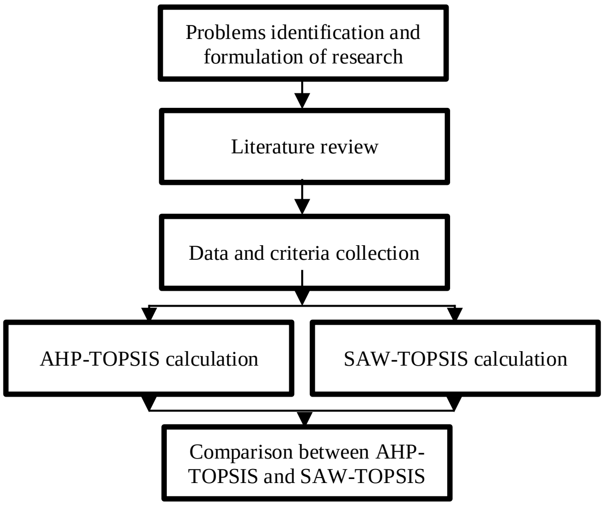

Fig. 1 Research Framework

TABLE I
LECTURER DATA

Alternatives	Information
AL1	Alternative Lecturer 1
AL2	Alternative Lecturer 2
AL3	Alternative Lecturer 3
……….	……..
AL145	Alternative Lecturer 145

TABLE III
CRITERIA DATA

Criteria	Information
C1	Lecture Attendance
C2	Score Entry Accuracy
C3	Submission of Mid-semester Exam Questions
C4	Submission of End -of -Semester Test Questions
C5	Student Questionnaire Evaluation
C6	Monitoring and Evaluation of the Learning Process
C7	Research
C8	Service

TABLE IIIII
LECTURER CRITERIA SCORE DATA,

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	87,50	100	90	80	82,86	100	300	0
AL2	96,88	100	80	100	84,53	100	36	0
AL3	100	96,67	100	100	86,96	100	200	0
…	…	…	…	…	…	…	…	…
AL145	100	100	100	100	79,37	100	40	60

A. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is an analysis and synthesis method that can assist the decision-making process. AHP is a powerful and accurate decision-making tool because the scale or weight has been determined and uses a three-level hierarchy, namely objectives, criteria, and alternatives [8]. The AHP method is not suitable for alternatives with large numbers because the number of pairwise comparisons will also be large. Therefore, in this condition, AHP is mostly used for weighting criteria [9].

According to Asgharpour in [9], the AHP method was proposed by Thomas E Saaty in 1970 based on the analysis of the human brain for complex problems and biases. In AHP, pairwise comparisons are made by scoring using numerical values taken from the absolute fundamental scale of AHP from 1 to 9. The relative value scale is derived from all these pairs of comparisons and it belongs to an absolute scale that does not change under identity transformations like the real number system [10].

In general, the steps in AHP are as follows [11]:

- Create a Pairwise comparison matrix

$$A = [r_{im}] = \begin{bmatrix} 1 & r_{12} & \dots & r_{n2} \\ \frac{1}{r_{12}} & 1 & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ \frac{1}{r_{in}} & \frac{1}{r_{2n}} & \dots & 1 \end{bmatrix} \quad (1)$$

- Matrix normalization

$$\tilde{x}_i = r_{1i} + r_{2i} + \dots + r_{ni} \quad (2)$$

Information:

$\tilde{x}_i$ = Number of matrix columns

i = Column variables i

n = Row variables n

r = Pairwise comparison matrix index

- Determine the weight of the criteria

$$\tilde{x}_j = r_{1i}' + r_{2i}' + \dots + r_{ni}' \quad (3)$$

Information:

$\tilde{x}_j$ = Number of matrix columns

i = Column variables i

n = Row variables n

r' = Normalization of decision matrix

- Calculate the weight of the criteria

$$w_i = \frac{\tilde{x}_j}{n} \quad (4)$$

Information:

$\tilde{x}$ = Number of matrix columns

i = Column variables i

j = Row variables j

n = Number of criteria

w = Criteria weight

B. Simple Additive Weighting (SAW)

The SAW method is a simple additive weight method, which is used to carry out the selection process using two value criteria, the criteria value is used for existing alternative assessments, where the value of the attributes used are the cost attribute and the profit attribute after that the weight multiplication calculation is carried out to get the preference value [12]. The SAW method is often also called the weighted summing method.

