A Hybrid Model using Artificial Neural Network and Genetic Algorithm for Degree of Injury Determination

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A Hybrid Model using Artificial Neural Network and Genetic Algorithm for Degree of Injury Determination

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Abstract**: *Essentially, determination degree of injury is crucial for to support the law enforcement process. The existing models are deemed difficult in identifying the critical features for degree of injury classification. Some of which are considerable irrelevant and cause the inconsistency decision on process to determine degree of injury among the practitioners. If the Visum et Repertum (VeR) report is not well interpreted, the victim will get injustice decision. The purpose of this study is to develop a hybrid model for determining degree of injury. Based on Visum et Repertum (VeR) data. The model can classify the output of either having a minor, moderate, or serious injury which inclusively stated in Indonesian Penal Code. A hybrid model is developed from literature and case studies are conducted in three hospitals in Pekanbaru, Indonesia. Analysis is performed to discover the suitable component of the model-due to lack of comparison and analysis on the combination of critical features analysis and optimize the classification algorithm. Development and testing of the model are utilized VeR Dataset as private dataset (289 patients' data). In validating model, three case studies are investigated based on Subject Matter Expert (SME) groups to identify the agreement level. The questionnaires consist of a component, implementation, and viability of model that involved. Hybrid model components are validated by the SMEs, whereby the group determined highest rank of accuracy performance. Result from the questionnaire reveal that the average agreement level of SMEs. In conclusion, the finding shows hybrid model is generated 99.23% accuracy. The model components are implementable as a model and acceptable by the Practitioners as contribution for determining degree of injury.***

Keywords: **Data Mining, Neural Network, Forensic Medicolegal, Artificial Intelligence.**

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I. INTRODUCTION

Generally, a doctor carries out an individual examination task by conducting the medical examination, treatment, and determining the prognosis to the patient. It is aims to fulfill the responsibility of a doctor [1]. In the matter of fact, the medical examination also leads to support the process judgement in the sake of law enforcement. The process will engage with the live or dead victim of persecution case. The result will state in the form of report. This report is well known as Visum et Repertum (VeR). The VeR is requested by the investigators because the suspected criminal act [2] [3].

The making process of VeR in the injury case to living or dead victim will consider the persecution event fulfills the formulation of the Criminal Code. This criminal code will consist the article related minor maltreatment (article 351), formulation serious injuries (article 90) which can concerning article 351 paragraph (2), article 353 paragraph (2), article 354 paragraph (1), article 355 paragraph (1), article 360, article 365 paragraph (2) number 4, article 365 paragraph (4), and law article [4][5][6][7].

In the verification stage of judicial process, judgement will consider various legal facts based on evidence and conviction to make a decision. It must go through fulfill the sufficient of the correct evidence. For instance, one of evidence that is often use by the judge is the doctor's examination result that already stated in VeR that contains the health status of the victim. The description effect of the violence and abuse also explain there [4].

The challenge of this process occurs when there is no clear definition and boundaries between the minor and moderate injury that can lead the imbalance decision and less accuracy in determine the degree of injury. The current method of degree injury determination still depends on the opinion from the doctor. This will cause the various decision result among the practitioners. Inappropriate determination will have an impact to the punishment that will be imposed to the perpetrator. Criminal Code stated that the perpetrator of minor maltreatment will give sentence of imprisonment for maximum 3 months, while the moderate injury will imprisonment for 2 years and 8 months. Lastly, punishment increase up to 5 years if the victim classified in the serious injury [7]. Another challenge come from the insufficient suitable determination model due to lack of comparison and analysis on determination degree of injury.

