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A GROUP OF MEDICAL SPECIALIST IN DETERMINING THE PRIORITY OF STROKE PATIENT TREATMENT

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Abstract. *The hemorrhagic stroke patients require the urgent and accurate treatments to handle the patients and they can be done by the approaches of the science of the intelligent systems and one of them is by using a decision support system method, based on the parameter features experienced and suffered by the patient. These patient's symptoms and features parameters are used as the input for the decision support system to determine the priority of the medical treatment, namely the operative or the conservative treatments. This study aimed to develop a decision support model for a medical expert group by utilizing the parameter features obtained from the examination results in the emergency installation unit. The results of this study were in the form of a group of medical expert decision models in which each of them had various parameter features that were used to support the operative and the conservative treatments for hemorrhage stroke patients. For individual decision models, the features weighting was carried out directly by the specialist doctors. To determine the patient's feature score towards the patient's treatment, a method was developed by using a linear interpolation to determine the score to substitute the use of gap.*
Keywords: Group decision support models, Linear interpolation, Medical treatments, Stroke patient treatment

1. **Introduction.** Stroke patients have a very high risk of disability or death if they experience delays in the treatment. In general, the treatments for the stroke patients are divided into two types, namely operative and conservative. The operative treatment can be interpreted as a medical treatment that needs to be carried out with the aim of healing a patient by opening or dissecting certain parts of the patient's body [1], whereas conservative treatment is a medical treatment using medication to be taken orally, and/or accompanied by non-invasive therapeutic treatments. In both types of the treatment, there are some requirements that must be fulfilled by the patient, which will be recommended based on the results of the examinations done by several specialist doctors. To overcome the time management or the meetings problems among the specialist doctors in determining the treatments for the patients, then it is necessary to have a medical

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decision support system technology that can assist the decision-making process based on the specific requirements to recommend the best treatment to the patient [2].

The decision model used for the decision support system DSS consists of a parameter weighting model, a scoring model, and a priority model. The determination of the medical treatment on the patients often involves several specialist doctors who may provide different priority recommendations [3]. The group decision model consists of the decision maker weighting model, the results of individual recommendations, and the decision model. The role of the decision support system in diagnosing a disease from time to time has developed towards a group decision support system. This system has some advantages because the decision-making process is based on several decision makers and it is expected that the results of these decisions will be better if it combines mathematical calculations that cannot only be done by humans just by doing direct observation [4].

The research of clinical group decision support systems conducted by [5] developed a multi-agent system to support group decisions to emulate the stadium cancer stages. This system advised the user about the most suitable agent to help the patient [6] created a prototype of a group decision support system for the public health emergency management. Meanwhile, [7] developed a rule-based knowledge base model in the Clinical Group Decision Support System (CGDSS) that accommodated the different preference formats for each decision maker. Furthermore, a clinical group decision-making model is built to diagnose mental disorders, by utilizing the experts' competence to give the preferences to several types of mental disorders using multi attribute decision making [8]. The process of generating the priority recommendations was carried out by determining the priority object to be produced, determining the parameter features used to make decisions and the types of criteria that support the decision, determining the weight of the parameter features, determining the scoring of object data based on the criteria, and determining the objects ranking.

From several research references that have been described above, the concentration of this research is in the form of a decision model of a medical expert group that can assist in the management of hemorrhagic stroke patients with emergency conditions, as well as rapid treatment that requires caution in conducting examinations. The expertise of each specialist doctor has different parameter features used to support operative and conservative management measures in patients. For individual decision models, feature weighting is carried out directly by specialist doctors, while to determine the patient's feature score against doctor's knowledge for patient care using linear interpolation. The difference from previous studies is in the calculation of the feature score which will have a significant effect even though the change in the number in the score is very small but can affect the final result to decide whether the patient should receive operative or conservative treatment.