The basic concept of the SAW method is to find a weighted number of performance ratings on each alternative on all attributes. SAW is one of the most frequently used techniques to solve spatial decision analysis problems, decision makers directly assign weights to each attribute [13]. The SAW method requires the process of normalizing the decision matrix (X) to a scale that is proportional to all available alternative branches [14] this method requires the decision maker to determine the weight for each attribute [15], after the decision matrix is formed (X) then proceed with the step of making a matrix R's decision is as follows [16]:

$$R_{ij} = \frac{X_{ij}}{Max\ X_{ij}} \quad \text{If j is a profit attribute} \quad (5)$$

$$R_{ij} = \frac{Min\ X_{ij}}{X_{ij}} \quad \text{If j is a cost attribute} \quad (6)$$

C. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a multi-criteria decision support system. TOPSIS has the principle that the chosen alternative must have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution [17][18]. TOPSIS uses logical mathematics and Euclidean distance-based techniques to evaluate and compare the range of available alternatives from a set of attributes [19]. The steps for calculating TOPSIS according to Opricovic S and Tzeng GH in [20] are as follows:

- Create a normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (7)$$

- Weighted normalized matrix,

With weight $w_j = (w_1, w_2, w_3, \ldots, w_n)$ (8)
where w_j is the criterion weight for all j

Matrix normalization is V

$$V_{ij} = w_j * r_{ij} \quad (9)$$

- Determine the ideal solution matrix of positive and negative ideal solutions

A^{+}= {(max v_{ij} | j ∈ J),(min v_{ij} | j ∈ J'),i = 1,2,3, ...,n}={$V_1^+, V_2^+, V_3^+, \ldots, V_n^+$} (10)

A^{-}= {(min v_{ij} | j ∈ J),(max v_{ij} | j ∈ J'),i = 1,2,3, ...,n}={$V_1^-, V_2^-, V_3^-, \ldots, V_n^-$} (11)

- Calculating Distance

S^+ is the alternative distance of the positive ideal solution, defined as follows :

$$S^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad (12)$$

where i=1,2,3,…,m

S^- is the negative ideal alternative distance

$$S^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (13)$$

where i=1,2,3,…,m

- Calculating positive ideal solutions and negative ideal solutions

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \quad (14)$$

- Alternate rank

Alternative C^+ sorted from largest to smallest, alternative with value C^+ biggest is the best solution.

D. AHP-TOPSIS

The AHP-TOPSIS hybrid method combines the steps in AHP and TOPSIS described in Fig. 2. The step begins with preparing data in the form of lecturer data and scores from 8 criteria for each lecturer, followed by the AHP process namely making a Pairwise comparison matrix, normalizing the decision matrix and determining the weight of the criteria. . The steps are followed by the TOPSIS process, namely normalizing the decision matrix, normalizing the weighted decision matrix, determining the ideal positive and negative ideal solution matrix, calculating the distance between the positive and negative ideal alternatives, calculating the positive and negative ideal solutions, and ranking alternatives.