Several studies compared the method used in the field of medicolegal prognosis to get the better determination model. The experience of doctor still influenced for the cases of abuse with bruises or abrasions on many parts of the human body [8]. The degree of minor injury usually written as "injury that does not cause disease of obstruction in carrying out work or livelihood", while the moderate injury is usually written "which causes a disease that result the obstacle in doing work, livelihood temporarily. Injury assessment by classifying trauma victims gathered from Injury Severity Score (ISS) and the value of Abbreviated Injury Scale (AIS) which has score of injury severity based on the anatomic parameters. The ISS score is highly correlated with possibilities life / Probability of Survival (Ps) trauma patient. ISS uses six different regions, namely the head and neck, face, chest, abdomen or contents of the pelvis, extremities and external structures. ISS scoring with description 1 is minor; 2 is moderate; 3 is severe, not life-threatening; 4 is severe, life-threatening; 5 is critical, survival is uncertain; 6 is unrevivable. Weakness of the ISS if there is severe multiple injury in one body region and the ISS gives equal weight to each body region, for example: AIS 3 scores in the chest region will provide a different prognosis when compared with the AIS 3 score in the head region. Another example: AIS 5 score in the chest region will give the prognosis is different when compared with the AIS 5 score in the head region. In 1997, to correct the limitations of the ISS, a New Injury Severity Score (NISS) was found which summed the quadrants of three injuries with the highest AIS score without considering whether they came from different regions. different from the ISS, the NISS only looks at the degree injury severity so that it can consider multiple injuries in one region of the body. Practically, a single indicator that mostly known as Trauma and Injury Severity Score (TRISS). TRISS resulted the probability of survival (prognosis) in the form of percentage. Practically, the indicators that mostly known as Trauma and Injury Severity Score (TRISS) and International Classification of Disease, 9th Revision, Injury Severity Score (ICISS). The TRISS method use a database from the Major Trauma Outcome Study (MTOS). TRISS has deficiencies in describing injuries that occur until problems are not considered the aspects of pre-existing medical/ disease conditions [9]. Based on the background above, the researcher interested in conducting research with the hybrid model which is Artificial Neural Network and Genetic Algorithm techniques by using critical features obtained from previous studies to increase the accuracy of the degree of injury determination model [3][10].

II. RELATED WORK

Examination techniques in the case of victims living either injury, or sexual crime / rape, in principle are the same as other clinical procedures. The examination generally includes history, physical examination and investigation if needed. There are fundamental differences between medicolegal examinations and clinical examinations for the benefit of medicine, namely medicolegal examinations aimed at enforcing the law in a criminal event experienced by the victim through the preparation of a good Visum et Repertum report [11].

Differences in the criteria used for assessing injuries are very necessary because they are related to the possibility of death, costs, negligence, quality of life, and disability. The method used is an ICISS (ICD-based Injury Severity Score), which involves the value of Survival Risk Ratio (SRR) which calculates the ratio of life expectancy for each individual (ratio of the number of patients with surviving injury codes compared to the total number patients who have been diagnosed with the code) [12]. The ICISS score comes from ICD-10-AM which contains the code due to the injury experienced. ICSS is also combined with age and the Revised Trauma Score (RTS) score in the analysis method which is similar to the analysis of the Trauma Related Injury Severity Score (TRISS). Another study Adding new value to data collected by proposing decision analysis, as well as link between various perception among the practitioners [13]. The research also underlined that finding and improving the worst degree of injury. A suggestion of formalized decision analysis approach that utilized a ruled based on expert for selecting multi criteria is the one of contribution in this research [14].

III. PROBLEM FORMULATION

This paper aims to develop an optimal Artificial Intelligence Algorithm which can overcome with all kind of injury degree which are minor, moderate and serious injury. Developing algorithm for every kind of injuries for the same model will lead outcome into a very limited time. The aim is to develop a hybrid algorithm in order to improve the consistency in determine the degree of injury. It's not an easy job as it looks to be as nature of every injury is different and may be fall in different classifications.

This research is adapted mix method which are generally embedded design through case study at three hospitals in Pekanbaru Indonesia. The qualitative and quantitative data simultaneously were collected. The qualitative form used to support the other form of data. The reason for collecting the second form of data was used to support the primary form of data. The supportive data may either qualitative or quantitative [15][16].