2. **Proposed Method.**

2.1. **Individual decision support system.**

The individual decision support system consists of the weighting models, the scoring models, and the decision models that generate the priorities. The process of generating the priority recommendations is done by determining the priority object that will be generated, determining the parameter features that are used to make decisions and determining the types of criteria that support the decision, determining the weight of the parameter features, determining the scoring of object data based on the criteria, and determining the ranking of objects. The weighting model is used to determine the weight of the parameters used by each decision maker. The model that can be used is direct weighting, or AHP (Analytic Hierarchical Processes) weighting. While the scoring model uses a normalization, a rating, an interpolation, an AHP scoring, or a profile matching. The decision models that can be used include SAW

(Simple Additive Weighting), TOPSIS (Techniques for Order Preference by Similarity to Ideal Solution), or Electre [9]. In this study, the object that will be prioritized is the treatment that will be recommended for the patient, namely operative and conservative treatments [10]. The parameters used are the patient features that determine these treatments based on the specialist doctors' recommendations [11]. While the used criteria were in the form of the feature requirements to determine the types of the treatment. The parameter weights were determined directly by a specialist. The scoring was obtained based on the patient's condition through the value of the patient's features, and was assessed using the profile matching to determine the extent to which the patient's features match the feature requirements to determine a treatment. Finally, the weight values and the patient data scores were used to prioritize the recommendations using SAW.

2.2. **Profile matching.** Profile matching is a method of determining the parameter score of an object based on the proximity to the specified preferences for each alternative, or the alternative scores towards the specified criteria preferences. In [12], it used a profile matching in mobile social network communications to match the data that would be transferred by adopting the cryptographic techniques using homomorphic encryption that was used to process ciphertext [13]. Investigated the profile matching on DNA and the protein matching in biology with an appropriate score and threshold value approach to increase the model specificity and the searching sensitivity [14]. In the illustration, for example to choose someone to occupy into a certain position, then the requirements to occupy that position are needed. The profile matching method can be used to determine what position is most suitable for the person based on the proximity of the person's condition to the alternative position that will be chosen. Another example is that in choosing a land in a certain area, the requirement that is used as the preference is the size of the area, and then the profile matching method can be used to determine the alternative areas that are very close to the requirements of the desired size of the area. The calculation process in the profile matching method can use a gap, namely gap (data) = data − preference. Furthermore, the data is scored based on the gap value. The highest score is achieved when the gap = 0, so the closer the gap is to 0, the higher the score is. Moreover, after calculating all the scores for all alternatives, then a weighted total score for each alternative will be obtained by using SAW decision method. Finally, these results are used to determine the ranking.

2.3. **Interpolation.** Interpolation is a way of determining the value that lies between two known values based on an equation function. Interpolation is one of the easiest value determination techniques and is widely used to solve various problems, from ancient astronomy to the era of digital image processing [15]. One type of interpolation theorem is linear interpolation [16]. Linear interpolation is a way of determining the value that lies between two known values based on a linear equation (equation of a straight line). Linear equations are also called straight-line equations because if the results of linear equations are drawn on graph paper, the curve is a straight line. Linear interpolation is based on comparison theory. Linear interpolation calculation is as follows:

$$\frac{(X - X_1)}{(X_2 - X_1)} = \frac{(Y - Y_1)}{(Y_2 - Y_1)} \tag{1}$$

$$Y = Y_1 + \frac{(X - X_1)}{(X_2 - X_1)}(Y_2 - Y_1) \tag{2}$$

The ratio of distance $(X - X_1)$ to distance $(X_2 - X_1)$ is the same as the ratio of distance $(Y - Y_1)$ to distance $(Y_2 - Y_1)$. In this way, every point that lies between two points is known to have a linear relationship and will be determined by a calculation using the linear interpolation formula. Linear interpolation is one type of interpolation that is widely used in various fields, especially in the field of mathematics. Because it is widely used in calculations, this interpolation formula is usually already available in the calculation programs using software.