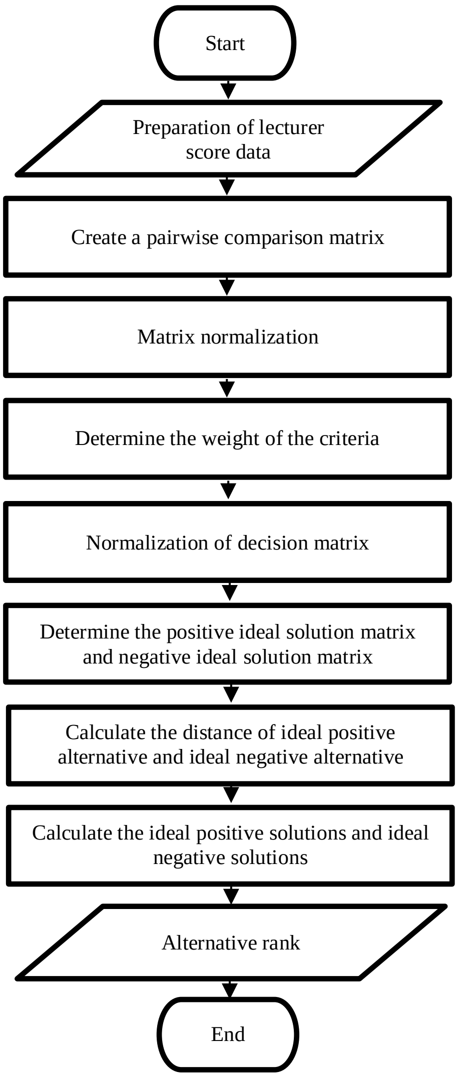

Fig. 2 AHP-TOPSIS Stages

E. SAW-TOPSIS

The step in the SAW-TOPSIS hybrid is described in Fig. 3, which starts with preparing data in the form of lecturer data and scores from 8 criteria for each lecturer, then normalization of the R matrix is made with all the criteria for entering the advantage or benefit attribute this step is a step in SAW. The results of the normalization of the R matrix are then continued with the calculation using the TOPSIS method namely weighted matrix normalization, determining the ideal positive and negative ideal solution matrices, calculating the distance between positive and negative ideal alternatives, calculating positive and negative ideal solutions, and ranking alternatives.

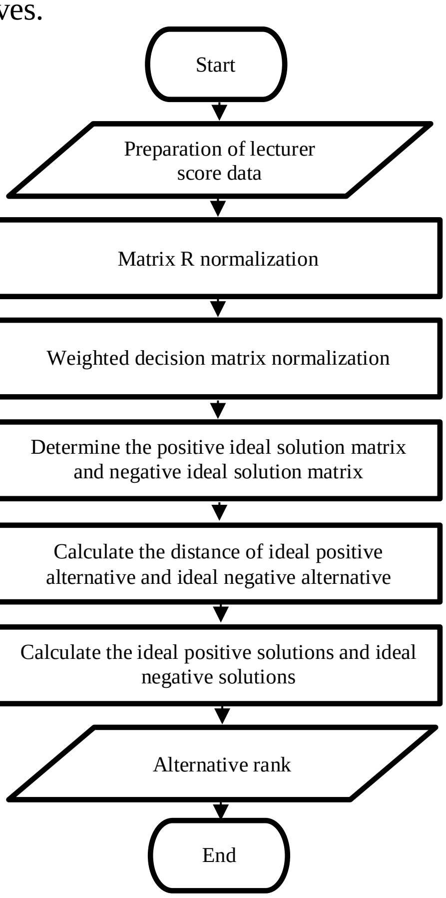

Fig. 3 SAW-TOPSIS Stages

III. Results and Discussion

The data obtained from the SPM ITTP unit, namely lecturer data, criteria data, and lecturer score data are data that will be processed in the calculation of 2 hybrid methods, in Table IV explains the lecturer score data which becomes the decision matrix.

TABLE IVV
DECISION MATRIX

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	87,50	100	90	80	82,86	100	300	0
AL2	96,88	100	80	100	84,53	100	36	0
AL3	100	96,67	100	100	86,96	100	200	0
…	…	…	…	…	…	…	…	…
AL145	100	100	100	100	79,37	100	40	60

A. AHP-TOPSIS

The calculation process on the AHP-TOPSIS hybrid begins with a calculation using the AHP method of making a Pairwise comparison matrix. Observations and interviews were conducted with the SPM unit as the decision maker in making the matrix which is described in Table V.

TABLE VV
PAIRWISE COMPARISON MATRIX

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	1	1	0,33	0,25	0,25	0,14	0,25
C2	1	1	1	0,50	0,50	0,25	0,14	0,33
C3	1	1	1	0,50	0,50	0,20	0,14	0,33
C4	3	2	2	1	3	2	0,14	0,33
C5	4	2	2	0,33	1	0,50	0,14	0,33
C6	4	4	5	0,50	2	1	0,14	1
C7	7	7	7	7	7	7	1	5
C8	4	3	3	3	3	1	0,20	1
Sum.	25	21	22	13,17	17,25	12,20	2	8,58

From the comparison matrix, it is continued with the normalization of the comparison matrix described in Table VI. below,

