A Development of Modified Profile Matching and Borda for Determining Treatment Priorities for Hemorrhage Stroke Patients

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***Abstract*— Recommendations for treatment dealing with stroke patients can be done with an intelligent system science approaches. One of them is through a decision support system based on the symptoms and features possessed and suffered by patients. The patient's symptoms and features are used as input for the decision support system to determine the priority of treatment, namely operative or conservative. This study aims to develop a decision support model for a medical expert group by utilizing the parameter features obtained from the examination results in the emergency unit. The results of this study are in the form of a group of medical expert decision models that each specialist has various parameter features that are used to support operative and conservative measures in hemorrhage stroke patients. For individual decision models, weighting of features is carried out directly by specialist doctors, whereas to determine patient feature scores on doctor's knowledge for patient treatment, the Profile Matching method is applied. The profile matching method was developed and modified by utilizing linear interpolation to determine the score instead of using a gap which had several weaknesses. For determining priority treatment, the SAW (Simple Additive Weighting) method is used. The group decision decision model uses BORDA to determine group common priorities. A testing for 10 patients using our GDSS compared with the common recommendation of specialist group shows the similarity of 70% (based on the confusion matrix).**

Keywords—Stroke Hemorrhage; Operative; Conservative; Decision Model; Profile Matching; SAW (Simple Additive Weighting).

I. INTRODUCTION

The field of medicine to determine the treatments needed for a patient suffering from hemorrhage stroke often has to involve several different specialist doctors: for example a neurologist, cardiologist, and internist. In general, operatives can be interpreted as medical actions carried out with the aim of healing patients by opening or dissecting certain parts of the patient's body. Surgery or operative are all medical treatment using invasive methods by opening or displaying the body part to be treated [1]. Whereas conservative treatment is a medical treatment using medication to be taken, and/or accompanied by therapeutic treatments without invasive methods. Based on the doctor's consideration, the requirements for operative and conservative treatments are needed. With the patient's condition, the most fulfilled requirements will be determined by the patient's conditions.. The most recommended treatment is the most fulfilled by the patient's requirements. Therefore a medical decision support system is needed that can help decision making based on requirements by specialist doctors to recommend treatment to these patients.

It is often that determining the treatment to the patient involves several specialists who may give different priority recommendations. Therefore a medical group decision support system is needed that has the ability to produce common decisions by utilizing the expertise of each specialist doctor. The group decision model consists of the decision maker weighting model, individual recommendations, and decision models. The role of the decision support system in diagnosing a disease from time to time has progressed towards a group decision support system, this system has advantages because decision making is based on several decision makers, and it is expected that the results of the decision will be acceptable.

The research of clinical group decision support systems conducted by Miranda et al. [2] is developing a multiagent system to support group decisions to emulate the stadium of cancer. This system advises users about the most suitable agent to help patients. Jingyi et al. [3] created a prototype of a group decision support system for public health emergency management. Whereas Kusumadewi et al. [4] developed a rule-based knowledge base model in the Clinical Group Decision Support System (CGDSS) that accommodates the different preference formats for each decision maker. Furthermore, Kusumadewi et al. [5] built a model for clinical group decision making to diagnose mental disorders, by utilizing expert competencies to give preference to several types of mental disorders using the Multi Attribute Decision Making. The process of generating priority recommendations is done by determining the priority objects to be produced, determining the parameters / features used to produce decisions and the types of criteria that support the decision, stopping the weight of parameters / features, determining scoring of object data based on criteria, determining object ranking.