There are two part in this research such as qualitative (survey dataset) and quantitative (compute dataset). The quantitative dataset collected in the private dataset which are Bhayangkara Hospital Pekanbaru, Indonesia. The dataset used in the development and testing phase, then the qualitative dataset collected in the initial phase and validation process. The initial phase will do survey on three hospitals that consists of private and public hospital in Pekanbaru. The aim of this survey is to gather the challenge and requirement on the environment situation. This part will consider as case study approach. The validation of the model done by qualitative survey on 3 hospitals in Pekanbaru, and divides by 3 case studies such as general doctor, specialist doctor,

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IT expert. The qualitative aspect consisted of an interview about the critical feature in determining degree of injury with number of subjects of 20 subject matter Experts to their knowledge. The purpose of this mixed method study was to use the qualitative interview to discover the quantitative findings.

Model is used to give overall picture of possible result of the action based on preferred method to an idea. The model concerns on how to present the relationship among all the aspects of the research. The dependency, structured among the literature, problem, purpose, methodology, data collection, analysist, functions, and resources are loosely illustrated using model of the research. The develop model will describe the entire process to design research, data collection, model component, and process of the evaluation and validation of degree injury determination model. The purpose aim is to implement the model as a system design. The proposed model is developed by adapting the CRIPS-DM methodology (Figure 1).

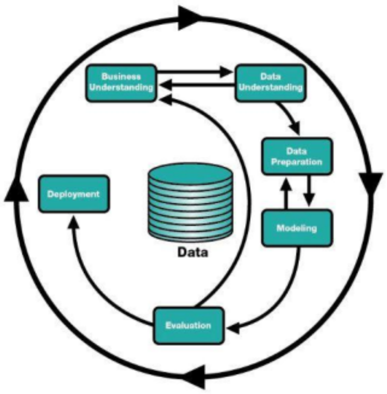

Figure 1: CRISP-DM Standard Methodology

The CRISP-DM (Cross Industry Standard Process for Data Mining) project recommended a comprehensive process model for carrying out data mining technique. This research claim in a general process model for data mining and shows some experiences with the CRISP-DM process model in practice. This research adopted methodology in a response modeling application project. The process model serves an excellent foundation for developing a specialized process model.

In this study, 260 samples from VeR of survivor used randomly by using sampling method from the data collection which exist in the forensic department at Bhayangkara Hospital Pekanbaru. The results of this study are presented in the form of diagrams, tables, and curves.

PROPOSED SOLUTION

The proposed solution is designed after concerning on the problem definition. The solution is divided into series of activities.

a) Performing a hybrid Artificial Intelligence and Genetic Algorithm Model using VeR data for the classification of the proposed solution.
b) Evaluation of the parameter to optimize the performance result.
c) Test and discuss the result.

Simulation Environment

This activity is to design the model for classification for determining the injury degree. The experimental is done by trial and error in order to tuning the parameters on the model such as training cycle, learning rate, momentum and hidden nodes. There are several stages to build the model using Artificial Neural Network algorithm.

Step 1: Normalization of training and testing data with the following formula.

$$xx_{ik} = \frac{x_{ik} - \min(x_i)}{\max(x_i) - \min(x_i)}$$

Where:
xx_{ik} = Normal value (0-1) from variable i to k data
x_{ik} = Real value from variable i to k data
max (x_i) = Maximum value from variable i
min (x_i) = Minimum value from variable i

Step 2: Set predictor variables, response variables, learning rate, momentum, number of hidden layers, number of hidden neurons expected number of iterations and expected convergence.

- In this case the output variable (y) = Degree of injury obtained from the results of multi criteria analysis
- Number of variables = 51 variables
- Learning rate (α) = 0.9
- Momentum (μ) = 0.2
- Number of hidden layers (j) = 1
- The number of neurons in the hidden layer (i) = 15
- The maximum number of iterations to reach convergence ($\Delta\varepsilon$) = 0.00001 is the max iteration = 1000
- The amount of training data set = 260 data
- Total testing data = 29 data

Step 3: Weight Initiation (wj) with small random numbers 0-1.