TABLE VI
MATRIX NORMALIZATION

	C1	C2	C3	C4	C5	C6	C7	C8
C1	0,04	0,048	0,045	0,025	0,014	0,020	0,071	0,029
C2	0,04	0,048	0,045	0,038	0,029	0,020	0,071	0,039
C3	0,04	0,048	0,045	0,038	0,029	0,016	0,071	0,039
C4	0,12	0.095	0,091	0,076	0,174	0,164	0,071	0,039
C5	0,16	0.095	0,091	0,025	0,058	0,041	0,055	0,039
C6	0,16	0,190	0,227	0,038	0,116	0,082	0,071	0,117
C7	0,28	0,333	0,318	0,532	0,406	0,574	0,494	0,583
C8	0,16	0,143	0,136	0,228	0,174	0,082	0,099	0,117

Ensuring that the calculation can be continued to the next stage, it is necessary to calculate the CR (Consistency Ratio) value to find out whether it is consistent or not, it is said to be consistent if the CR value is 0.1 while the IR (Random Consistency Index) value according to Kusrini in [21] is described in Table VII where n is the size of the matrix.

TABLE VII
MATRIX NORMALIZATION

n	IR	n	IR
1	0,00	6	1,24
2	0,00	7	1,32
3	0,58	8	1,41
4	0,90	9	1,45
5	1,12	10	1,49

$$CR = \frac{CI}{IR} \qquad (15)$$

information :

CR = Consistency Ratio

CI = Consistency Index

$$CI = \frac{(\lambda \max - n)}{(n-1)} \qquad (16)$$

where n is the number of elements

$$CR = \frac{0{,}128}{1{,}41} = 0{,}091$$

The value of CR = 0.091 < 0.1 then the calculation can be said to be consistent and can be continued to the next stage. From the results of these calculations, the weight value of each criterion is described in Table VIII.

TABLE VIII
CRITERIA WEIGHT

C	C1	C2	C3	C4	C5	C6	C7	C8
W	0,037	0,041	0,041	0,104	0,071	0,125	0,440	0,142

The AHP calculation process is complete until the decision matrix normalization is followed by the TOPSIS method starting from making the normalized decision matrix described in Table IX followed by the normalization of the weighted decision matrix described in Table X below.

Table XI describes the matrix of positive ideal and negative ideal solutions, then proceeds to calculate the distance between alternative positive ideal solutions and negative ideal solutions described in Table XII.

TABLE IX
DECISION MATRIX NORMALIZATION

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	0,073	0,087	0,082	0,071	0,085	0,085	0,166	0
AL2	0,081	0,087	0,073	0,089	0,087	0,085	0,020	0
AL3	0,084	0,084	0,091	0,089	0,089	0,085	0,110	0
…	…	…	…	…	…	…	…	…
AL145	100	100	100	100	79,37	100	40	60

TABLE X
WEIGHTED DECISION MATRIX

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	0,003	0,004	0,003	0,007	0,006	0,011	0,073	0
AL2	0,003	0,004	0,003	0,009	0,006	0,011	0,009	0
AL3	0,003	0,003	0,004	0,009	0,006	0,011	0,049	0
…	…	…	…	…	…	…	…	…
AL145	0,003	0,004	0,004	0,009	0,006	0,011	0,010	0,022

TABLE XI
MATRIX OF POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

	C1	C2	C3	C4	C5	C6	C7	C8
A+	0,003	0,004	0,004	0,009	0,006	0,011	0,116	0,044
A-	0,002	0	0	0	0,004	0	0	0

TABLE XII
ALTERNATIVE DISTANCE POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

S+	S-
0,062	0,074
0,116	0,017
0,080	0,051
…	…
0,108	0,029

From the results of the calculation of the distance between the alternative positive ideal solution and the negative ideal solution, it can be continued in the calculation of the positive ideal solution and the negative ideal solution which will be the final value described in Table XIII below.

TABLE XIII
POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

Alt.	C^{+}
AL1	0,546
AL2	0,130
AL3	0,387
…	…
AL145	0,209

The ranking process or ranking is obtained from the results of positive ideal solutions and negative ideal solutions sorted from the largest value to the smallest value described in Table XIV below.