2.4. **Group decision support system.** Group Decision Support System (GDSS) is a computer-based application system that helps groups of decision makers to generate a common decision as a team. In [16,17], the decision-making process characterizes the GDSS in this study, namely 1) the decision-making process is a joint activity involving groups of the specialist doctors; 2) the results of the decision are partly based on the knowledge of the specialist doctors; 3) the results of the decision depend on the decision-making process used by the group of the specialist doctor; 4) the results of the decision are generated through the negotiations between the group of the specialist doctors based on the ranking among them. From the description above, it can be concluded that the results of group decisions will be very dominant depending on the level of interest of each member in the group of the specialist doctors [17]. One important aspect in the GDSS is the method for generating the group decisions. One method that is widely used is the BORDA method [15,19,20] which can be explained in the picture as follows: Suppose it is known the results of the decision of each decision maker (Decision Maker) with the weight of the decision maker as follows.

Decision maker	Weight decision maker	A_1	A_2	A_3	$\ldots$	A_m
DM_1	W_1	R_{11}	R_{12}	R_{13}	$\ldots$	R_{1m}
DM_2	W_2	R_{21}	R_{22}	R_{23}	$\ldots$	R_{2m}
DM_3	W_3	R_{31}	R_{32}	R_{33}	$\ldots$	R_{3m}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
DM_n	W_n	R_{n1}	R_{n2}	R_{n3}	$\ldots$	R_{nm}

Figure 1. Individual medical decision support scheme using Borda

Notes:
DM_i = ith decision maker, $i = 1, 2, 3, \ldots, n$
W_i = ith decision maker's weight, $i = 1, 2, 3, \ldots, n$
A_j = jth alternative, $j = 1, 2, 3, \ldots, m$
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, if the ranking is given from 1 to m (m is the number of alternatives), then ranking 1 is given a score, say m, and the lowest rank is scored 1. Suppose S_{ij} = Score for ranking R_{ij}

$$V_j = \sum_{i=1}^{n} W_j S_{ij} \tag{3}$$

V_j is the total score of alternative A_j. Then the group ranking results for the alternative A_j are based on the value of V_j. The largest V_j value gets the highest ranking.

The scoring process on the parameter features of bleeding stroke patients will be calculated using the profile matching method. This method is one of the methods used in decision support systems to determine data scores of alternatives. The profile matching method in general is how close the alternative data is to the specified target. In this study, the profile matching method was modified by a) utilizing linear interpolation calculations for numerical data; b) profile matching process by determining how close the patient's condition is to the requirements for operative or conservative measures.

3. **Case and Solution.** This study would recommend the treatments for the stroke patient, namely the operative or conservative treatments, based on the joint decision of

the neurologist, the neurosurgeon, the anesthesiologists, the cardiologist, and the pulmonologist. The recommendations from each specialist doctor were done by considering the patient's condition. The recommendations from each specialist doctor were carried out using an individual decision support system with a direct feature weighting model by the specialist doctor, an assessment model using a modified profile matching method with interpolation method, and a decision model using Simple Additive Weighting (SAW) and BORDA method.

3.1. **A case of patient xyz.** A patient with the name of xyz has the examination results in the ER and the Laboratory, the parameter features in the table were the parameter features that were used by the specialist doctor in carrying out the treatments to treat the hemorrhage stroke patients. The specialist doctor determined the necessary requirements for each feature, and the ideal value for the operative or conservative treatments.

Table 1. The patient examination results

Parameter	Fiture value	Unit
Age	46	Year
Consciousness	8	Scale
Shifting the midline structure	3.5	mm
Location of bleeding	3.7	cm^3
Bleeding volume	40	cc
Systolic blood pressure	115	mmHg
Diastolic blood pressure	75	mmHg
Pulse	70	x/minute
Respiration	20	x/minute
Hemoglobin	11.5	g/dl
Blood sugar	80	Mg/dl
Airway	90	%
Oxygen saturation	Unblocked	%
Body temperature	36	°C
Urea	10	Mg/dl
Creatinine	3	Mg/dl
Sodium	132	Mg/dl
Potassium	3.2	Mg/dl
SGOT	30	U/L
SGPT	35	U/L
Total bilirubin	0.7	mg/dl
Direct bilirubin	9.7	mg/dl
Indirect bilirubin	8.75	mg/dl

