Improved hybridization of Fuzzy Analytic Hierarchy Process (FAHP) algorithm with Fuzzy Multiple Attribute Decision Making - Simple Additive Weighting (FMADM-SAW)

B E Zaiwani¹, M Zarlis² and S Efendi³

Department of Information and Technology, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Medan, Indonesia.

zaiwani.babyesly@students.usu.ac.id

Abstract. In this research, the improvement of hybridization algorithm of Fuzzy Analytic Hierarchy Process (FAHP) with Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) in selecting the best bank chief inspector based on several qualitative and quantitative criteria with various priorities. To improve the performance of the above research, FAHP algorithm hybridization with Fuzzy Multiple Attribute Decision Making - Simple Additive Weighting (FMADM-SAW) algorithm was adopted, which applied FAHP algorithm to the weighting process and SAW for the ranking process to determine the promotion of employee at a government institution. The result of improvement of the average value of Efficiency Rate (ER) is 85.24%, which means that this research has succeeded in improving the previous research that is equal to 77.82%. Keywords: Ranking and Selection, Fuzzy AHP, Fuzzy TOPSIS, FMADM-SAW.

1. Introduction

In the research [1] hybridization algorithm of Fuzzy Analytic Hierarchy Process (FAHP) with Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) was conducted. Hybridization is done by weighting with FAHP algorithm and ranking with FTOPSIS algorithm. The result of this research is the average value of Efficiency Rate (ER) of 77.82% which is still felt too low. The conclusion of this research suggest that in this method developed again by hybridization of FAHP algorithm with Multiple Attribute Decision Making (FMADM).

2. Study of Literature

Decision Support System (DSS) is an interactive computer-based system that helps decision makers utilize data and models to solve a problem. There are several methods including Analytical Hierarchy Process (AHP) and Technique For Order Preference by Similarity to Ideal Solution (TOPSIS) [2]. AHP is a method in a decision-making system that uses several variables with a multilevel analysis process [3]. The analysis is done by giving the priority value of each variable, then do the pairwise comparison of the variables and alternative. TOPSIS is a method based on the concept that the best-chosen alternative not only has the shortest distance from the ideal solution, but also has the longest distance from the ideal solution.

In [1] an integrated approach of Fuzzy Analytical Hierarchical Process (FAHP) and Fuzzy Technique for Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) is used to calculate...
the weight of criteria and the FTOPSIS method is applied to prioritize the optimal alternative according to the criteria.

3. Findings and Discussions

3.1. Flowchart Research
The Flowchart hybridization algorithm Fuzzy Analytic Hierarchy Process (FAHP) with Fuzzy Multiple-Attribute Decision Making - Simple Additive Weighting (FMADM-SAW) can be seen as in Figure 1.

![Flowchart Research](image)

**Figure 1.** Flowchart Research

In the flowchart above, the input data in the form of SKP value and the value of Work Behavior taken 2 years. Furthermore, the data is processed by using FAHP, FMADM-SAW and hybridization algorithm is a combination of FAHP-FMADM-SAW algorithm. The result of the process is the Work Performance Value of each algorithm and validation value which is the determination of whether or not an employee is given promotion.

3.2. Data used
The data used comes from Aparatur Sipil Negara (ASN) at Badan Kepegawaian Daerah dan Pengembangan Sumber Daya Manusia of Medan City (BKDPSDM) which is calculated according to the provisions of Badan Kepegawaian Negara as in Table 1.
Table 1. Employee Criteria Assessment Data

| Alternative | Name Employee | Value SKP-1 | Value SKP-2 | Value SKP-3 | Value Behavior-1 | Value Behavior-2 | Value Behavior-3 |
|-------------|---------------|-------------|-------------|-------------|------------------|------------------|------------------|
| A1          | Agus          | 65          | 85          | 65          | 75               | 90               | 40               |
| A2          | Budi          | 74          | 80          | 60          | 85               | 96               | 85               |
| A3          | Charli        | 60          | 80          | 60          | 85               | 95               | 80               |
| A4          | Deni          | 85          | 65          | 76          | 90               | 94               | 45               |
| A5          | Endang        | 84          | 74          | 84          | 75               | 94               | 55               |
| A6          | Fajar         | 90          | 84          | 90          | 75               | 80               | 96               |
| A7          | Gina          | 50          | 56          | 60          | 70               | 70               | 87               |
| A8          | Harry         | 74          | 55          | 50          | 60               | 70               | 75               |
| A9          | Indah         | 75          | 71          | 45          | 62               | 90               | 65               |
| A10         | Jenny         | 60          | 48          | 60          | 70               | 60               | 85               |

In Table 1 contains the assessment results of each criterion for each employee scale 100 consisting of criteria SKP Value (Employee Objectives) 1 to 3 and Work Behavior 1 to 3.

3.3. FAHP algorithm

The calculation steps of the FAHP algorithm are as in Table 3.

3.3.1. Structure of hierarchy

The hierarchical structure of the selection problem of promotion can be seen in Figure 2.

![Employee Selection Hierarchy](image)

**Figure 2. Structure of Employee Selection Hierarchy**

Figure 2 above shows the hierarchical structure of the employee selection problems with selection criteria are SKP-1, SKP-2, SKP-3, Work Behavior-1, Work Behavior-2 and Work Behavior-3. The purpose of this assessment is to obtain the category of Good (B), Enough (C) or Less (K).