TABLE XIV
ALTERNATIVE RANK

Alt.	C^+
AL29	0,915
AL60	0,727
AL93	0,713
…	…
AL81	0,094

B. SAW-TOPSIS

In the SAW-TOPSIS hybrid calculation, the first stage in the SAW calculation is the calculation of the normalized decision matrix from the results of the calculation, followed by the TOPSIS calculation at the weighted decision matrix normalization stage with the weight of the criteria set by the ITTP SPM unit described in Table XV.

TABLE XV
ALTERNATIVE RANK

Criteria	Weight	Status
C1	0,05	*Benefit*
C2	0,1	*Benefit*
C3	0,05	*Benefit*
C4	0,05	*Benefit*
C5	0,05	*Benefit*
C6	0,1	*Benefit*
C7	0,4	*Benefit*
C8	0,1	*Benefit*

The normalized decision matrix described in Table XVI is obtained from the value of the matrix divided by the maximum value of the matrix for each column.

TABLE XVI
DECISION MATRIX NORMALIZATION

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	0,875	1	0,900	0,800	0,938	1	0,630	0
AL2	0,969	1	0,800	1	0,957	1	0,076	0
AL3	1	0,967	1	1	0,985	1	0,420	0
…	…	…	…	…	…	…	…	…
AL145	1	1	1	1	0,899	1	0,084	0,500

The results of the normalization of the decision matrix on the AHP are continued to the TOPSIS weighted decision matrix described in Table XVII below.

TABLE XVII
WEIGHTED DECISION MATRIX NORMALIZATION

Alt.	C1	C2	C3	C4	C5	C6	C7	C8
AL1	0,044	0,100	0,045	0,040	0,047	0,100	0,252	0
AL2	0,048	0,100	0,040	0,050	0,048	0,100	0,030	0
AL3	0,050	0,097	0,050	0,050	0,049	0,100	0,168	0
…	…	…	…	…	…	…	…	…
AL145	0,050	0,100	0,050	0,050	0,045	0,100	0,034	0,100

The matrix of positive ideal and negative ideal solutions is described in Table XVIII, followed by calculating the distance between alternative positive ideal solutions and negative ideal solutions described in Table XIX.

TABLE XVIII
MATRIX OF POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

	C1	C2	C3	C4	C5	C6	C7	C8
A+	0,050	0,100	0,050	0,050	0,050	0,100	0,400	0,200
A-	0,040	0	0	0	0,035	0	0	0

TABLE XIX
ALTERNATIVE DISTANCE POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

S+	S-
0,249	0,296
0,421	0,159
0,306	0,230
…	…
0,380	0,191

The calculation of the positive ideal solution and the negative ideal solution which will be the final value is described in Table XX below.

TABLE XX
POSITIVE IDEAL SOLUTION AND NEGATIVE IDEAL SOLUTION

Alt.	C^+
AL1	0,543
AL2	0,274
AL3	0,429
…	…
AL145	0,334

Table XXII describes the ranking of alternatives with positive ideal solution values and negative ideal solutions from largest to smallest.

TABLE XXII
ALTERNATIVE RANK

Alt.	C^+
AL29	0,899
AL60	0,715
AL56	0,681
…	……..
AL79	0,167

The results of the alternative rankings for the top rank in both AHP-TOPSIS and SAW-TOPSIS are recommended for AL29 and AL60, while the subsequent rankings are different.

In the comparative analysis, the method used is Hamming Distance to compare with the manual results of the SPM unit. The results of the decision support system with the results of manual calculations will certainly be different, so the Hamming Distance discrepancy is used to measure its accuracy. Hamming Distance measurement is a discrepancy between the calculation of the decision support system with manual calculations, namely the number of alternatives that are not suitably divided by the total number of alternatives multiplied by 100% [11].

Hamming Distance discrepancy between AHP-TOPSIS with manual calculations obtained a value of 91%, while the Hamming Distance discrepancy between SAW-TOPSIS with manual calculations obtained a value of 96%. Hamming Distance result from AHP-TOPSIS is smaller than SAW-TOPSIS.