II. DECISION SUPPORT SYSTEMS

A. Decision Support Systems

Decision Support Systems consist of: weighting models, scoring models (scoring), and decision models that produce priority. The weighting model is used to determine the weight of the parameters used by each decision maker. Models that can be used are direct, or AHP (Analytic Hierarchical Processes) weighting. While the scoring model can include normalization, rating, interpolation, AHP scoring, or Profile Matching. Decision models that can be used include SAW (Simple Additive Weighting), TOPSIS, or Electre. The process of generating priority recommendations is done by determining the priority objects to be generated, determining the parameters / features used to produce decisions and the types of criteria that support decisions, determining the weight of parameters / features, determining the scoring of object data based on criteria, and determining the ranking of objects

In this study, the priority object to be determined is treatment recommendations for patients, namely operative, and conservative. The parameters used are the features of patients that determine these treatments based on specialist doctor’s needs. While the criteria used are in the form of feature requirements to determine actions. Parameter weight is determined directly by a specialist. Scoring is obtained based on the patient's condition through the value of the patient's features, and is assessed using a matching profile to determine the extent to which the patient's features match the feature requirements to determine a treatment. Finally, the weight values and patient data scores are used to prioritize recommendations using SAW.

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH, Volume 10, Issue 2 Edition,, FEBRUARY-2019
ISSN 2229-5518

B. *Profile Matching*

Profile matching is a method of determining the parameter score of an alternative based on the proximity to the specified criteria preference. For example, to choose someone to occupy a certain position for, then a requirement is required to fulfill that position. The profile matching method can be used to determine the priority of the person based on the proximity of the alternative conditions to the position. Another example is, for example in choosing land, the conditions that are used as preferences are a certain extent, then the profile matching method can be used to determine which land alternatives are the area closest to that broad preference. The calculation process in the Profile Matching method, can use gaps, namely gap (data) = data - preferences. Then the data is scored based on the gap value. The highest score is achieved if the gap = 0, so the more the gap is close to 0, the higher the score. Furthermore, after calculating all the scores for all alternatives, the SAW decision method will have a weighted total score for each alternative. The results are used to determine ranking.

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C. *Group Decision Support Systems*

A Group Decision Support System (GDSS) is a computer-based application system that helps decision-making groups to produce common decisions as a team. In [6], the decision-making process that characterizes the GDSS, namely:

1) the decision-making process is a joint activity involving groups of decision makers who have the same status;

2) The results of decisions depend on the part of the knowledge of decision makers;

3) The results of decisions depend on the decision-making process used by the group;

4) The results of decisions are made through negotiations between group members based on ranking among members.

From the description above, it can be concluded that the results of group decisions will be very dominant depending on the level of importance of each group member decision [6]. One important aspect in the GDSS is the method of producing group decisions. One method that is widely used is the BORDA method, in Figure 1 which can be explained as follows: Suppose it is known the results of the decision of each decision maker (Decision Maker) with the weight of the decision makers as follows.

Table.1 Borda Group Decision Model

DM	DM weight	A_1	A_2	A_3	....	A_m
DM_1	W_1	R_{11}	R_{12}	R_{13}	....	R_{1m}
DM_2	W_2	R_{11}	R_{12}	R_{13}	....	R_{1m}
DM_3	W_3	R_{11}	R_{12}	R_{13}	....	R_{1m}
......	....	.....	.....	......	....	....
DM_n	W_n	R_{11}	R_{12}	R_{13}	....	R_{1m}

Note:
DM_i = i-th Decision Maker, i=1, 2, 3, ..., n
W_i = i-th decision maker's weight, i=1, 2, 3, ..., n
A_j = j-th alternative, j=1, 2, 3, ..., m
R_{ij}= Ranking result of alternative A_j by decision maker DM_i

In Borda's method, the highest ranking is given the largest score, while the lowest ranking is given the smallest score. For example, ranking is given from 1 to m (m is the number of alternatives), ranking 1 is given a score, say m, and the lowest ranking is scored 1

Supposed that $S_{ij} = Score\ for\ ranking\ R_{ij}$

$$V_j = \sum_{i=1}^{i=n} W_j * S_{ij} \quad (1)$$

Vj is the total score of alternative A_j. Group ranking results for alternative A_j are based on teh value of V_j. The biggest value of V_j indicates A_j has the highest rank.

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH, Volume 10, Issue 2 Edition,, FEBRUARY-2019
ISSN 2229-5518

III. CASE AND SOLUTION

In this study, recommendations for treatments to the patients will be determined, in the form of operative or conservative, based on the joint decisions of a neurologist, neurosurgery, anesthesia, heart, and lung after each provides recommendations. Recommendations from each specialist by considering the patient's condition. The recommendations of each specialist are conducted with the help of an individual Decision Support System with a direct feature weighting model, an assessment model using the modification of Profile Matching method, and a decision model with SAW.