In the example of feature, suppose the patient's condition for that feature is x, while the highest score is given $S_{\max}$, and the lowest score is $S_{\min}$, then the operative score for x is given using linear interpolation with Formula (2). The implementation of an example of the parameter features on age, presented with the following Formula (4):

$$Operative(Age) = \begin{cases} 1, & \text{If } Age \leq 15 \text{ or } Age \geq 65 \\ \frac{Age-15}{30-15}(5-1)+1, & \text{If } 15 \leq Age \leq 30 \\ 5, & \text{If } 30 \leq Age \leq 50 \\ \frac{Age-50}{65-50}(1-5)+5, & \text{If } 50 \leq Age \leq 65 \end{cases} \tag{4}$$

The ideal value is given a score of 5 on an ordinal scale of 1 to 5. For the values above the ideal value or below the ideal value, an interpolation value calculation is carried out to obtain the right score according to the level of proximity to the ideal value. In the operative treatment, score 1 is given if the patient's age is in the range of $Age \leq 15$ or $Age \geq 65$, if $15 \leq Age \leq 30$ then the score is resolved using the interpolation formula $\frac{Age-15}{30-15}(5-1)+1$, and if in the range $30 \leq Age \leq 50$, the score is 5. And if $50 \leq Age \leq 65$ it will be completed using the interpolation formula $\frac{Age-50}{65-50}(1-5)+5$, the optimal value of age in the age range of 40 years.

The conservative function equation is given a score 5 if the patient's age is in the range of age is less than or equal to 15 or age is greater or equal to 65, if u is $15 \leq Age \leq 30$ then to obtain the score value is completed using the interpolation formula $\frac{Age-15}{30-15}(1-5)+5$, and if in the range $30 \leq Age \leq 50$, the score is 1. And if the range is between $50 \leq Age \leq 65$, it will be completed using the interpolation formula $\frac{Age-50}{65-50}(5-1)+1$. The following is an equation formula (5) of the conservative function of the patient's age parameter feature in hemorrhage stroke patient.

$$Conservative(Age) = \begin{cases} 5, & \text{If } Age \leq 15 \text{ or } Age \geq 65 \\ \frac{Age-15}{30-15}(1-5)+5, & \text{If } 15 \leq Age \leq 30 \\ 1, & \text{If } 30 \leq Age \leq 50 \\ \frac{Age-50}{65-50}(5-1)+1, & \text{If } 50 \leq Age \leq 65 \end{cases} \tag{5}$$

3.2. **The individual decision support system by the neurologist.** Based on the condition of the patient's medical record named xyz on Table 1, the value of the profile maching score would be calculated using the interpolation according to the neurologist, and then the score would be used in calculating the clinical decision support system using Simple Additive Weighting (SAW) method to get the total value of each treatment as an alternative solution for the neurologist's decisions. The results of the calculation score will determine the type of treatment for stroke patients recommended by neurologists. For other specialists doctor, they will use the same method, but with different features, and the requirements that can be different according to the risk level and the specialization.

Furthermore, by using the SAW method, the neurologist determines the weight of the features, together with the results of the obtained score.

Explanations:

$S_{iOperative}$ = Score of i feature for operative that can be obtained from the computation of the score formula

$S_{iConservative}$ = Score of i feature for conservative that can be obtained from the computation of the score formulas. W_i = Weight of the ith parameter feature that can be determined by the specialist by considering the level of the dominant features and the supporting features. The weights are normalized so that

$$\sum_{i}^{\text{a number of features}} W_i = 1 \tag{6}$$

Using SAW (Simple Additive Weighting) method, it can be derived that weighted score for the ith feature for operative is $W_i S_{iOperative}$, weighted score for the ith feature for conservative is $W_i S_{iConservative}$. Therefore, the total score for each alternative is