IV. CONCLUSIONS

The 2 TOPSIS hybrid methods were successfully implemented in this study with the highest ranking results, namely AL29 and AL60 but the next ranking was different, the comparison test using Hamming Distance, the discrepancy between manual calculations and 2 TOPSIS hybrid calculations gave the results that AHP-TOPSIS was 91% while SAW-TOPSIS was 96 %. The result of a smaller Hamming Distance gives better accuracy, the accuracy of AHP-TOPSIS is better than SAW-TOPSIS.

The calculation of the two TOPSIS hybrid methods shows different treatments in obtaining the weighted criteria. In AHP-TOPSIS the weights are calculated using the AHP method where the weights are obtained from the calculation of the Pairwise matrix results and must meet the requirements that the CR value is below 0.1 then can proceed to the ranking calculation using TOPSIS. Unlike the SAW-TOPSIS, the SAW method is only used for calculating the normalization of the R matrix by looking at the criteria used whether it is categorized as benefit or cost, after that the calculation is continued with the TOPSIS method where the decision normalization matrix calculation is weighted by the weighted value of the criteria using a weight that has been determined by the decision maker. decision. From this, according to the researchers, it is not appropriate if SAW is called a method that can overcome the weakness of TOPSIS in calculating the weight of the criteria, but it is true that if the SAW method can be combined with TOPSIS, it can be seen that the results of the top ranking are the same as AHP-TOPSIS.

Further research can be carried out to compare AHP-TOPSIS with the ANP-TOPSIS and Entropy-TOPSIS methods to find out whether the TOPSIS hybrid method gets the weight of the criteria from a special calculation.

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REFERENCES

[1] M. W. L. Moreira, J. J. P. C. Rodrigues, V. Korotaev, J. Al-Muhtadi, and N. Kumar, "A Comprehensive Review on Smart Decision Support Systems for Health Care," *IEEE Syst. J.*, vol. 13, no. 3, pp. 3536–3545, Sep. 2019, doi: 10.1109/JSYST.2018.2890121.

[2] S. S. M. M. M. E. Imam Tahyudin, *SISTEM PENDUKUNG KEPUTUSAN (SPK) KONSEP DASAR DAN PENERAPANNYA & DATA MINING*, I. Banyumas: Zahira Media Publisher, 2014.

[3] A. Q. Abdulhadi, "Review of Hybrid TOPSIS with other Methods," *Int. J. Acad. Res. Bus. Soc. Sci.*, vol. 9, no. 14, Oct. 2019, doi: 10.6007/IJARBSS/v9-i14/6504.

[4] G. Wibisono, A. Amrulloh, and E. Ujianto, "PENERAPAN METODE TOPSIS DALAM PENENTUAN DOSEN TERBAIK," *Ilk. J. Ilm.*, vol. 11, no. 2, pp. 102–109, Sep. 2019, doi: 10.33096/ilkom.v11i2.430.102-109.

[5] P. Painem and H. Soetanto, “Decision Support System with Simple Additive Weighting for Recommending Best Employee,” *Proceeding Electr. Eng. Comput. Sci. Informatics*, vol. 6, Oct. 2019, doi: 10.11591/eecsi.v6i0.1976.

[6] A. K. M. Masum, A. N. M. R. Karim, F. Bin Al Abid, S. Islam, and M. Anas, “A New Hybrid AHP-TOPSIS Method for Ranking Human Capital Indicators by Normalized Decision Matrix,” *J. Comput. Sci.*, vol. 15, no. 12, pp. 1746–1751, Dec. 2019, doi: 10.3844/jcssp.2019.1746.1751.

[7] M. Saputra, O. S. Sitompul, and P. Sihombing, “Comparison AHP and SAW to promotion of head major department SMK Muhammadiyah 04 Medan,” *J. Phys. Conf. Ser.*, vol. 1007, p. 012034, Apr. 2018, doi: 10.1088/1742-6596/1007/1/012034.

[8] R. E. Sari, A. Meizar, D. H. Tanjung, and A. Y. Nugroho, “Decision making with AHP for selection of employee,” in *2017 5th International Conference on Cyber and IT Service Management (CITSM)*, Aug. 2017, pp. 1–5, doi: 10.1109/CITSM.2017.8089285.

