International Journal of Electrical and Computer Engineering (IJECE)
Vol. 9, No. 6, December 2019, pp. 5537~5544
ISSN: 2088-8708, DOI: 10.11591/ijece.v9i6.pp5537-5544

Estimation of fines amount in syariah criminal offences using adaptive neuro-fuzzy inference system (ANFIS) enhanced with analytic hierarchy process (AHP)

Ahmad Fitri Mazlam, Wan Nural Jawahir Hj Wan Yussof, Rabiei Mamat
School of Informatics and applied Mathematics, Universiti Malaysia Terengganu, Malaysia

Article Info

Article history:

Received Feb 15, 2019
Revised Apr 18, 2019
Accepted Jun 10, 2019

Keywords:

Adaptive neuro fuzzy inference system (ANFIS)
Amount of fines
Analytic hierarchy process (AHP)
Syariah criminal

ABSTRACT

All syariah criminal cases, especially in khalwat offence have their case-fact, and the judges typically look forward to all the facts which were tabulated by the prosecutors. A variety of criteria is considered by the judge to determine the fines amount that should be imposed on an accused who pleads guilty. In Terengganu, there were ten (10) judges, and the judgments were made by the individual decision upon the trial to decide the case. Each judge has a stake, principles and distinctive criteria in determining fines amount on an accused who pleads guilty and convicted. This research paper presents an Adaptive Neuro-fuzzy Inference System (ANFIS) technique combining with Analytic Hierarchy Process (AHP) for estimating fines amount in Syariah (khalwat) criminal. Datasets were collected under the supervision of registrar and syarie judge in the Department of Syariah Judiciary State of Terengganu, Malaysia. The results showed that ANFIS+AHP could estimate fines efficiently than the traditional method with a very minimal error.

Corresponding Author:

Wan Nural Jawahir Hj Wan Yussof,
School of Informatics and Applied Mathematics,
Universiti Malaysia Terengganu,
21030 Kuala Nerus, Terengganu Darul Iman, Malaysia.
Email: wannurwy@umt.edu.my

1. INTRODUCTION

Decision making is the process of helping someone solves the problem by assessing alternative resolution. It is a mandatory activity in real life which involves several steps including identifying the results and gathering information. Typically, many uncertainties and inaccurate data and criteria are used to make decisions. Sometimes, it seems natural to decide, but when it comes to multi-criteria to be considered, the decision-making process becomes a fuzzy task.

Since decision-making can be regarded as human needs, there are techniques used by people to deal with the problems. Traditionally, people always hold meetings between experts, vote for majority decisions and jump to a conclusion to end the process. This process is somewhat subjective. Therefore, modern methods of decision making have been introduced rapidly over several decades. In 1992, [1] discussed several methods of multi-criteria decision making and they updated the article in 2008 [2].

Adaptive Neuro-Fuzzy Inference System (ANFIS) method is one of the most widely used approaches to handle the multi-criteria decision-making process. ANFIS is a fuzzy inference system that has been used in numerous areas of research such as diagnosis [3-7], modelling [8] and prediction [9]. In diagnosis application, ANFIS was employed for risk diagnosis risk in dengue patients [3]. The use of the ANFIS for the diagnosis of malaria has been performed by [4] to provide better decision than the traditional diagnosis of methods characterized by erotic guesswork and patient observations by doctors. This work achieves a very close result to the expectation of the researchers with a very minimal error. Another diagnosis works using ANFIS was presented in [5-7], as a base for hypertension diagnosis and for heart disease diagnosis, respectively. Besides diagnosis, ANFIS model was used to forecast the return on stock price index of the Istanbul Stock Exchange (ISE) [8] and predict the future actions of the exchange rate [9].