$$Operative = \sum_{i=1}^{n} W_i S_{iOperative} \tag{7}$$

$$Conservative = \sum_{i=1}^{n} W_i S_{iConservative} \tag{8}$$

TABLE 2. Result of calculation of recommended treatment score by a neurologist

No.	Feature	Patient's feature	Score		Performance	
			Operative	Conservative	Operative	Conservative
1	Age	59	2.6	3.4	0.20	0.26
2	Shifting the midline structure	3.2	4.2	1.8	0.37	0.15
3	Consciousness	8	3	3	0.26	0.26
4	Location of bleeding	3.3	2.2	3.8	0.19	0.33
5	Bleeding volume	39	5	1	0.44	0.08
6	Systolic blood pressure	140	5	1	0.34	0.06
7	Diastolic blood pressure	100	5	1	0.34	0.06
8	Pulse	101	4.8	1.2	0.28	0.07
9	Respiration	20	1	5	0.05	0.29
10	Hemoglobin	21	1	5	0.06	0.34
11	Body temperature	38	5	1	0.24	0.04
12	Blood sugar	140	5	1	0.19	0.03
13	Urea	50	5	1	0.19	0.03
14	Creatinine	2	4.3	1.7	0.16	0.06
15	Sodium	128	4.2	1.8	0.16	0.07
16	Potassium	4.1	5	1	0.19	0.03
Total					3.66	2.16
Priority					1	2

From the results of these calculations, the patient's total score for the operative treatment was 3.66, and the total score of the conservative treatments was 2.16. Based on the neurologist recommendations, it can be concluded that the patient had priority 1 that was the operative treatment, and priority 2 that was the conservative treatment. Thus, the neurologists recommended the first priority was for the operative treatment, and for the second one was the conservative treatment. For other specialists, they made the recommendations by using the same method, but with different features and requirements.

In order to make a decision for the specialist group of doctors, the coordinating doctor (neurologist) determines the level of importance of the specialist in recommending action to the patient. The level of importance is expressed in the weight of the specialist. The more important the specialist, the greater the weight. In this study, the weighting was given to the doctors involved, namely neurologist, neurosurgeon, anesthesiologist, heart specialist and lung specialist. The weight of each specialist doctor is determined based on the coordinator (neurologist) and agreement.

3.3. **The individual decision of the neurosurgeon.** The neurosurgeon used the following features: age, shifting the midline structure, consciousness, bleeding volume, systolic blood pressure, diastolic blood pressure, hemoglobin, body temperature, and then gave the recommendations for the first priority of the conservative treatment, then secondly the operative one. The results of the calculation were obtained by using an analogous formula from the previous neurologist. The obtained total score for the patient to have the operative treatment was 2.81 and the total score for the conservative treatment was 3.18. Based on the neurosurgeon's recommendation, it can be concluded that the patient had priority 1 that was the conservative treatment, and priority 2 that was the operative treatment.

3.4. **The individual decision of the anesthesiologist.** The anesthesiologist used the following features: age, consciousness, location of bleeding, bleeding volume, systolic blood pressure, diastolic blood pressure, pulse, respiration, hemoglobin, body temperature, airway, oxygen saturation, blood sugar, creatinine, then gave the recommendations for the first priority was the conservative treatment, and then second one was the operative treatment. The obtained total score for the patient to have the operative treatment was 2.34, and the total score for the conservative treatment was 3.65. Based on the anesthesiologist's recommendation, it can be concluded that the patient had priority 1 that was the conservative treatment, and priority 2 that was the operative treatment.

3.5. **The individual decision of the cardiologist.** Furthermore, the cardiologist used the following features: pulse, respiration, hemoglobin, body temperature, airway, oxygen saturation, blood sugar, total cholesterol, triglyceride, HDL, LDL, then gave the recommendations for the first priority was the conservative treatment, and then second one was the operative treatment. The obtained total score for the patient to have the operative treatment was 2.47 and the total score for the conservative treatment was 3.52. Based on the cardiologist's recommendation, it can be concluded that the patient had priority 1 that was the conservative treatment, and priority 2 that was the operative treatment.

