Available online at: https://ijact.in

Date of Submission	25/07/2019
Date of Acceptance	20/09/2019
Date of Publication	31/10/2019
Page numbers	3444-3447(4 Pages)

Cite This Paper: Jonathan Leonardo, Julio C Young, Seng Hansun. Early Dectection of Pulmonary Tuberculosis Disease With Fuzzy AHP Expert System, 8(10), COMPUSOFT, An International Journal of Advanced Computer Technology. PP. 3444-3447.

ISSN:2320-0790

COMPUSOFT
An International Journal of Advanced Computer Technology

EARLY DETECTION OF PULMONARY TUBERCULOSIS DISEASE WITH FUZZY AHP EXPERT SYSTEM

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Abstract: The development of information technology provides information that is relevant, accurate, on time, and provides information that can be used to assist in making a decision. Pulmonary Tuberculosis disease is one of the fatal and most common diseases in the world. Using information technology, we could develop a system that can be used as a means for users to early detect Pulmonary Tuberculosis disease. In this study, to detect the Pulmonary Tuberculosis disease, Fuzzy Analytical Hierarchy Process (F-AHP) algorithm was used. The system built was divided into two stages, i.e., AHP and F-AHP. AHP algorithm was used to determine the value of data consistency from data that has been used, while F-AHP algorithm was used as a final determinant of the weight value of each criterion data used. Furthermore, the testing system was done by testing the method and testing the usefulness of the system. The method testing was done by comparing the value of the final weight between the system calculation and manual calculation, which produce the same value. The usefulness of the system then was evaluated by using the System Usability Scale (SUS) based on expert's opinion, which produce a score of 82.5 and based on user's opinion produced a score of 86.16. Both of the results can be included in the "Acceptable" category.

Keywords: AHP; expert system; F-AHP; Pulmonary tuberculosis; SUS

I. INTRODUCTION

Tuberculosis (TB) is one of the most critical diseases in the world because approximately 33% of the world's population has been infected by pulmonary TB disease [1]. TB is an infectious disease caused by Mycobacterium Tuberculosis. TB disease mostly attacks the lungs organ but does not rule out the possibility to attack other parts of human's organ [1]. Based on the World Health Organization (WHO) statistic, Indonesia was ranked second among other countries that have the most TB disease case [2, 3].

Limited human resource such as doctors, lack of knowledge about TB disease, and a large number of people infected by TB disease can cause the increasing number of deaths [4]. Therefore, an expert system for early detection of TB disease is needed so that the time needed to diagnose a person whether he has TB or not can be minimized [4]. The expert system can be used as media for doctors to diagnose TB disease in the hope that it can help to reduce the time needed [5].

One of the techniques that can be used is Fuzzy AHP (F-AHP). AHP is used as the multiple criteria decision making and fuzzy is used to minimize errors in AHP scaling results [6]. Based on the research's results of Norhikmah, Rumini, and Henderi [7], F-AHP excels the conventional fuzzy method in problem selection and decision-making process. It was because the F-AHP can accommodate subjectivity of the decision-makers. The same result had been claimed by Anggraeni, Kusumawardani, and Ardianto [8]. They claimed that F-AHP method could produce a more objective, consistent, and measurable result compare to the experts' decision. Therefore, in this study, we used F-AHP as the main method to make a system that could early detect the Pulmonary Tuberculosis disease.

II. ANALYTICAL HIERARCHY PROCESS

AHP is a functional hierarchy method with its main input is based on a measure of human perception. The measure of human perception is selected by the experts who understand completely and correctly about the problem proposed as the main input [9].

AHP is divided into some principles, i.e.

1. Decomposition

Complex systems are easier to understand by solving them into smaller elements.

2. Comparative judgement

Criteria and alternatives can be made by pair comparison, given a scale of one to nine to determine the results of experts' opinion.

