

Estimation of Fines Amount in Syariah Criminal Offences Using Adaptive Neuro-Fuzzy Inference System (ANFIS)

Ahmad Fitri Mazlam, Wan Nural Jawahir Hj Wan Yussof and Rabiei Mamat
*School of Informatics and Applied Mathematics,
Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.
afitrimazlam@gmail.com*

Abstract—All Syariah criminal cases, especially in khalwat offence have its own case-fact, and the judges typically look forward 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 individual *ijtihad* upon the trial to decide the case. Each judge has a stake, principles and distinctive criteria in deciding fines amount on an accused who pleads guilty and convicted. This research paper presents Adaptive Neuro-fuzzy Inference System (ANFIS) technique for estimating fines amount in Syariah (khalwat) criminal. Data sets 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 could estimate fines efficiently than the traditional method with a very minimal error.

Index Terms—Adaptive Neuro Fuzzy Inference System (ANFIS); Amount of Fines; Syariah Criminal.

I. INTRODUCTION

Decision making is a must-do activity in real life. Normally, many uncertainties and imprecise data and criteria are used to make a decision. Sometimes, it seems easy to decide, and when it comes to multi-criteria to be considered, then the decision-making process becomes a fuzzy task. Since the decision-making activity can be said as a human being needs, there are techniques that people use to face the problems traditionally and untraditionally across the decades. Traditionally, people always set up a meeting between specialist, voting for majority decision and jump into conclusion to end up the process. This process is quite subjective. Thus, untraditional or modern method for decision making had been introduced very fast over the last few years.

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 improved and has been used in numerous areas of research for diagnosis [1], modelling [2] and prediction [3]. [4] employed ANFIS to serve a model for Malaria diagnosis. This work achieves a very close result to the expectation of the researchers with a very minimal error for system design which was able to explain human decisions. Also [5] presented ANFIS as a base for Hypertension Diagnosis. The aim of their study was to present the methodology of ANFIS used to diagnose and compare the proposed system to the existing fuzzy expert system based on

performance matrices which are accuracy and sensitivity. The paper also concluded that ANFIS technique is more efficient as compared to the fuzzy expert system. In the paper presented by [6], ANFIS was successfully used in the heart disease diagnosis where multilayer feed forward neural network, Fuzzy Inference System (FIS) and Adaptive Neuro-Fuzzy System (ANFIS) were used to classify heart disease in a person. The experiment came out with a comparison between three methods used, and ANFIS result was better than FIS.

Typically, ANFIS is widely used in the medical area [7 - 9] and medical area always has a definite attribute to reflect the right output. However, there is not even once in the world to use ANFIS in Syariah judgment even though decision making is a heart of judgment. This paper will present how ANFIS 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. Normally, it reflects the accuracy of the results where some judges estimate a very low amount of fines where some of them put a very high amount of fines for the same criteria. ANFIS will calculate based on all previous judgment to estimate an acceptable amount. Therefore, this paper is organized as follows. Section 2 discusses on the basic definition for ANFIS as a method used for estimating fines amount. A framework for estimation fines amount using ANFIS is presented in Section 3. Experimental results and discussion are tabulated in Section 4 while Section 5 will conclude the paper.

II. ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS)

In general, ANFIS is a combination of neural networks and fuzzy inference system (FIS), and it is similar to Sugeno fuzzy model in FIS. It is first proposed in 1993 by [10] to construct a set of fuzzy if-then rules to generate the stipulated input-output pairs [10] where the input can be considered as a set of criteria, and the output is a final decision in the context of decision making. It is mapped out in five layers as Fig. 1. If we consider the fuzzy inference system with two inputs (x and y) and one output (z), then the fuzzy model with two rules set can be represented as follows:

Rule 1: If x is A_1 and y is B_1 , then $f_1 = p_1x + q_1y + r_1$

Rule 2: If x is A_2 and y is B_2 , then $f_2 = p_2x + q_2y + r_2$

The architecture of ANFIS representation for this system is shown in Figure 1 as proposed by [10].