For each pair of training data, do steps (7-15) followed by steps (4-6)

Step 4: Calculate RMSE for all observations.

$$\text{RMSE} = \sqrt{\frac{(y_k - y)^2}{n}}$$

Where:
yk = Prediction value for k data
y = Real value from observed result at k data

Step 5: Calculate convergence change ($\Delta\varepsilon$).
$\Delta\varepsilon$ = RMSE (t+1)– RMSE(t)
Where:
RMSE (t+1) = Value of RMSE which obtained from next iteration
RMSE (t) = Value of RMSE which obtained from previous iteration

Step 6: Calculate convergence change ($\Delta\varepsilon$).

The decision if $\Delta\varepsilon \leq$ threshold (= 0.00001) then the learning process has been completed and the parameters on the ANN can be used to make predictions. But if $\Delta\varepsilon >$ threshold (= 0.00001) then take steps (7-15) followed by steps (4-6)

Step 7: Each input receives a signal and continues to the hidden unit.

Step 8: Calculate output in hidden unit (Zj) where (j = n * j).

$$z\_net_j = v_{j0} + \sum_{i=0}^{n} x_i * v_{ji}$$

Zj = f (Znet$_j$)

$$Z_j = \frac{1}{1 + e^{-Znet_j}}$$

Where:

vj = Neuron weight at j and variable at i

Xi= variable at i

Z net j = net to neuron at j

Z_j = Output of hidden unit at j

n = number of variable x

Step 9: Calculate output in unit Y_k.

$$y\_net_k = w_{k0} + \sum_{i=0}^{n} z_j * w_{kj}$$

$$y_k = \frac{1}{1 + e^{-y\_net_k}}$$

Where:

wkj = weight on the output unit to k and the neuron to j

y_net j = net on the first neuron

yk = output at unit output to k

n = Number of variables x

Step 10: Calculate variance (e).

$e = (yk-y)^2$

where:

e = variance or difference in predictive value of ANN

y = Real value

Step 11: Calculate the δk factor in the output unit Yk.

$\delta_k = (t_k - y_k) * y_k * (1 - y_k)$

Step 12: calculate the rate of change in weight on the output unit (jwkj) with the learning rate (α) = 0.4

$\Delta w_{kj} = \alpha * \delta_k * Z_j$

Step 13: Calculate the sum of errors in the hidden unit δj.

$\delta\_net_j = \delta\_w_k$

$\delta j = \delta\_net_j * (Z_j) * (1 - Z_j)$

Step 14: Calculate the weight change rate (Δvji) on the hidden unit δj.

$\Delta v_{ji} = \alpha * \delta_{ji} * Z_j$

Step 15: Calculate all changes in weight.

5 New weight on the output unit

Wkj (t + 1) = Wkj (t) + Δwkj + μ (Wkj (t) - Wkj (t-1))

t-1 = initial time

t = first iteration (before)

t + 1 = second iteration (after)

5 New weight on hidden units

vji (t + 1) = vji (t) + Δvji + μ (vji (t) - vkj (t-1))

in order to run the step above, the Rapidminer modelling tools is used to help the modelling process. First stage is determination of training cycles by conducting the test range from 50 to 1000, as well as learning rate from 0.1 to 1. Followed by the momentum from 0 to 0.9. and hidden neuron size from 1 to 25. All of the parameter started by the default setting using Rapid Miner Software for the trial. The first step experiment reported below in Table 1.

Table- I: Determination of Training Cycle Using ANN and Genetic Algorithm Model

No	Training Cycle	Learning Rate	Momentum
1	50	0.3	0.2
2	100	0.3	0.2
3	150	0.3	0.2
4	200	0.3	0.2
5	250	0.3	0.2
6	300	0.3	0.2
7	350	0.3	0.2
8	400	0.3	0.2
9	450	0.3	0.2
10	500	0.3	0.2
11	550	0.3	0.2
12	600	0.3	0.2
13	650	0.3	0.2
14	700	0.3	0.2
15	750	0.3	0.2
16	800	0.3	0.2
17	850	0.3	0.2
18	900	0.3	0.2
19	950	0.3	0.2
20	1000	0.3	0.2

Training cycle selected based on the highest values of classification accuracy and Kappa. Based on the experiment above, the selected training cycle value is 1000. This training cycle result then use for the next experiments in determining the learning rate. Learning rate is determined by conducting the trial by putting the value range from 0.1 to 1, while the momentum value 0.2 still used as default from Rapid Miner Studio. The experiment of determining the learning rate shown in Table 2.