A. *A case of Patient*

The following is an example of a patient's condition can be seen in the table below

Table 2. Patient's Fiture Data

Parameter/Fiture	Fiture value	Unity
Age	60	years
Consciousness	7	
Location of Bleeding	3.8	cm^3
Bleeding Volume	40	cc
Systolic blood pressure	115	mmHg
Diastolic Blood Pressure	75	mmHg
Pulse	70	x/menit
Respiration	20	x/menit
Haemoglobin	11.5	g/dl
Blood sugar	80	Mg/dl
Airway	90	%
Oxygen Saturation	Unblocked	
Body temperature	36	°c
Ureum	10	Mg/dl
Creatinine	3	Mg/dl
Natrium	132	Mg/dl
Calium	3.2	Mg/dl

In determining the action of the patient, in the form of operative or conservative, as an alternative in the individual DSS, features are needed in accordance with the needs of the specialist. In each treatment, the specialist determines the requirements for patients needed for each feature, and their ideal values. Suppose the Fi feature requires for operative treatment of patient feature requirements in the range [a, d], while the ideal value is in the range [b, c] $\subseteq$ [a,b]. For example, for surgery, the required age feature is [15.65] years, while the ideal age is [30.50] years The modified profile matching concept is: not using a gap, the score is determined by how close the patient is to the treatment requirements, not how near alternatives to the patient's condition. In the example of the Fi feature, suppose the patient's condition for that feature is x, while the highest score is given smax, and the lowest score is smin, then the operative score for x is given using linear interpolation with the formula:

$$Op(x) = \begin{cases} smin \quad if\ x \le a, or\ x \ge d \\ \frac{x-a}{b-a}(smax - smin) + smin \quad if\ a \le x \le b \\ smax \quad if\ b \le x \le c \\ \frac{x-c}{d-c}(smin - smax) + smax \quad if\ c \le x \le d \end{cases}$$

Meanwhile, the conservative score is presented with formulas:

$$Co(x) = \begin{cases} smax \quad if\ x \le a, or\ x \ge d \\ \frac{x-a}{b-a}(smin - smax) + smax \quad if\ a \le x \le b \\ smin \quad if\ b \le x \le c \\ \frac{x-c}{d-c}(smax - smin) + smin \quad if\ c \le x \le d \end{cases}$$

An application of the formula for the feature age is as follows:

$$Op(age) = \begin{cases} 1 \quad if\ age \le 15\ or\ age \ge 65 \\ \frac{age-15}{30-15}(5-1) + 1 \quad if\ 15 \le age \le 30 \\ 5 \quad if\ 30 \le age \le 50 \\ \frac{age-50}{65-50}(1-5) + 5 \quad if\ 50 \le age \le 65 \end{cases}$$

The ideal value is given a score of 5 on an ordinal scale of 1 to 5. For values above the ideal value or below the ideal value, an interpolation value is calculated to get the right score according to the level of closeness to the ideal value. In the operative treatment, a score of 1 is given if the patient's age is in the range if age ≤15 or age ≥65,

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH, Volume 10, Issue 2 Edition,, FEBRUARY-2019
ISSN 2229-5518

if 15≤age≤30 then the score is completed using an interpolation formula $\frac{age-15}{30-15}(5-1)+1$, and if in the range of 30≤age≤50 the score is 5. And if 50≤age≤65 will be completed using an interpolation formula $\frac{age-50}{65-50}(1-5)+5$, the optimal value of age at the age range of 40-50 years. Following this the conservative function for features the patient's age.

$$Co(age) = \begin{cases} 5, & if\ age \le 15\ or\ age \ge 65 \\ \frac{age-15}{30-15}(1-5)+5, & if\ 15 \le age \le 30 \\ 1, & if\ 30 \le age \le 50 \\ \frac{age-50}{65-50}(5-1)+1, & if\ 50 \le age \le 65 \end{cases}$$

The conservative function is given a score of 5 if the patient's age is in the range if age ≤15 or age ≥65, if 15≤age≤30 then to get the score scores is done using interpolation formula $\frac{age-15}{30-15}(1-5)+5$, and if in the range 30≤usia≤50 the score is 1. And if the range between 50≤age≤65 will be done using an interpolation formula $\frac{age-50}{65-50}(5-1)+1$.