Meanwhile, Analytic Hierarchy Process (AHP) is a method to find a weight between factors. AHP measures all the factors involved in the decision-making process through pairwise comparison. The comparison is conducted using a scale of absolute judgement that represents how vital one factor to one another and its also been used by researchers in many fields and researches. [10] shows an implementation of AHP in identifying the factors associated with obesity. The result indicated that the factor of Sedentary Lifestyle (SED) contributes the highest weight compared to Medical Psychiatric Illness (MED) and Genetics (GEN).

Based on the strength of ANFIS and AHP reported in the literature, this paper presents how ANFIS+AHP could help syarie judge to estimate fines amount to the khalwat offences based on five criteria before trial without interfering of influence judicial decision. These criteria are chosen because there are only five criteria that have been noted in the case fact tabulated by the enforcement officer for prosecution. Data that has been collected is a combination of different judges based on five criteria. In current practice, some judges estimate a meagre amount of fines while some judges put a very high amount of fines for the same criteria. In the previous study [11], we only implemented ANFIS for the same case study. Therefore, this paper aims to improve previous work by incorporating ANFIS with AHP.

The remainder of this paper is organized as follows: Section 2 discusses on the basic definition for ANFIS as a method used for estimating fines amout. Section 3 defines a simple step for AHP. A framework for estimation fines amount using ANFIS+AHP is presented in Section 4. Experimental results and discussion are tabulated in Section 5 and finally, Section 6 will conclude the paper.

2. METHODOLOGY

In this paper, 75 cases were trained, and 30 cases were tested with ANFIS solution. Then AHP solution is used to determine the weightage and finally the ANFIS+AHP solution is used to generate a new result.

2.1. ANFIS solution

This study used datasets from the Department of Syariah Judiciary State of Terengganu which is an institution that has Appeal Court, High Court and Sub Ordinary Court. Observation, literature survey and interview were used to gather information about the accused person who pleaded guilty and fines amount charged to that person. In this study, 75 datasets cases sentenced by fines were collected. Table 1 lists the attributes of Khalwat dataset while Table 2 lists the value of sex, marital status, location type of arrest and the time of arrest. The figure of age and the fines amount is used as the value for age and fines attributes accordingly. Table 3 shows the raw dataset that had been collected and the set of data that has been converted into value is shown in Table 4.

Table 1. Attributes of khalwat offences dataset

Abbreviation	Decsription	Representation of Fuzzy Variables
age	Age in years	x_1
sex	Sex (male; female)	x_2
marstatus	Marital status (divorced, married, bachelor)	x_3
location	Location of crime (hotel, residence, closed area, open area)	x_4
time	Time of arrest Day (7.00 am – 7.00 pm) Night (7.01 pm – 12.00 am) Early Morning (12.01 am – 6.59 am)	x_5
fines	Fines amount	y

Table 2. Value for sex, marital status, location and time

value	sex	marstatus	location	time
1	Female	Single	Open Area	Day
2	Male	Married	Closed Area	Night
3		Divorced	Residence	Early Morning
4			Hotel	

Table 3. Raw dataset for khalwat offences

Case No	age x_1	sex x_2	mar status x_3	location x_4	time x_5
11003-143-0012-2015	17	female	bachelor	residence	early morning
11008-143-0001-2015	28	male	married	hotel	night
11003-143-0024-2015	59	male	divorced	residence	early morning
11005-143-0107-2015	37	female	divorced	residence	early morning
…	…	…	…	…	…
11009-143-0028-2015	28	female	divorced	closed area	early morning

Table 4. Converted data set according to value defined in Table 3

Case No	age x_1	sex x_2	mar status x_3	location x_4	time x_5
11003-143-0012-2015	17	1	1	3	3
11008-143-0001-2015	28	2	2	4	2
11003-143-0024-2015	59	2	3	3	3
11005-143-0107-2015	37	1	3	3	3
…	…	…	…	…	…
11009-143-0028-2015	28	1	3	2	3

Based on the data collected and ANFIS parameters need, rules are generated using numerical data introduced by [12]. These rules will be used in the layers in ANFIS. Table 5 is a set of data that has been sorted by age.

