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by Sugiyarto Sugiyarto

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Fuzzy Multi-Attribute Decision Making (FMADM) Application on Decision Support Systems (SPK) to Diagnose a Type of Disease

Sugiyarto[1], Mustika Sari[2]

Abstract:. Fuzzy logic is widely applied to daily life with various methods. One method is fuzzy multi-attribute decision making (FMADM). FMADM is able to select the best alternative from a number of alternatives. In FMADM there is a supporting method so that the results obtained are accurate and optimal, namely the classic MADM method. One method in classic MADM is the Simple Additive Weighting (SAW) method. The SAW method is precisely used to minimize diagnostic errors, but if a decision support system is made, the SAW method still requires a further development method, one of which is the FMADM method with its development. The purposes of this study are to describe the steps of SAW method and the development of FDM in theory, implement SAW method and the development of FDM to diagnose a type of disease and implement it in a decision support system using GUI matlab . The completion step of those two methods is through two stages, the first one will go through FMADM stage with SAW, which is weighted sum, then the output will be used as input to the FDM method based on total integral values. The result of this study is proven by patient experienced initial symptoms of high fever at a temperature of 39.5 ° C - 40 ° C, very much spots appear in rumple leed test (> 50 petheciae), bleeding gums, rarely got nausea and headache, as well as diarrhea. Accuracy for the decision support system using MAPE was obtained 93% so that the decision support system with FMADM method to diagnose the disease was feasible to use

Keywords— Diagnosing a Type of Disease, FDM, FMADM, SAW.

I. INTRODUCTION

Decision making is a problem solving process that produces a goal of factors such as subjectivity and linguistics which tend to be presented in real life to a lower or greater level [1]. Difficulties are often encountered when a problem involves several alternatives and the factors that influence it (criteria), to overcome this problem, it is able to use the Multi-Attribute Decison Making (MADM) method. The results of these methods still contain uncertainty so that in this case fuzzy logic plays an important role in overcoming problems that contain uncertainty. Fuzzy logic is the basis of a system that can implement a problem and so on sharp problems [2]. However, Fuzzy MADM is only able to solve the problem of uncertainty in the data presented and numbers of diverse attributes is usually conflicting, thus to make a decision there needs to be a classic MADM method, so that decisions are more precise and more accurate [3], besides this method can also be used to provide input to the doctor so that there is no mistake in diagnosing dengue disease. One of the classic MADM methods that can be used is Simple Additive Weighting.

Simple Additive Weighting is often referred as a method with weighted sum. The basic concept of SAW method is to find a weighted sum of performance branches on each alternative of all attributes [4]. One of the problems that can be solved by this method is the misdiagnosis of DHF. DHF is a type of infectious disease caused by the degue virus which is transmitted through the bite of the aedes aegypti and aedes albopictus mosquitoes. DHF is often misdiagnosed with Typoid Fever, Morbili, ARI, Ensafalitis and Acute Pharyngitis. These errors occur because the initial symptoms that arise from the five diseases are almost the same as DHF [5]. However, in this case the application of SAW method is less effective if a Decision Support System is made so that a development method is needed. The development method that can be used is the FMADM method with its development or often called Fuzzy Decision Making (FDM). This method is development method of the classic MADM method. The results of SAW method will be used as a level of importance or input on the FDM method. The combination of these two methods will produce more optimal output.

II. METHODOLOGY AND REALIZATION

A. Designing FMADM with SAW and FDM

The data used are primary and secondary data, primary data obtained from the results of doctor interviews and secondary data is data on patients with DHF, secondary data will be used to validate the system. Completion of cases of dengue diagnosis will be through SAW method then the results of SAW method are used in the FDM method.

The first method will use one crisp value with 1 degree membership and use preference weight multiplication while the second method uses 3 crisp values namely right boundary, left boundary and crisp value with 1 membership degree which will later go through the aggregation process and total integral value.