3.3.2. Determination of synthesis value

Table 2. Comparison of SKP matrix in pairs of Fuzzy AHP criteria

|     | K1 = SKP-1 | K2 = SKP-2 | K3 = SKP-3 |
|-----|------------|------------|------------|
| B   | 1          | 0.33       | 0.5        |
| C   | 3          | 1          | 0.33       |
| K   | 1          | 3          | 1          |

Value Table 2 above is obtained from the comparison between 1 element of SKP criteria with other SKP criteria elements.

Table 3. Comparison of Matrix Working Matched Behaviour of Fuzzy AHP criteria

|     | K1 = Value Behaviour-1 | K2 = Value Behaviour-2 | K3 = Value Behaviour-3 |
|-----|------------------------|------------------------|------------------------|
| B   | 1                      | 0.33                   | 0.55                   |
| C   | 3                      | 1                      | 0.33                   |
| K   | 1                      | 3                      | 1                      |
3.4. FMADM-SAW algorithm
Step I: Evaluate the Fuzzy set of selected alternatives.

a. The linguistic variables that represent the weight of importance for each criterion are T (importance)

\[ W = \{SR, R, C, T, ST\} \]

With:
- SR = Very Low
- R = Low
- C = Enough
- T = High
- ST = Very High

Where each is represented by the triangle fuzzy number as follows:
- SR = (0, 0, 0.25)
- R = (0, 0.25, 0.5)
- C = (0.25, 0.5, 0.75)
- T = (0.5, 0.75, 1)
- ST = (0.75, 1, 1)

b. The degree of suitability of alternatives to the decision criteria is:

\[ T (match)S = \{SK, K, C, B, SB\} \]

with:
- SK = Very Less
- K = Less
- C = Enough
- B = Good
- SB = Very Good

Where each is represented by the triangle fuzzy number as follows:
- SK = (0, 0, 0.25)
- K = (0, 0.25, 0.5)
- C = (0.25, 0.5, 0.75) B = (0.5, 0.75, 1)

Ratings for each decision criterion can be seen as in Table 4.

| Table 4. Rating of interest for each criterion |
|-----------------------------------------------|
| **Criterion**       | **Alias** | **Rating Interests** |
|---------------------|-----------|----------------------|
| Value SKP-1         | C1        | Enough (C)           |
| Value SKP-2         | C2        | Very High (ST)       |
| Value SKP-3         | C3        | Enough (C)           |
| Value Behaviour-1   | C4        | High (T)             |
| Value Behaviour-2   | C5        | Enough (C)           |
| Value Behaviour-3   | C6        | Enough (C)           |
3.5. Implementation of Hybridization Algorithm (FAHP-FMADM-SAW)

Hybridization algorithm is the application of FAHP algorithm on weighting and FMADM-SAW for ranking based on input from FAHP to determine promotion of ASN with the case study of BKDPSDM. Ways of weighting and consistency ratio with FAHP algorithm and ranking with the FMADM-SAW algorithm can be seen as Chapter 3.3 and 3.4 above.

| Table 5. Result Weighted FAHP Algorithm | Table 6. Result FMADM-SAW Algorithm |
|----------------------------------------|-------------------------------------|
| **Criterion** | **Weight** | **Percentage** | **No.** | **Alternative** | **End Value** | **Point** |
| SKP-1 | 0.028 | 0.2% | 1 | Agus | 0.366 | 100 |
| SKP-2 | 0.085 | 0.8% | 2 | Budi | 0.342 | 85 |
| SKP-3 | 0.14 | 14.0% | 3 | Fajar | 0.191 | 70 |
| Behaviour-1 | 0.20 | 2.0% | 4 | Denny | 0.121 | 50 |
| Behaviour-2 | 0.25 | 25.0% | 5 | Charli | 0.010 | 50 |
| Behaviour-3 | 0.28 | 28.0% | 6 | Gina | 0.000 | 0 |

In Table 5 we can see the weighting results for each criterion (SKP or Work Behavior). In Table 6 shows the ranking for each employee (alternative).

Furthermore, the weight obtained with FAHP algorithm is calculated by the FMADM-SAW algorithm to step rank for determination of promotion in the employee. Flowchart Hybridization algorithm can be seen as in Figure 3.

![Figure 3. Flowchart Hybridization Algorithm](image-url)
4. User interface

4.1. View of example alternative data

In this form look the data input alternative the employee biodata that will be processed ranking for determination promotion.

4.2. View of ranking process

In this form seen the ranking process of each alternative that can be seen the result on the bottom right.

5. Conclusion

There is an improvement of Dooki, A.E., Bolhasani, P. & Fallah, M. (2017) research, where the average value of Efficiency Rate (ER) is only 77.82% which is still too low. In Dooki, Bolhasani and Fallah's research, hybridization of Fuzzy Analytic Hierarchy Process (FAHP) algorithm was adopted by Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) to select the best bank chief inspector based on several qualitative and quantitative criteria with various priorities. The AHP and TOPSIS Fuzzy Methods are used to determine the criteria and ranking weight of each of the selected inspectors. In this research, we made an improvement of Dooki and Bolhasani and Fallah research by improving the FAHP algorithm with Simple Additive Weighting (SAW), which is done by applying FAHP Algorithm to the weighting process and SAW for the ranking process to determine the promotion of the employee. The result of improvement is the average value of ER is 85.24%, which means that this research has succeeded in improving Dooki and Bolhasani and Fallah research by 7.42%.

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