[9] A. Azimifard, S. H. Moosavirad, and S. Ariafar, “Selecting sustainable supplier countries for Iran’s steel industry at three levels by using AHP and TOPSIS methods,” *Resour. Policy*, vol. 57, pp. 30–44, Aug. 2018, doi: 10.1016/j.resourpol.2018.01.002.

[10] M. R. Zakaria and Y. H. Putra, “Employee Performance Appraisal to Determine Best Engineer Candidates with Analytical Hierarchy Process Approach,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 407, p. 012169, Sep. 2018, doi: 10.1088/1757-899X/407/1/012169.

[11] V. D. Iswari, F. Y. Arini, and M. A. Muslim, “Decision Support System for the Selection of Outstanding Students Using the AHP-TOPSIS Combination Method,” *Lontar Komput. J. Ilm. Teknol. Inf.*, p. 40, May 2019, doi: 10.24843/LKJITI.2019.v10.i01.p05.

[12] S. V. B. Manurung, F. G. N. Larosa, I. M. S. Simamora, A. Gea, E. R. Simarmata, and A. Situmorang, “Decision Support System of Best Teacher Selection using Method MOORA and SAW,” in *2019 International Conference of Computer Science and Information Technology (ICoSNIKOM)*, Nov. 2019, pp. 1–6, doi: 10.1109/ICoSNIKOM48755.2019.9111550.

[13] J. Seyedmohammadi, F. Sarmadian, A. A. Jafarzadeh, M. A. Ghorbani, and F. Shahbazi, “Application of SAW, TOPSIS and fuzzy TOPSIS models in cultivation priority planning for maize, rapeseed and soybean crops,” *Geoderma*, vol. 310, pp. 178–190, Jan. 2018, doi: 10.1016/j.geoderma.2017.09.012.

[14] H. Adela, K. Azmi Jasmi, B. Basiron, M. Huda, and A. Maseleno, “Selection of dancer member using simple additive weighting,” *Int. J. Eng. Technol.*, vol. 7, no. 3, p. 1096, Jun. 2018, doi: 10.14419/ijet.v7i3.11983.

[15] S. K. M. P. Asmawati S *et al.*, *Sistem Pendukung Keputusan*. Bandung: Media Sains Indonesia, 2022.

[16] Sunarti, J. Sundari, S. Anggraeni, F. B. Siahaan, and Jimmi, “Comparison Topsis And Saw Method In The Selection Of Tourism Destination In Indonesia,” in *2018 Third International Conference on Informatics and Computing (ICIC)*, Oct. 2018, pp. 1–6, doi: 10.1109/IAC.2018.8780550.

[17] Sukiman, Hendry, Jimmy, Sugianto, Waisen, and L. Suryati, “Decision Support System for Academic Administration Staff Achievement in STMIK IBBI Using TOPSIS-HFLTS Method,” in *2020 3rd International Conference on Mechanical, Electronics, Computer, and Industrial Technology (MECnIT)*, Jun. 2020, pp. 282–286, doi: 10.1109/MECnIT48290.2020.9166660.

[18] S. K. M. T. I. Ferry Susanto, *Pengenalan Sistem Pendukung Keputusan*, I. Yogyakarta: Deepublish, 2020.

[19] S. Motia and S. R. N. Reddy, “Application of TOPSIS method in selection of design attributes of decision support system for fertilizer recommendation,” *J. Inf. Optim. Sci.*, vol. 41, no. 7, pp. 1689–1704, Oct. 2020, doi: 10.1080/02522667.2020.1799513.

[20] R. Rahim *et al.*, “TOPSIS Method Application for Decision Support System in Internal Control for Selecting Best Employees,” *J. Phys. Conf. Ser.*, vol. 1028, p. 012052, Jun. 2018, doi: 10.1088/1742-6596/1028/1/012052.

[21] I. Indriaturrahmi and F. Fitriani, “Rancang Bangun Sistem Pendukung Keputusan Potensi Promosi Calon Mahasiswa Baru Studi Kasus Universitas Pendidikan Mandalika,” MATRIK J. Manajemen, Tek. Inform. dan Rekayasa Komput., vol. 20, no. 2, pp. 397–406, May 2021, doi: 10.30812/matrik.v20i2.1049.