2.1.1. Generating rules using numerical data

In generating the rules, eight steps have to be considered:

Step 1 : Identify the number of data collected, A = 75

Step 2 : Identify the number of attributes, B = 6 (age, sex, marstatus, location, time, fines)

Step 3 : Calculate the total number of rules, $R = \frac{A}{B} = \frac{75}{6} = 12$

Step 4 : Data are sorted according to age as shown in Table 4.

Step 5 : The maximum value is identified for each variable

Step 6 : The fuzzy numbers in Table 4 forms the antecedents and consequent parts of the rule.

Step 7 : Rule 1 is framed as

If (x_1 is 17) or (x_2 is female) or (x_3 is bachelor) or (x_4 is hotel) or (x_5 is earlymorning) then y is 2.7.

Step 8 : To frame the next rule, the next 6 data are taken and the 4th and 5th steps are repeated and generated rule 1 are shown in Table 5.

Table 5. First frame of data to generate rule 1

Case No	age x_1	sex x_2	mar status x_3	location x_4	time x_5	fines y
11009-143-0016-2015	15	1	1	3	3	2.0
11004-143-0120-2014	15	1	1	3	3	2.6
11003-143-0012-2015	17	1	1	3	3	2.3
11006-143-0072-2015	17	1	1	4	2	2.5
11006-143-0073-2015	17	1	1	4	2	2.5
11005-143-0141-2015	17	1	1	4	2	2.7
	Maximum values for fuzzy variables					
Rule 1	17	1	1	4	3	2.7

2.1.2. Predicting output variable using linear equation

Based on 12 rules framed earlier, output variable, c for each rule equation is then predicted for linear equation as follow:

$$y = p_i^1 x_1 + p_i^2 x_2 + p_i^3 x_3 + p_i^4 x_4 + p_i^5 x_5 + c_i \quad (1)$$

while parameter p_i^j is predicted using the linear equation using the formula introduced by [12] as follow:

$$p_i^j = \frac{\frac{mean\,(y)}{max(x_j)} + \frac{mean\,(y)}{mean(x_j)}}{mean(y)(no.atrributes)} \quad (2)$$

where j = 1,2,3,4,5 and i = 1,2,3…11,12.

The predicted fuzzy values and generated rules are used in ANFIS method to estimate fines amount are presented in Table 6. For example:

Rule 1: If (x_1 is young) or (x_2 is female) or (x_3 is bachelor) or (x_4 is hotel) or (x_5 is earlymorning) then y is high, $y_1 = p_1^1 x_1 + p_1^2 x_2 + p_1^3 x_3 + p_1^4 x_4 + p_1^5 x_5 + c_1$.

$$p_i^j = \frac{\frac{mean\ (y)}{max(x_j)} + \frac{mean\ (y)}{mean(x_j)}}{mean(y)(no.atrributes)} = \frac{\frac{2.4}{17} + \frac{2.4}{16}}{(2.4)(5)} = 0.02 \quad (3)$$

Table 6. Predicted fuzzy values for p_i^j for Rule 1

	age x_1	sex x_2	mar status x_3	location x_4	time x_5
$mean(y)$			2.4		
$max(x_j)$	17	1	1	4	3
$mean(x_j)$	16	1	1	4	3
no. of attributes			5		
	p_1^1	p_1^2	p_1^3	p_1^4	p_1^5
$\frac{\frac{mean\ (y)}{max(x_j)} + \frac{mean\ (y)}{mean(x_j)}}{mean(y)(no.\ atrributes)}$	0.02	0.40	0.40	0.11	0.15

c_i For all rules are calculated using linear equation with the value for each rule framed. For example, c_1 is calculated as follows:

$$c_1 = y_1 - p_1^1 x_1 + p_1^2 x_2 + p_1^3 x_3 + p_1^4 x_4 + p_1^5 x_5$$
$$c_1 = 2.7 - ((0.02)(17) + (0.40)(1) + (0.40)(1) + (0.11)(4) + (0.15)(3)) \quad (4)$$
$$c_1 = 0.67$$

The c_i values for Rule 1 to Rule 12 are presented in Table 7.