Table 1: Pairwise Comparison Intensity [10]

Intensity	Information
1	Both elements are equally important
3	One element is slightly important than the other elements
5	One element is more important than the other elements
7	One element is absolutely important than the other elements
2,4,6,8	Values between two values of adjacent considerations
invers	The invers value of pairwise comparison

3. Synthesis of Priority

The predetermined priority is based on the views of experts who have been appointed to determine the value of decision making, either through discussions or questionnaires.

4. Normalization of Matrices

Calculation of matrix normalization with N_{new} = value of new matrix element, N_i = value of column matrix elements, and K_i = value of the total number in that column, using formula (1).

$$N_{new} = \frac{N_i}{K_i} \quad (1)$$

5. Eigen Vector

Eigen Vector can be calculated with P = Eigen Vector, NTB = total number of matrix rows, and n = total criteria, by using formula (2).

$$P = \frac{NTB}{n} \quad (2)$$

6. Consistency

Calculate the consistency value to prove that the data is consistent and can be used on the next step.

$$\lambda_{max} = \frac{P}{X} \quad (3)$$

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (4)$$

$$CR = \frac{CI}{RI} \quad (5)$$

The number of criteria determines the RI value.

Table :. RI Value[11]

Number of Criteria	RI
1,2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48

III. FUZZY AHP

F-AHP method is the result of the development of the AHP analysis method [7]. F-AHP method covers the weaknesses in AHP. F-AHP gives more accurate results than AHP when having more subjective data [12].

F-AHP steps can be determined as follows:

1. Determine pairwise comparisons on the Triangular Fuzzy Number (TFN) scale.

Table 3: TFN Scale

AHP	Fuzzy	Fuzzy Inverse
1	1=(1,1,1)	(1,1,1)
3	3=(1,3,5)	(1/5,1/3,1)
5	5=(3,5,7)	(1/7,1/5,1/3)
7	7=(5,7,9)	(1/9,1/7,1/5)
9	9=(7,9,9)	(1/9,1/9,1/7)
2	2=(1,2,4)	(1/4,1/2,1)
4	4=(2,4,6)	(1/6,1/4,1/2)
6	6=(4,6,8)	(1/8,1/6/,1/4)
8	8=(6,8,9)	(1/9,1/8,1/6)

2. Determine the value of Fuzzy Synthesis (S_i) Priority, by using formula

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \times \left[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} \quad (6)$$

where:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left[\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right] \quad (7)$$

3. Determine the value of Vector (V) and defuzzification values (d'). The value of the Vector is found by using formula (8).

$$V(M_2 \geq M_1) = \begin{cases} 1, & if\, m_2 \geq m_1 \\ 0, & if\, l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & for\ others \end{cases} \quad (8)$$

Determine the value of Ordinate defuzzification by using formula (9).

$$d'(A_i) = \min V(S_i \geq S_k) \quad (9)$$

For k = 1,2,...,n, k ≠ i; then the vector weight values can be obtained such as:

$$W' = (d'(A1), d'(A2), ..., d'(An))^T \quad (10)$$

4. Normalize the vector weight value of fuzzy (W).

$$W\ (d(A1), d(A2), ..., d(An))^T \quad (11)$$

5. In the third and fourth steps can produce a zero value so that the criteria data used disappears. Then the defuzzification process can be replaced with the Best Nonfuzzy Performance (BNP) stage as an alternative step to avoid the amount of information loss from the usual defuzzification stage [13]. BNP formula is:

$$\text{BNP} = \frac{(l_i + m_i + u_i)}{3} \quad (12)$$

IV. SYSTEM PROCESS

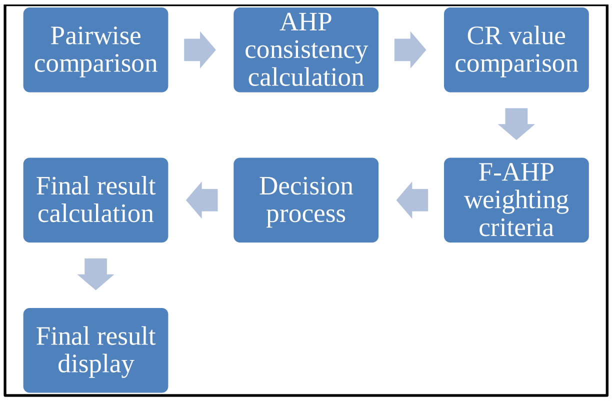


Figure 1: General system process

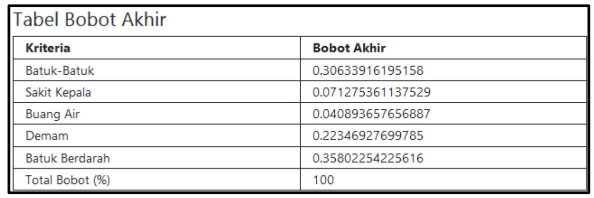
Several processes and steps are being built for the system, as shown in Figure 1. The first process is to fill in pairwise comparisons scale with experts' opinion. The second process is for calculating AHP consistency value, third process is for comparing the value of consistency ratio, fourth process is forweighting criteria using F-AHP, the fifth process is the decision of diagnosing result, if yes then user will input the criteria, the sixth process is the final result calculation where the user input will be multiplied to the weight of the criteria to get the final result calculation, and last process is to display the final result.

V. RESULTS AND DISCUSSION

Implementation of F-AHP to the system was done by following step by step procedures from AHP steps until Fuzzy steps. Figure 2 displays the user page where user can answer several questions given by the system based on his condition. If the user clicks the submit button, the user's input will be forwarded to the system and calculated by using F-AHP method.

Figure 2: User page

Figure 3 displays the output of the last weighting criteria calculation after Fuzzy steps.After the calculation process finished, the result of each criterion will be displayed on the Results page, as shown in Figure 4.



Tabel Bobot Akhir

Kriteria	Bobot Akhir
Batuk-Batuk	0.30633916195158
Sakit Kepala	0.071275361137529
Buang Air	0.040893657656887
Demam	0.22346927699785
Batuk Berdarah	0.35802254225616
Total Bobot (%)	100

Figure 3: Weighting criteria

Figure 4: Results page

After the successful system development, the system evaluation will be carried out through two processes, i.e., method testing and system usability testing.

The method testing for system evaluation will be carried out by comparing the final weight values of each criterion between the system calculation and manual calculation. Table 4 shows the result of the system calculation and manual calculation comparison.

Table 4: Comparison of Weight Calculation

Criteria	Manual	System
Batuk Batuk	30,63%	30,63%
Sakit Kepala	7,12%	7,12%
Buang Air	4,08%	4,08%
Demam	22,34%	22,34%
Batuk Berdarah	35,802%	35,802%

System usability testing was tested by using the System Usability Scale (SUS) method. SUS was tested through two types of samples, i.e., expert and user. Table 5 shows the SUS score by an expert's input.

Table 5: SUS by expert

Code	Score
R1	5
R2	1
R3	5
R4	1
R5	4
R6	3
R7	4
R8	1
R9	4
R10	3

In the system usability test conducted by expert produces a SUS score of 82.5 and can be categorized as "Acceptable." The user usability test system was done by using Google Form tool which was distributed online from 18 to 20 June 2019, and got a total of 28 respondents in the Gading Serpong population with an average SUS score of 86.16 and included in the "Acceptable" category.

VI. CONCLUSION

Based on the research that had been done, it can be concluded that the implementation of F-AHP algorithm on an expert system to early detect Pulmonary Tuberculosis disease has been successfully built.

Based on the system evaluation testing methods, we got the same value of each criteria weight between the system calculation and the manual calculation. Furthermore, based on the system evaluation with SUS method on expert produced a score of 82.5 and included in the "Acceptable" category. For the system evaluation on user's side, we got an average SUS score of 86.16 that can be categorized as "Acceptable."

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