Table- II: Determination of Learning Rate Using ANN and Genetic Algorithm Model

No	Training Cycle	Learning Rate	Momentum
1	1000	0.1	0.2
2	1000	0.2	0.2

3	1000	0.3	0.2
4	1000	0.4	0.2
5	1000	0.5	0.2
6	1000	0.6	0.2
7	1000	0.7	0.2
8	1000	0.8	0.2
9	1000	0.9	0.2
10	1000	1	0.2

Learning rate selected based on the highest value of accuracy and kappa. Based on the result of experimental above, the learning rate is chosen as 0.9. The learning rate value used for the further experiments in order to retrieve the momentum. Refer to previous trials, training cycle selected as 1000 and learning rate is 0.9 which are used to determine the momentum. The experiment for determining the momentum shown below in Table 3.

Table- III: Determination of Learning Rate Using ANN and Genetic Algorithm Model

No	Training Cycle	Learning Rate	Momentum
1	1000	0.9	0
2	1000	0.9	0.1
3	1000	0.9	0.2
4	1000	0.9	0.3
5	1000	0.9	0.4
6	1000	0.9	0.5
7	1000	0.9	0.6
8	1000	0.9	0.7
9	1000	0.9	0.8
10	1000	0.9	0.9

Refer to Tabl[illegible] the parameter setting for training cycles become 1[illegible], learning rate 0.9 and momentum 0.2. The next step will determine the number of hidden layers to find the highest value of accuracy and smallest classification error. One hidden layer was used in this experiment. The neurons size range is set up from range 1 to 25. Table 4 shown the result of determination process of hidden neuron size.

Table- IV: Determination of Hidden Neuron Size Using ANN and Genetic Algorithm Model

No	Training Cycle	Learning Rate	Momentum	Hidden Neuron Size
1	1000	0.9	0.2	1
2	1000	0.9	0.2	2
3	1000	0.9	0.2	3
4	1000	0.9	0.2	4
5	1000	0.9	0.2	5
6	1000	0.9	0.2	6
7	1000	0.9	0.2	7
8	1000	0.9	0.2	8
9	1000	0.9	0.2	9
10	1000	0.9	0.2	10
11	1000	0.9	0.2	11
12	1000	0.9	0.2	12
13	1000	0.9	0.2	13
14	1000	0.9	0.2	14
15	1000	0.9	0.2	15
16	1000	0.9	0.2	16
17	1000	0.9	0.2	17
18	1000	0.9	0.2	18
19	1000	0.9	0.2	19
20	1000	0.9	0.2	20
21	1000	0.9	0.2	21
22	1000	0.9	0.2	22
23	1000	0.9	0.2	23
24	1000	0.9	0.2	24
25	1000	0.9	0.2	25

The value of one hidden layer with neuron size is 15 is chosen in order generated the highest accuracy 99.23 % and classification error value of 0.77% with kappa 0.975. from the experiment, the ANN Model is developed with architecture that produces one hidden layer and 15 hidden neuron size with 93 (ninety-three) attributes of the input layer and 3 (three) attributes output layer. Table 5 shown the overall result of parameter that already tuned in order to improve the ANN performance to determine the degree of injury.

Table- V: Experiment Result ANN-GA Model for Degree of Injury Determination Model

No	ANN-GA Model	
1	Training Cycle	1000
2	Learning Rate	0.9
3	Momentum	0.2
4	Hidden Neuron Sizes	15
5	Accuracy	99.23%
6	Classification Error	0.77%
7	Kappa	0.975
8	Absolute Error	0.017
9	Root Mean Square Error	0.068

IV. RESULT OF SIMULATION

Evaluation Analysis

The ANN – GA model has good ability in predicting the degree of injury based on VeR. The validation model is done in two ways. Firstly, is by comparing the rating value with the surface area from the results of the assessment with statistical tests paired with T test and non-parametric level of injury classification accuracy test with Ci-Square. The ANN-GA model gives R^2 0.917. Meaning that 91.7% if the variation on the surface can be understood by the Hybrid Model (ANN-GA).