B. *The FMADM method with SAW to diagnose a type of disease*

Completion using the FMADM method with SAW:

1. Determine alternative sets and criteria.
   Alternative (A_i) is a_1 = Morbili, a_2 = DBD, a_3 = ARI, a_4 = Typoid fever, a_5 = Acute pharyngitis, a_6 = Ensafalitis. C_i criteria are c_1 = Fever, c_2= Spots, c_3 = Bleeding gum, c_4 = Nausea, c_5 = Headache, c_6 = Defecation Disorders

2. Determine the criteria weight

The weight of the criteria is obtained from triangular fuzzy numbers which are then converted into the form of crisp.

a. Fever

The author defines the universal value for the criteria for fever is [0,1] and divides it into 5 categories of fuzzy triangle sets, which are normal (N), low fever (DR), moderate fever (DS), high fever (DT), very high fever (DST)

By using the concept of the Likert scale and the defuzzy method, Large of Maximum, Table 2.1 is obtained as the weight of the criteria for fever.

Table. 2.1. Weight of Fever

Fever	Fuzzy Set	Crisp Value (weight)
36°C-37,5°C	Normal (N)	**0**
37,5°C-38°C	Low Fever (DR)	**0.25**
38°C-39,5°C	Moderate Fever (DS)	**0.5**
39,5°C-40°C	High Fever (DT)	**0.75**
>40°C	Very High Fever (DST)	**1**

b. Spots (Petheciae)

The author defines the universal value for the criteria of spots is [0,1] and divides them into 5 categories of fuzzy triangle sets which are none (TA), few (SDK), somewhat a lot (ABYK) many (BYK), very much (SBYK) . By using the concept of the Likert scale and the defuzzy method, Large of Maximum, the 2.2 Table is obtained as the weight of the criteria for spots:

Table.2.2. Weigth of Spots

Spots	Fuzzy Set	Crisp Value (weight
0-10 spots	None (TA)	**0**
10-20 spots	few (SDK)	**0.25**
20-30 spots	Somewhat a lot (ABYK)	**0.5**
30-50 spots	Many (BYK)	**0.75**
>50 spots	Very Much (SBYK)	**1**

c. Bleeding Gum

We are defines the universal value for bleeding gum criteria is [0,1] and divides it into 2 fuzzy triangle set categories namely never (TP), ever (P). By using the concept of the Likert scale and the defuzzy method, Large Of Maximum, the 2.3 Table is obtained as the weight of the bleeding gum criteria..

Table.2.3. Weight of Bleeding Gum

Bleeding Gums	Fuzzy Sets	Crisp Value (weight)
0 No	Never (TP)	0
Once or More	Ever (P)	1

d. Nausea

The author defines the universe value for the nausea criteria is [0.1] and divides it into 4 fuzzy triangle set categories namely never (TP), ever (P), rare (J) and often (S). By using the concept of the Likert scale and the defuzzy method, Large of Maximum, Table 2.4 is obtained as the weight of the criteria for nausea.

Table.2.4. Weigth of Nausea

Nausea	Fuzzy Sets	Crisp Value (weight)
0	Never (TP)	**0**
1 time a day	Ever (P)	**0.25**
2-3 times a day	Rare (J)	**0.5**
>3 times a day	Often (S)	**0.75**

e. Headache

The author defines the universal value for the headache criteria is [0,1] and divides it into 4 fuzzy triangle set categories namely never (TP), ever (P), rarely (J) and often (S). By using the concept of the Likert scale and the defuzzy method, namely Large Of Maximum, Table 2.5 is obtained as the weight of the headache criteria.

Table.2.5. Weight of Headache

Headache	Fuzzy Set	Crisp Value (weight)
0	Never (TA)	**0**
1 time a day	Ever (P)	**0.25**
3-4 times a day	Rare (J)	**0.5**

4-5 times a day	Often (S)	**0.75**

f. Defecation Disorder

The author defines the universal value for the criteria for defecation disorder is [0,1] and divides it into 3 categories of fuzzy triangles, namely normal (N), difficult to do defecation (SB) and diarrhea (D). By using the concept of the Likert scale and the defuzzy method, Large of Maximum, Table 2.6 is obtained as the weight of the criteria for BAB defects.