Table 7. Predicted fuzzy value for p_i^j, c_i

	p_i^1	p_i^2	p_i^3	p_i^4	p_i^5	c_i
Rule 1	0.02	0.4	0.4	0.11	0.15	0.67
Rule 2	0.02	0.23	0.4	0.13	0.15	0.51
Rule 3	0.02	0.21	0.4	0.11	0.14	0.72
Rule 4	0.02	0.27	0.22	0.13	0.17	0.33
Rule 5	0.02	0.25	0.2	0.1	0.15	0.59
Rule 6	0.02	0.2	0.4	0.11	0.14	0.82
Rule 7	0.01	0.22	0.17	0.11	0.15	0.88
Rule 8	0.01	0.22	0.15	0.11	0.17	0.85
Rule 9	0.01	0.23	0.17	0.11	0.14	0.84
Rule 10	0.01	0.25	0.14	0.13	0.15	0.89
Rule 11	0.01	0.22	0.15	0.11	0.14	0.68
Rule 12	0.01	0.22	0.14	0.11	0.13	0.72

2.2. AHP solution

In the study, five criteria involved to estimate the fines amount. However, judges also have different thoughts regarding which domain factor contribute to the order. This situation proved in [11] where some cases that have the same values show different fines amount concerning a different judge. The difference will affect the training data and the final result at once. A survey had been conducted to find the weight of each criterion using AHP to ensure the consistency of the results. Two sections were surveyed which is first to identify the experience of judges in handling the khalwat cases and the second one is to calculate the domain factor of each criterion defined by the judges.

2.2.1. Finding weightage judge experience

Based on the survey collected, here are the experience of each judge as present in Table 8.

Table 8. Judge years of experience

Judge Name	Experience (years)
Judge A	15
Judge B	20
Judge C	4
Judge D	2

Step 1: Sum all the years of experience, Y

$$Y = 20 + 15 + 4 + 2 = 41 \tag{5}$$

Step 2: Find the experience weightage by dividing each experience by Y

$$\text{Experience Weightage, } E.W_{\text{n}} = \frac{Y_n}{Y} \tag{6}$$

For example, Judge A Experience Weightage, $E.W_{\text{A}} = \frac{Y_A}{Y}$

$$E.W_{\text{A}} = \frac{15}{41} = 0.37 \tag{7}$$

The weightage of all judge experience are tabulated in Table 9.

Table 9. Judge experience weightage

Judge Name	Weightage
Judge A	0.37
Judge B	0.49
Judge C	0.10
Judge D	0.05

2.2.2. Finding weightage criteria

Step 1: Compare the factors. 10 pair-wise comparisons were questioned to four judges in the study area.

a. Age compared with Sex
b. Age compared with Marital Status
c. Age compared with Time of Arrest
d. Age compared with Location of Arrest
e. Sex compared with Marital Status
f. Sex compared with Time of Arrest
g. Sex compared with Location of Arrest
h. Marital Status compared with Time of Arrest
i. Marital Status compared with Location of Arrest
j. Time of Arrest compared with Location of Arrest

Step 2: The degree of scale by the four judges was collected and the result is completed in the matrix for each judge. Table 10 shows an example of pair-wise comparison by judge A.

Table 10. Pair-wise comparison result by judge A

Factor	Age	Sex	Marital Status	Time of Arrest	Location of Arrest
Age	1.00	8.00	0.13	0.14	0.17
Sex	0.13	1.00	0.17	0.17	0.17
Marital Status	8.00	6.00	1.00	0.33	6.00
Time of Arrest	7.00	6.00	3.00	1.00	7.00
Location of Arrest	6.00	6.00	0.17	0.14	1.00
Total	22.13	27.00	4.46	1.79	14.33

Step 3: Normalized the pair-wise comparison for each judge. As shown in Table 11, the normalized values are presented as priority vector of criteria by all the judges.