Whereas about 7.3% of the variation in the surface are cannot be seen by ANN-GA. This occurs because the surface is is not only the determinant feature of the injury degree that set by the forensic doctor but also by the body region, type of injury (Figure 3).

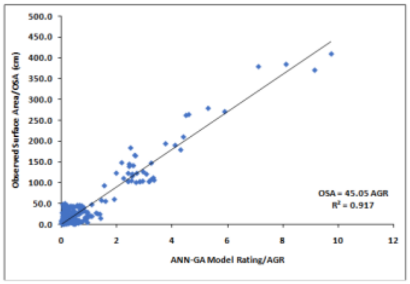

Figure 2: The Graph of Relationship Rating on Observation Surface Area and ANN-GA Model

In addition of using the T-test, the analysis also carried out using the Chi-Square test. Analysis using Chi-Square produce accuracy model 99.23% and significant at the 95% confident level with value of X^2=499.26 and P-Value < 0.05. It shown in Table 6.

Other statistical test using ROC Curve shows that the model is relatively accurate by giving AUC of 0.987 with P-Value 0.000 <0.05 significant at the 95% confidence level (Figure 3 and Table 7).

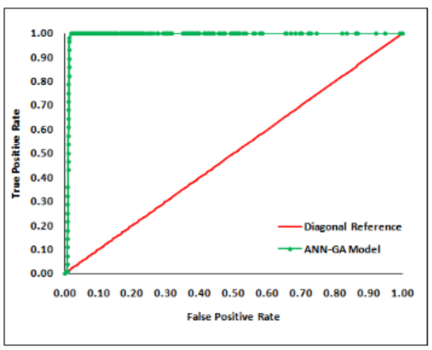

Figure 3: ROC Curve from ANN-GA Model

Table- VII: Result Evaluation of the Accuracy ANN-GA Model using Chi-Square

Area Under the Curve				
Area	Std. Error [a]	P-Value	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.987	0.008	0.000	0.972	1.000
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

Thus, it can be concluded that the ANN-GA model has reliable level of accuracy in classify the degree of injury.

Expert Evaluation

Evaluation of the features and implementation of the proposed model is carried out by the general doctor, specialist doctor and IT expert. There are 7 questions given regarding the feature and implementation of the proposed mode. The results showed that the response of the evaluators to the feature developed in ANN-GA was relatively good as seen from the number of evaluators who answered agreeing with the developed system of more than 50% of the total evaluators and none of them responded disagreeing with the ANN-GA feature. Whereas the aspect of ANN-GA implementation is also the same. While, the number of evaluators who answered agreed and strongly agreed more than 50% (Figures 4 and 5) and Tables 8 and 9.

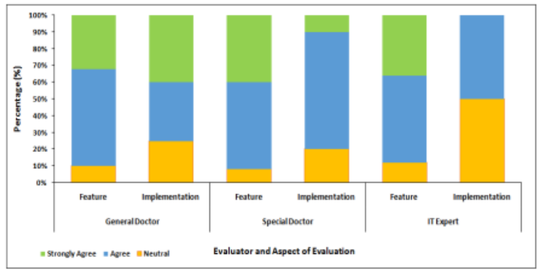

Figure 4: The Distribution of Evaluation Results Based on the Evaluator to Feature and Implementation

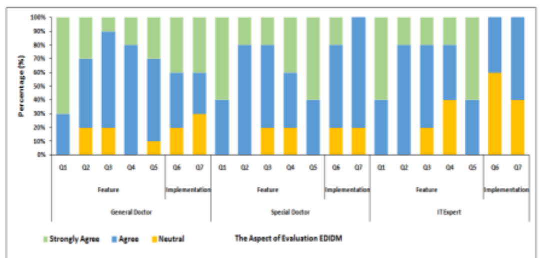

Figure 5: Distribution of Evaluators Details Based on the Evaluation Results to features and implementation

In more detail, almost all the questions about ANN-GA feature and implementation also received a good response from all that was marked by the number of respondents who agreed with ANN-GA feature and implementation of more than 50% of the total evaluators.