B. An individual decision support system

Based on the condition of the patient's medical record in Table above, the score of the Profile Maching score will be calculated using interpolation according to the expertise table at each specialist doctor according to his specialty, then the score will be used in calculating the clinical decision support system SAW method to get the total value of each treatment as an alternative solution to the specialist's decision. For example the results of calculating scores for recommendations for action by neurologist as follows:

Table 3. Result of Calculation of Recommended Treatment Score by a Neurologist

No.	Fiture	Patient's fiture	a	b	c	d	Score	
							Operative	Conservative
1	Age	45	15	30	50	65	5	1
2	Shifting the midline structure	3,5	2	3	3	4	3	3
3	Consciousness	7	5	7	7	9	4	2
4	Location of Bleeding	3,8	3	4	4	5	3,2	2,8
5	Bleeding Volume	40	20	35	45	60	5	1
6	Systolic blood pressure	135	130	135	140	145	4	2
7	Diastolic Blood Pressure	95	90	100	100	110	2	4
8	Pulse	95	80	100	100	120	3	3
9	Respiration	24	20	25	25	30	3,2	2,8
10	Haemoglobin	22	10	11	11	12	1	5
11	Body temperature	36	36,5	38	38,5	40	1	5
12	Blood sugar	135	100	130	150	180	5	1
13	Ureum	49	45	50	50	55	3,2	2,8
14	Creatinin	3	1,2	1,8	1,9	2,5	1	5
15	Natrium	132	125	127,5	127,5	130	1	5
16	Calium	3,2	3	4	4,5	5,5	0,8	5,2

Furthermore, the neurologist determines the weight of the feature, and together with the results of the obtained score, using the SAW method can be derived:

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH, Volume 10, Issue 2 Edition,, FEBRUARY-2019
ISSN 2229-5518

Table 4. Result of the SAW Method

No.	Fiture	Fiture Weight	Score		Performance	
			Op	*Co*	*Op*	*Co*
1	Age	0,0784	5	1	0,39216	0,07843
2	Shifting the midline structure	0,0882	3	3	0,26471	0,26471
3	Consciousness	0,0882	4	2	0,35294	0,17647
4	Location of Bleeding	0,0882	3,2	2,8	0,28235	0,24706
5	Bleeding Volume	0,0882	5	1	0,44118	0,08824
6	Systolic blood pressure	0,0686	4	2	0,27451	0,13725
7	Diastolic Blood Pressure	0,0686	2	4	0,13725	0,27451
8	Pulse	0,0588	3	3	0,17647	0,17647
9	Respiration	0,0588	3,2	2,8	0,18824	0,16471
10	Haemoglobin	0,0686	1	5	0,06863	0,34314
11	Body temperature	0,0490	1	5	0,04902	0,24510
12	Blood sugar	0,0392	5	1	0,19608	0,03922
13	Ureum	0,0392	3,2	2,8	0,12549	0,10980
14	Creatinin	0,0392	1	5	0,03922	0,19608
15	Natrium	0,0392	1	5	0,03922	0,19608
16	Calium	0,0392	0,8	5,2	0,03137	0,20392
SUM					3,05882	2,94118
Priority					1	2