Table 11. Priority vector of criteria by all judges

	Judge A Priority Vector or Weight	Judge B Priority Vector or Weight	Judge C Priority Vector or Weight	Judge D Priority Vector or Weight
Age	0.09	0.26	0.08	0.07
Sex	0.04	0.03	0.03	0.03
Marital Status	0.28	0.31	0.56	0.54
Time of Arrest	0.45	0.17	0.20	0.21
Location of Arrest	0.14	0.23	0.13	0.15

2.2.3. Finding weightage criteria in consideration with judge experience

Step 1: Multiply each factor weightage with judge experience weightage.
Step 2: Total the result for each factor to get the final weightage. The results are shown in Figure 1.

Judge	Judge A			Judge B			Judge C			Judge D			Final Weightage, w
Criteria	$C.W_{AXn}$	$E.W_A$	Multiplied, w_A	$C.W_{BXn}$	$E.W_B$	Multiplied, w_B	$C.W_{CXn}$	$E.W_C$	Multiplied, w_C	$C.W_{DXn}$	$E.W_D$	Multiplied, w_D	Total
Age	0.09	0.37	0.034	0.26	0.49	0.128	0.08	0.10	0.008	0.07	0.05	0.003	0.174
Sex	0.04	0.37	0.014	0.03	0.49	0.012	0.03	0.10	0.003	0.03	0.05	0.001	0.030
Marital Status	0.28	0.37	0.105	0.31	0.49	0.153	0.56	0.10	0.056	0.54	0.05	0.027	0.340
Time of Arrest	0.45	0.37	0.167	0.17	0.49	0.083	0.20	0.10	0.020	0.21	0.05	0.011	0.281
Location of Arrest	0.14	0.37	0.050	0.23	0.49	0.114	0.13	0.10	0.013	0.15	0.05	0.008	0.185

C.W = Criteria weightage, E.W = Judge Experience Weightage

Figure 1. Result of final criteria weightage

2.3. ANFIS enhanced with AHP solution

Based on (4), output variable, $\boldsymbol{c}$ for each rule equation is then predicted again for linear equation enhanced with AHP weightage result as in (5) and (6). The results are then shown in Table 12.

$$y = p_i^1 w_1 x_1 + p_i^2 w_2 x_2 + p_i^3 w_3 x_3 + p_i^4 w_4 x_4 + p_i^5 w_5 x_5 + c_i \tag{8}$$

$$c_1 = y_1 - p_i^1 w_1 x_1 + p_i^2 w_2 x_2 + p_i^3 w_3 x_3 + p_i^4 w_4 x_4 + p_i^5 w_5 x_5$$
$$c_1 = 2.7 - \big((0.02)(0.194)(17) + (0.40)(0.029)(1) + (0.40)(0.338)(1) + (0.11)(0.196)(4) + (0.15)(0.252)(3)\big)$$
$$c_{1new} = 2.29 \tag{9}$$

Table 12. Predicted fuzzy value for $p_i^j, c_{i(new)}$

	p_i^1	p_i^2	p_i^3	p_i^4	p_i^5	c_i	$c_{i(new)}$
Rule 1	0.02	0.4	0.4	0.11	0.15	0.67	2.29
Rule 2	0.02	0.23	0.4	0.13	0.15	0.51	2.27
Rule 3	0.02	0.21	0.4	0.11	0.14	0.72	2.38
Rule 4	0.02	0.27	0.22	0.13	0.17	0.33	2.45
Rule 5	0.02	0.25	0.2	0.1	0.15	0.59	2.50
Rule 6	0.02	0.2	0.4	0.11	0.14	0.82	2.56
Rule 7	0.01	0.22	0.17	0.11	0.15	0.88	2.56
Rule 8	0.01	0.22	0.15	0.11	0.17	0.85	2.56
Rule 9	0.01	0.23	0.17	0.11	0.14	0.84	2.56
Rule 10	0.01	0.25	0.14	0.13	0.15	0.89	2.59
Rule 11	0.01	0.22	0.15	0.11	0.14	0.68	2.37
Rule 12	0.01	0.22	0.14	0.11	0.13	0.72	2.55