Table- VI: Result of the Accuracy Evaluation of ANN-GA using Chi-Square Method

ANN-GA Classification RESULT	OBSERVATION CLASS			TOTAL	P-Value
	MINOR	MODERATE	HEAVY		
MINOR	221			221	
MODERATE	2	26		28	
HEAVY			11	11	
TOTAL	223	26	11	260	
Accuracy				99.23%	
Chi-Square				499.26	0.000
Coefficient Contingency				0.811	0.000
Kappa				0.975	0.000

Table- VIII: Number and percentage of evaluators based on the results of evaluation of EDIDM features and implementation

Evaluator	The Evaluation Subject of EDIDM	Number of Evaluator by Rating						Total
		Neutral		Agree		Strongly Agree		
		N	%	N	%	N	%	
General Doctor	Feature	5	10	29	58	16	32	50
	Implementation	5	25	7	35	8	40	20
Special Doctor	Feature	2	8	13	52	10	40	25
	Implementation	2	20	7	70	1	10	10
IT Expert	Feature	3	12	13	52	9	36	25
	Implementation	5	50	5	50		0	10
Grand Total	Feature	10	7	74	53	44	31	140
	Implementation	12	5	119	52	72	31	230

Table- IX: Number and percentage of evaluators based on the results of evaluation of EDIDM features and implementation

The Evaluator	Subject of Evaluation	Question	The Opinion of Evaluator						
			Neutral		Agree		Strongly Agree		Total
			N	%	N	%	N	%	
General Doctor	ANN-GA Feature	Q1		0.0	3	30.0	7	70.0	10
		Q2	2	20.0	5	50.0	3	30.0	10
		Q3	2	20.0	7	70.0	1	10.0	10
		Q4		0.0	8	80.0	2	20.0	10
		Q5	1	10.0	6	60.0	3	30.0	10
	ANN-GA Implementation	Q6	2	20.0	4	40.0	4	40.0	10
		Q7	3	30.0	3	30.0	4	40.0	10
Special Doctor	ANN-GA Feature	Q1		0.0	2	40.0	3	60.0	5
		Q2		0.0	4	80.0	1	20.0	5
		Q3	1	20.0	3	60.0	1	20.0	5
		Q4	1	20.0	2	40.0	2	40.0	5
		Q5		0.0	2	40.0	3	60.0	5
	ANN-GA Implementation	Q6	1	20.0	3	60.0	1	20.0	5
		Q7	1	20.0	4	80.0		0.0	5
IT Expert	ANN-GA Feature	Q1		0.0	2	40.0	3	60.0	5

		Q2		0.0	4	80.0	1	20.0	5
		Q3	1	20.0	3	60.0	1	20.0	5
		Q4	2	40.0	2	40.0	1	20.0	5
		Q5		0.0	2	40.0	3	60.0	5
	ANN-GA Implementation	Q6	3	60.0	2	40.0		0.0	5
		Q7	2	40.0	3	60.0		0.0	5

V. CONCLUSION AND FUTURE WORKS

Determination degree of injury model is a hybrid technique of Artificial Neural Network with Genetic Algorithm (ANN-GA) to optimize the weight of Artificial Neural Network. This model is used the VeR as the input of the feature to classify the injury degree. The result of proposed model ANN-GA shows that the patients' physical factors that have an influence on the degree of injury are the surface area, body region, type of injury. Evidently, based on the ANN-GA model, the more surface area of injury in certain critical body region with certain type of injury can affect the degree of injury to the victim. The proposed model also can identify the optimal solution on the context degree of injury determination. It can be concluded that the features collected from ANN-GA model can be used to complement the predictive scoring of injury system that have been built using AHP in the previous studied and optimized the model development using ANN-GA. Nevertheless, the model can explain 99.23% accuracy with 95% confident level. The recommendation for future works suggested that the optimization parameters need to be adjusted for more effective use in the implementation of determination process. It may also suggest choosing the number of neurons or tuning another algorithm. Utilizing other optimization techniques also could be interesting to study.

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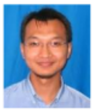

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