Table.2.6. Defecation Disorder Weight

Defecation Disorder	Fuzzy Set	Crisp Value (weight)
1 -2 times a day	Normal (N)	**0.5**
1-2 days unable to do defecation	Hard to do Defecation (SB)	**0.75**
>3 times a day	Diarrhea (D)	**1**

3. Determine the suitability rating of each alternative on each criterion. Interview results from an expert (doctor) on Table 2.7

Table.2.7. Linguistics Data

	c_1	c_2	c_3	c_4	c_5	c_6
a_1	DT	SDK	TP	J	P	SB
a_2	DT	SBYK	P	J	J	D
a_3	DT	TA	TP	T	J	N
a_4	DST	SDK	TP	P	S	D
a_5	DS	TA	TP	S	P	N
a_6	DST	TA	TP	J	S	SB

From the table, the match rating value is obtained as follows:

Table.2.8 Match Rating Value

	c_1	c_2	c_3	c_4	c_5	c_6
a_1	0.75	0.25	0	0.5	0.25	1
a_2	0.75	1	1	0.5	0.5	0.75
a_3	0.75	0.25	0	0	0.5	0.5
a_4	1	0	0	0.75	0.75	0.75
a_5	0.5	0	0	0.5	0.25	0.5
a_6	1	0	0	0.5	0.75	1

The compatibility rating in this method is also called the decision matrix which will be normalized.

4. The determination of the preference weight is stated in Table 2.9. as follows

Table.2.9 Preference Weight (W)

c_1	c_2	c_3	c_4	c_5	c_6	Total
30 %	30 %	10 %	10 %	10 %	10 %	100 %
0.3	0.3	0.1	0.1	0.1	0.1	1

5. Normalization of the matrix

$$R = \begin{bmatrix} 0.75 & 0.25 & 0 & 0.5 & 0.25 & 1 \\ 0.75 & 1 & 1 & 0.5 & 0.5 & 0.75 \\ 0.75 & 0.25 & 0 & 0 & 0.5 & 0.5 \\ 1 & 0 & 0 & 0.75 & 0.75 & 0.75 \\ 0.5 & 0 & 0 & 0.5 & 0.25 & 0.5 \\ 1 & 0 & 0 & 0.5 & 0.75 & 1 \end{bmatrix}$$

To find a matrix you can use the following formula:

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{max_i\ x_{ij}}, j\ is\ benefit\ attribute \\ \dfrac{min_i\ x_{ij}}{x_{ij}}, j\ is\ cost\ attribute \end{cases} \quad (1)$$

6. Finding preference values obtained from multiplication of weights W with normalized matrix R.

$$V_j = \sum_{j=1}^{n} w_j r_{ij} \quad (2)$$

The results of the calculation are shown in Table 2.10 as follows

Table.2.10 Preference Value

V_1 (Morbili)	V_2 (DBD)	V_3 (ARI)	V_4 (Typhoid Fever)
0.5	0.83	0.42	0.58
Rank 4	Rank 1	Rank 6	Rank 2

V_5 (Acute pharyngitis)	V_6 (Encephalitis)
0.30	0.57
Rank 5	Rank 3

The highest value achieved by the second alternative (V_2) is DBD so someone will be stated to suffer from DHF if they experience symptoms of high fever, spots (petheciae) very much, have experienced bleeding gums if they have entered a severe stage, rarely nausea, rarely headaches and have diarrhea, but to be sure to be able to use laboratory tests again.

In this case, SAW method is not appropriate if it is used to make a decision support system thus the author tries to use a method developed by Joo (2004) [6], namely the FMADM method with development or FDM.

C. *The FMADM method with SAW to diagnose a type of disease*

1. Representation of the Problem.
   Consists of 3 stages, namely:

   a. Objective Identification
   The purpose of this decision is to determine or diagnose an illness that is suffered based on the initial symptoms experienced.

   b. Identification of Criteria and Alternatives.
   The criteria used are still 6 types of diseases and 6 criteria (symptoms).

   c. The hierarchical structure that determines the disease is shown in the Figure 1.:

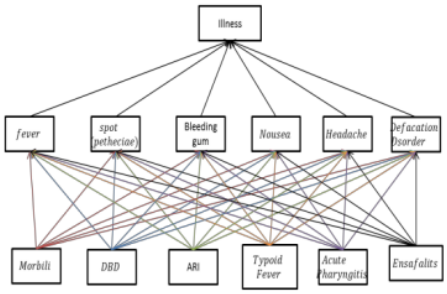

Figure 1. Hierarchy Structure

2. Evaluation of Fuzzy Sets
   Consists of 4 stages, namely:

   a. Selecting the set of ratings for the criteria weights. There are two things that must be done, namely determining the degree of importance and determining the degree of compatibility. T (importance) W = {c_1 = {N, DR, DS, DT, DST}, c_2 = {TA, DK, ABYK, BYK, SBYK}, c_3 = {TP, P}, c_4 =, c_5 = {, P, J, S}, c_6 = {NR, D, SB}}. T (match) S = {Very Low (SR), Low (R), Enough (C), High (T), Very High (ST)}.
   The parameters of each level of interest are as follows:

   N = (0, 0, 0.25),
   DR = (0, 0.25, 0.5),
   DS = (0.25, 0.5, 0.75),
   DT =(0.5, 0.75, 1)
   DST = (0.75, 1, 1)

   TA =(0, 0, 0.25),
   SDK=(0,0.25, 0.5),
   ABYK=(0.25,0.5,0.75),
   BYK= (0.5, 0.75, 1),
   SBYK=(0.75, 1, 1)

   TP = (0, 0, 1),
   P = (0, 1, 1),

   NR=(0.25, 0.5, 0.75),
   D=(0.5, 0.75, 1),
   SB=(0.75, 1, 1)

   J=(0.25, 0.5, 0.75),
   S=(0.5, 0.75, 1),

   The degree of compatibility of each decision criteria as follows:

   Very Low (SR) = (0, 0, 0.25),
   Low (R) = (0, 0.25, 0.5) ,
   Enough (C) = (0.25, 0.5, 0.75),
   Height (T) = (0.5, 0.75, 1)
   Very High (ST) = (0.75, 1, 1)

   Based on this, the degree of compatibility of each alternative is obtained to the decision criteria in table 2.11 and the branch of interest for the decision criteria in table 2.12

Table.2.11 the degree of compatibility of each alternative to the decision criteria

	c_1	c_2	c_3	c_4	c_5	c_6
a_1	T	R	SR	C	R	ST
a_2	T	ST	R	C	C	T
a_3	T	ST	SR	SR	C	C
a_4	ST	R	SR	T	T	T
a_5	C	SR	SR	C	C	C
a_6	ST	SR	SR	C	T	ST

Table. 2.12 Branch of Interest For Decision Criteria

Fever	Spot	Bleeding gum	Nausea
High	Very Much	Ever	Rare
(0.5,0.75, 1)	(0.75,1, 1)	(0, 1, 1)	(0.25, 0.5, 0.75)

Headache	Defecation Disorder
Rare	Diarrhea
(0.25, 0.5, 0.75)	(0.5, 0.75, 1)

   b. Aggregate the weight of criteria and the degree of compatibility of each alternative with its criteria, using the following equation:

$$Y_i = (\frac{1}{k}) \sum_{t=1}^{k} (o_{it} a_i)(3)$$

$$Q_i = (\frac{1}{k}) \sum_{t=1}^{k} (p_{it} b_i) \quad (4)$$

$$Z_i = (\frac{1}{k}) \sum_{t=1}^{k} (q_{it} c_i) \quad (5)$$

The result is compatibility index obtained from the aggregation of the weight of the criteria and the degree of compatibility of each alternative with its criteria that's shown in Table 2.13.

Tabel.2.13 Compatibility Index

Alternative	Compatibility Rate						Fuzzy Compatibility Index		
	c_1	c_2	c_3	c_4	c_5	c_6	Y_i	Q_i	Z_i
a_1	T	R	SR	C	R	ST	0.1146	0.3229	0.6146
a_2	T	ST	R	C	C	T	0.1979	0.4792	0.7708
a_3	T	ST	SR	SR	C	C	0.1667	0.3646	0.6250
a_4	ST	R	SR	T	T	T	0.1458	0.3854	0.7083
a_5	C	SR	SR	C	C	C	0.0625	0.2083	0.5208
a_6	ST	SR	SR	C	T	ST	0.1563	0.3542	0.6354

3. Selecting optimal alternatives

Prioritizing decision alternatives based on aggregation results by substituting the fuzzy match index value into the following equation:

$$I_T^{\alpha}(F) = \left(\frac{1}{2}\right)(\alpha c + b + (1-\alpha)a) \quad (6)$$

By taking optimism degree (α), namely: α = 0 (not optimistic), α = 0.5 (optimistic) and α = 1 (very optimistic). The following results are obtained on Table 2.14

Table 2.14 Integral Total Value

Alternative	Integral Total Value		
	α = 0	α = 0.5	α = 1
a_1	0.22	0.34	0.47
a_2	0.34	0.48	0.63
a_3	0.27	0.38	0.49
a_4	0.27	0.47	0.55
a_5	0.14	0.25	0.36
a_6	0.26	0.37	0.49

Based on the results above, it can be seen that regardless of the degree of optimism, the alternative a2 is that DHF has the greatest value compared to other alternatives.