3. RESULTS AND DISCUSSIONS

In this paper, 75 cases were trained, and 30 cases were tested with ANFIS and ANFIS+AHP. The cases in Table 13 are compared because of the same value for sex, marital status, time of arrest and location of arrest criteria. However, the value of age is different. The result shows that the human judgement is inconsistent where the fines amount for a 25-year-old man is lower than a 23-year-old man with the same value for the other criteria. The age difference is only two years, and it is quite confusing. By using ANFIS, the gap of fines amount is smaller where ANFIS+AHP shows a very consistent result for the range of age under 35 years old.

Table 13. Result comparison between human judgement, ANFIS and ANFIS+AHP

Case No	Age	Human Judgement	ANFIS	ANFIS+AHP
11003-143-0005-2016	23	2.9	2.7	2.8
11004-143-0080-2016	24	2.9	2.8	2.8
11005-143-0029-2016	25	2.7	2.7	2.8
11003-143-0034-2015	31	2.9	2.8	2.8
11005-143-0047-2016	32	2.7	2.8	2.8

ANFIS+AHP has processed the equation and present the result in its range. As an example, for the same value of other criteria (sex=female, marital status=single, location of arrest=open area, time of arrest = day) and only age is different, here Table 14 is the range for fines amount.

Table 14. Fines amount range based on range of age

Range of Age	Fines Amount using ANFIS+AHP
0 - 16	2.6
17 - 51	2.7
52 - 85	2.8
86 and above	2.9

4. CONCLUSION

This paper proposed ANFIS+AHP to estimate fines amount based on previous judgments. 75 datasets were used for training, and 30 datasets were used for testing. The estimation considered five inputs and one single output based on case fact from the Syariah criminal files in the studied department. The result of the proposed method has proven that ANFIS+AHP is an efficient way to estimate the fines and helps the judge make a preliminary judgment at once.

ACKNOWLEDGEMENTS

The authors would like to thank the Department of Syariah Judiciary State of Terengganu especially Y.A Tn Hj Kamalruazmi bin Ismail, the Syariah Highcourt Judge for their active cooperation and the data provided.

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BIOGRAPHIES OF AUTHORS

Ahmad Fitri Mazlam is an ICT Officer in Institut Pendidikan Guru Kampus Dato' Razali Ismail and a Post-Graduate Student at School of Informatics and Applied Mathematics, Universiti Malaysia Terengganu. He obtained Bachelor Degree in Science (Computer) from Universiti Teknologi Malaysia in 2005. His researches are in fields of Decision Support System, Artificial Intelligence and Artificial Neural Network. Recently, system's application on syariah judiciary department has been tackled and his article has been published in JTEC in 2017. Besides, he is also involved in NGOs, student associations, and managing non-profit foundation.

Wan Nural Jawahir Hj Wan Yussof received her B.IT in Software Engineering and M.Sc. in Artificial Intelligence from Kolej Universiti Sains dan Teknologi Malaysia. In 2014, she obtained her Ph.D. from Universiti Malaysia Terengganu. She is currently a senior lecturer at School of Informatics and Applied Mathematics, Universiti Malaysia Terengganu. Her research interests are in 2D/3D image analysis and underwater video processing.

Rabiei Mamat received his M.Sc. degree in High Performance System from University College of Science and Technology Malaysia (KUSTEM) in 2004 and getting his Ph.D. in Information Technology from the Universiti Tun Hussein Onn (UTHM) in 2014. Currently he is a lecturer in School of Informatics and Applied Mathematics, Universiti Malaysia Terengganu (UMT). His teaching topics includes Web and Mobile Application Development and Programming. His research interests include Soft Computing and Data Mining.