Note:
$Op = Operative$, $Co = Conservative$
$s_{i,Op} = score\ of\ i-th\ fiture\ for\ Op$ that can be obtained from computation of score formulas.
$s_{i,Con} = score\ of\ i-th\ fiture\ for\ Co$ that can be obtained from computation of score formulas
$w_i = weight\ of\ i-th\ Fiture$ that can be determined by specialist by considering the level of fitures that are dominant in supporting the decision. The weights are normalised so that

$$\sum_{i=1}^{number\ of\ fitures} w_i = 1 \quad (2)$$

Using SAW (*Simple Additive Weighting*) method, it can be derived that weighted Score for i-th fiture for Operative is

$$w_i * s_{i,Operative}$$

Weighted Score for i-th fiture for Conservative is

$$w_i\ s_{i,Conservative}$$

Therefore, the total score for each alternative is:

$$Op = \sum_{i=1}^{number\ of\ fitures} w_i * s_{i,Op} \quad (3)$$

$$Co = \sum_{i=1}^{number\ of\ fitures} w_i * s_{i,Co} \quad (4)$$

From the results of these calculations, the total score of the patient obtained for operative treatment is 3.05882, and the total score of conservative treatment is 2.94118. It can be concluded that for these patients based on neurologist is priority 1 is operative, and priority 2 is conservative. Thus, neurologists recommend the first priority is operative treatment, the second is conservative.

Other specialist doctors use the same method, but with the use of different features, and requirements. The comtputation can be done using the analogous formula for computing score using modified Profile Macthing method. Summarised results for all specialist doctors for priorotising the threatment can be shown in the following table.

Table 5. Result of DSS From Every Specialist

No	Specialist	**Operative**	**Conservative**
1	Neurologist	1	2
2	Neurosurgery	1	2
3	Anesthesia	1	2
4	Cardiologist	2	1
5	Pulmonary	2	1

IV. A GROUP DECISION SUPPORT SYSTEM.

In the medical group decision making process of hemorrhage stroke patients, it refers to the solution of the computation results of each Specialist Doctor referring to the case example. Before determining the outcome of a common decision, it is first determined the weight of the interests of the specialist in determining these treatments. Determination of weight can be obtained by agreement or determined by the coordinator doctor. The weight value in the following table is the value of the influence of specialists on the medical decision based on the condition of patients with inter-lateral hemorrhage stroke on the treatment. Suppose that the weight of a specialist doctor has been determined as follows (normalised values):

Table 6. Normalised Weight for Every Specialist

Specialist Doctors	**Weight of specialist interest for the treatment to the patient (normalised values)**
Neurologist	0,236842105
Neurosurgery	0,236842105
Anesthesia	0,210526316
Cardiologist	0,157894737
Pulmonary	0,157894737

With the Borda method, the priority results of previous recommendations, for high priority are given a big score. Furthermore, the weighting results combined with the results of the recommendations of previous treatments are presented in the following table:

Table 7. Weight and Score of Every Specialist

No	Spesialists	Weights	*Op*	*Co*
1	Neurologist	0,236842	2	1
2	Neurosurgery	0,236842	2	1
3	Anesthesia	0,210526	2	1
4	Cardiologist	0,157894	1	2
5	Pulmonary	0,157894	1	2

By multiplying the weight and score of Operative and Conservative for each specialists, it gives the following result:

Table 8. Coomon Results Of Operative And Conservative Treatment

No	Spesialists	Operative	Conservative
1	Neurologist	0,473684	0,236842
2	Neurosurgery	0,473684	0,236842
3	Anesthesia	0,421053	0,210526
4	Cardiologist	0,157895	0,315789
5	Pulmonary	0,157895	0,315789
Sum		1,684211	1,315789
Priority		1	2

Based on these result, the total value for all specialist doctors for operative treatment is 1.684211, and for conservative treatment is 1.315789474. Thus, priority 1 is operative treatment (biggest value), and priority 2 is conservative.