D. *System Implementation*

a. Algorithm of Decision Support System.
The following figure (Figure 2.) is a flowchart that shows how decision support system works.

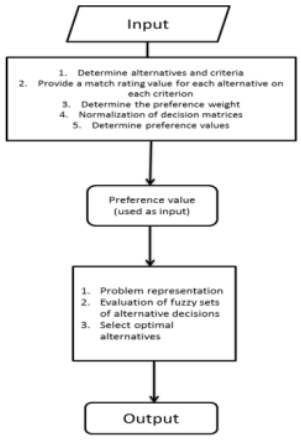

Figure. 2 Decision Support System Algorithm.

b. Implementation in Matlab.

Based on the *matlab* program algorithm, we must first do the FMADM process with SAW by making a coding in the editor according to the FMADM algorithm with SAW, then the results of the method will be used as input for the next method using the Graphical User Interface (GUI) that will be shown in the Figure 3.:

Figure. 3. View of GUI (Opening).

Figure 4 is the appearance of the two *matlab* programs with a GUI that contains: self-identity, symptoms experienced, save, clean, close, diagnosis, output, for self-identity and symptoms must be filled. The second display looks like the following picture:

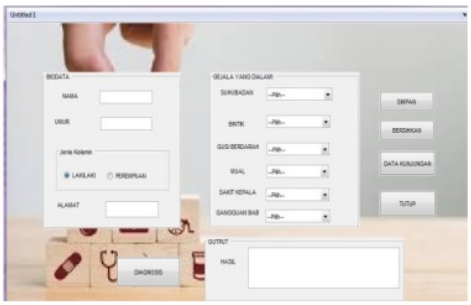

Figure .4 GUI Display (Form Filling)

Following are the steps to diagnose a type of disease: Fill in the biodata form and symptoms, then click the diagnosis button then click the save button. The results of the diagnosis are obtained as follows like what's shown in Figure 5.:

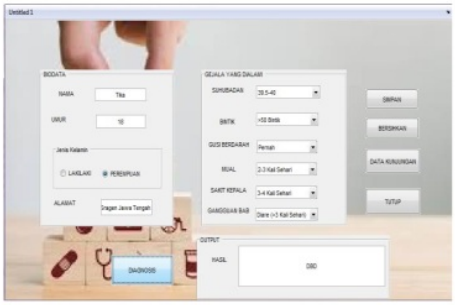

Figure.5 GUI Display (Diagnose Result)

The storage results are displayed in a form of what's shown in Figure 6.

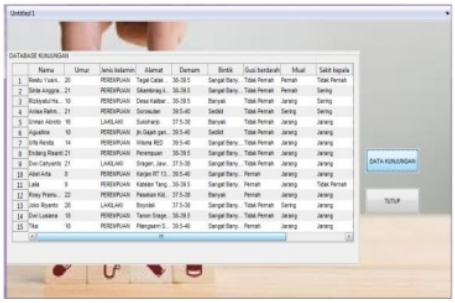

Figure .6 GUI Display (Data Base)

c. System accuracy testing

The accuracy of the FMADM decision support system with MAPE obtained the following equation

$$\text{The Accuracy} = \frac{\sum \text{Datauji benar}}{\sum \text{Totaluji}} \; x \; 100\% \quad (6)$$

Obtained from 30 data is as follows:

$$\text{The accuracy} = \frac{30-2}{40} \; x \; 100\% = 93\%$$

III. CONCLUSION

Based on the method in the first stage, the FMADM method with SAW rank 1 was obtained in the second alternative (V_2) so that someone can be confirmed to suffer from dengue if they experience the initial symptoms of high fever at 39.5 ° C - 40 ° C many spots appear during the lumple leed test (> 50 petheciae), bleeding gums, rarely experiencing nausea and headaches, then experiencing diarrhea. In the second method, the results of the first method will be the input for the second method, then the total integral value will be obtained with the degree of optimism α = 1, from the second method or FMADM with Development (FDM). Then the results of the accuracy of the decision support system with MAPE obtained 93% of 100% consisting of 40 patients suffering from DHF

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