3.6. **The individual decision of the pulmonologist.** Finally, the pulmonologist used the following features: blood sugar, hemoglobin, SGOT, SGPT, total bilirubin, direct bilirubin, indirect bilirubin, urea, creatinine, sodium, and potassium, then gave the recommendations for the first priority was the conservative treatment, and then second one was the operative treatment. The results of the calculation were obtained by using an analogous formula from the previous neurologist. The obtained total score for the patient to have the operative treatment was 3.07 and the total score for the conservative treatment was 2.92. Therefore, the priority was given to the treatment that possessed the biggest total value, namely the operative treatment with the value of 3.07.

Table 3. Result of calculation of recommended treatment score by a pulmonologist

No.	Feature	Patient's feature	Score		Performance	
			Operative	Conservative	Operative	Conservative
1	Blood sugar	140	3	3	0.31	0.31
2	Hemoglobin	21	1	5	0.12	0.6
3	SGOT	30	4.2	1.8	0.44	0.19
4	SGPT	35	5	1	0.53	0.1
5	Total Bilirubin	0.7	2.3	3.7	0.24	0.38
6	Direct Bilirubin	9.7	3.4	2.6	0.36	0.27
7	Indirect Bilirubin	8.75	1.7	4.3	0.176	0.45
8	Urea	9	5	1	0.3	0.06
9	Creatinine	2	3.5	2.5	0.21	0.15
10	Sodium	128	5	1	0.3	0.06
11	Potassium	4.1	1	5	0.06	0.3
Total					3.046	2.87
Priority					1	2

Based on the pulmonologist's recommendation, it can be concluded that the patient had priority 1 that was the operative treatment, and priority 2 that was the conservative treatment. Overall, the results of the individual decisions of each specialist were obtained.

4. **Result of Calculation.** The medical group decision-making process for hemorrhage stroke patients refers to the completion of the calculation results of each specialist doctors referring to the example of the case. Previously, it needs to define the weighting of the interests of the specialist in determining the action before the specialist doctors determining

the results of a common decision. The determination of the weighting can be obtained by having an agreement among the specialist or it can be done directly by the coordinator of the specialist doctors, the neurologist. The value of the weight in Table 4 is the value of the influence obtained from the specialists in making the medical decision based on the patient's condition with the treatment for the intracerebral hemorrhage stroke patient. By using the Borda method, the priority results of the previous recommendations for high priority were given a large score. Furthermore, the weighting results combined with the scores from the recommendations for the previous treatments are presented in Table 4. The results of the alternatives of the operative treatment and the conservative treatment from each specialist can also be seen in Table 4.

Table 4. The result of the recommended treatment by every specialist

Specialist	Weight	Normal weight	Operative	Conservative
Neurologist	9	0.23	0.45	0.23
Neurosurgeon	9	0.23	0.23	0.47
Anesthesiologist	8	0.21	0.21	0.42
Cardiologist	6	0.15	0.15	0.31
Pulmonologist	6	0.15	0.31	0.15
Total	38	0.97	1.35	1.58
Priority			2	1

Explanations:
W_i = weight of specialist i

$$\sum_{i=1}^{5} W_i = 1 \tag{9}$$

$d_{iOperative}$ = Priority ranking given by the i specialist for operative
$d_{iConservative}$ = Priority ranking given by the i specialist for conservative
Using SAW method, the total weight ranking for the ranking is

$$Operative = \sum_{i=1}^{5} d_{iOperative} \tag{10}$$

$$Conservative = \sum_{i=1}^{5} d_{iConservative} \tag{11}$$

The priority is given to the action with the smallest total value. Based on these data, the total score for all the specialist doctors for the operative treatment was 1.39 and for the conservative treatments was 1.60. Therefore, the first priority was the conservative treatment (the greatest value), and the second priority was the operative treatment.

5. **Conclusions.** Determining the treatments for the hemorrhage stroke patients requires careful consideration because it can bring serious results in permanent disability and even death. Therefore, each specialist needs to pay attention to the ideal value of each parameter feature that affects the treatment, namely operative and conservative and by having the support of the GDSS, which utilizes several methods to generate the recommendation for the treatments, which can speed up the final outcome of the treatment compared to the conventional method, by arranging a meeting schedule for the specialist doctors which will affect the golden time for the stroke patients to get final treatment immediately.

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