V. MODEL TESTING

The testing phase is carried out on 10 test data, which are the results of the calculation of the medical decision support system model of each specialist with a specialist doctor. Accuracy is determined based on the similarity of conclusions, not based on false right. Likewise for recall and precision based on similar conclusions.
Output of individual decision support systems for each specialist who provides first priority

Table 9. Result From System Of Every Specialist For All Patients

Patient	Neurologist	Neurosurgery	Cardiologist	Pulmonary	Anesthesia

INTERNATIONAL JOURNAL OF SCIENTIFIC & ENGINEERING RESEARCH, Volume 10, Issue 2 Edition,, FEBRUARY-2019
ISSN 2229-5518

Patient 1	Operative	Operative	Operative	Operative	Operative
Patient 2	Operative	Operative	Operative	Operative	Operative
Patient 3	Operative	Operative	Operative	Operative	Operative
Patient 4	Operative	Operative	Operative	Operative	Operative
Patient 5	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 6	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 7	Conservative	Conservative	Conservative	Operative	Conservative
Patient 8	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 9	Operative	Conservative	Operative	Operative	Operative
Patient 10	Conservative	Conservative	Conservative	Conservative	Conservative

For experts output in group,

Table 10. Recommendation From Every Specialist For All Patients

Patient	Neurologist	Neurosurgery	Cardiologist	Pulmonary	Anesthesia
Patient 1	Operative	Operative	Operative	Operative	Operative
Patient 2	Operative	Operative	Conservative	Conservative	Conservative
Patient 3	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 4	Operative	Operative	Operative	Operative	Operative
Patient 5	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 6	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 7	Operative	Operative	Conservative	Operative	Operative
Patient 8	Conservative	Conservative	Conservative	Conservative	Conservative
Patient 9	Operative	Operative	Operative	Operative	Operative
Patient 10	Conservative	Conservative	Conservative	Conservative	Conservative

For group test results, it is designed with the following scenario:

a) Group results in a system, and the results of expert group
b) For each patient, the operative decision is given a score of 1, and for conservatives is given a score of 2.
c) Using the normalised weight of each expert, both for the system and expert results, the score of the decision of each patient is calculated by multiplying with the expert weight, then the nearest number value is taken.
d) Suppose the normal weight of the j^{th}-expert is w_j ($j=1..n$), and the i^{th}-patient score ($i=1..m$) by the j^{th}-expert is r_{ij}, then the i^{th}-patient score for the expert group is

$$s_i = round\left(\sum_{j=1}^{n} w_j * r_{ij}\right) \qquad (5)$$

e) The formula is used both for system output and expert decisions.
f) Furthermore the combined output for i^{th}-patient is for $s_i=1$ is operative, and for $s_i=2$ is conservative
g) The results are then compared between expert group output on a system basis, with direct expert group output, to form a confusion matrix so that the value of accuracy, and average recall and precision precision are obtained.

Based on the scenario, the results of group testing are summarized as follows:

Comparison of outputs from expert groups by systems and experts.

Table 11. Result From GDSS And Specialist Group

Patient	GDSS	Expert Group
Patient 1	Operative	Operative
Patient 2	Operative	Conservative
Patient 3	Operative	Conservative
Patient 4	Operative	Operative
Patient 5	Conservative	Conservative
Patient 6	Conservative	Conservative
Patient 7	Conservative	Operative
Patient 8	Conservative	Conservative
Patient 9	Operative	Operative
Patient 10	Conservative	Conservative

Thus obtained confusion matrix is,

Table 12. Confusion Matrix

Output	System		
Expert	Treatment	Operative	Conservative
	Operative	3	1
	Conservative	2	4

And the results of accuracy, recall, and precision are as follows:

Table 13. Result From Confusion Matrix

	Operative	Conservative	Average
Accuracy	-	-	70%
Recall	75%	67%	71%
Precision	60%	80%	70%

VI. Conclusion

- The direct weighting model used in the medical decision support system involves a variety of specialist doctors to produce a treatment procedure for hemorrhage stroke patients by considering the value of the influence of specialist doctors on the health conditions of hemorrhage stroke patients
- The score calculation model uses interpolation profile matching resulting in a score value of each parameter feature against the influence of operative and conservative handling in hemorrhage stroke patients.
- The medical decision support system model of each specialist uses the SAW method which will produce alternative ranking values for operative and conservative treatment.
- Alternative ranking results of medical group decision support systems are obtained from combining the ranking values of each doctor involved in handling hemorrhage stroke patients.
- The result of the testing for the 10 patients shows that, there is 70% of same conclusion between output from GDSS and common recomendation of Specialist group.

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