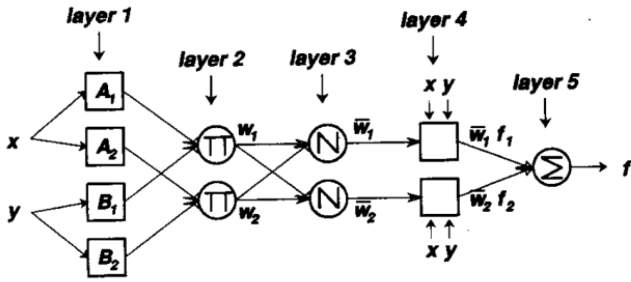


Figure 1: ANFIS architecture

A. Layer 1:

Every node i in this layer is an adaptive node with a node output defined by

$$\begin{aligned} O_i^1 &= \mu_{A_i}(x), i = 1,2 \\ O_i^1 &= \mu_{B_{i-2}}(y), i = 3,4 \end{aligned} \quad (1)$$

$\mu_{A_i}(x)$ and $\mu_{B_{i-2}}(y)$ can be used by any fuzzy membership function. x (or y) is the input node i and A_i (or, B_{i-2}) is a linguistic label such as low, high etc. Related with the node, the membership function can be any appropriate parameterized membership function. As an example, we used a bell shaped membership function given by:

$$\mu_A(x) = \frac{1}{1 + \left| \frac{x - c_i}{a_i} \right|^{2b_i}} \quad (2)$$

where a_i, b_i, c_i , are the parameters set and parameters in this layer are referred to as premise parameters.

B. Layer 2:

Every node in this layer is fixed and represents the fire strength of the rule. The output is the product of all input signals:

$$O_i^2 = w_i = \mu_{A_i}(x)\mu_{B_i}(x), i = 1,2 \quad (3)$$

C. Layer 3:

Every node in this layer is a fixed node which is labelled with N and it calculates the ratio of the i^{th} rule's firing strength to the sum of all rule's firing strengths:

$$O_i^3 = 4\bar{w}_i = \frac{w_i}{w_1 + w_2}, i = 1,2 \quad (4)$$

In this layer, the outputs are called normalized firing strength.

D. Layer 4:

The nodes in this layer are adaptive with a node function:

$$O_i^4 = \bar{w}_i f_i = \bar{w}_i(p_i x + q_i y + r_i) \quad (5)$$

where \bar{w}_i is the normalized firing strength from the layer 3

output and (p_i, q_i, r_i) is the parameter set of this node also referred to as consequent parameters.

E. Layer 5:

The single node in this layer is a fixed node labelled Σ , which computes the overall output as the summation of all incoming signals:

$$O_i^5 = \sum_i \bar{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \quad (6)$$

III. CASE STUDY

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 pleads guilty and fines amount charged to that person. Also, 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 1
Attributes of khalwat offences dataset

Abbreviation	Description	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 shows the raw dataset that had been collected and the set of data that had been converted into value as shown in Table 4.

Based on the data collected and ANFIS parameters need, rules are generated using numerical data introduced by [11]. These rules will be used in the layers in ANFIS. Table 3 is a set of data that has been sorted by age.

Table 3
Raw dataset for khalwat offences

Case No	age x_1	sex x_2	marstatus x_3	location x_4	time x_5
11003-143-0012-2015	17	female	bachelor	residence	early morning

Case No	age x_1	sex x_2	marstatus x_3	location x_4	time x_5
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 2

Case No	age x_1	sex x_2	marstatus 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

A. 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 3.
- Step 5 : The maximum value is identified for each variable.
- Step 6 : The fuzzy numbers in Table 3 forms the antecedents and consequent parts of the rule.
- Step 7 : Rule 1 is framed as
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.
- Step 8 : To frame the next rule, the next 6 data are taken and the 4th and 5th steps are repeated and generated rules are shown in Table 3.

Table 5
First frame of data to generate rule 1

Case No	age x_1	sex x_2	marstatus 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

B. 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:

$$y = p_1^1 x_1 + p_1^2 x_2 + p_1^3 x_3 + p_1^4 x_4 + p_1^5 x_5 + c_i \quad (7)$$

while parameter p_i^j is predicted using the linear equation using the formula introduced by [11].

$$p_i^j = \frac{\frac{\text{mean}(y)}{\max(x_j)} + \frac{\text{mean}(y)}{\text{mean}(x_j)}}{\text{mean}(y)(\text{no. attributes})} \quad (8)$$

while $j = 1,2,3,4,5$ and $i = 1,2,3 \dots 11,12$

The predicted fuzzy values and generated rules are used in ANFIS method to estimate fines amount. 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,

$$y_1 = p_1^1 x_1 + p_1^2 x_2 + p_1^3 x_3 + p_1^4 x_4 + p_1^5 x_5 + c_1$$

$$p_i^j = \frac{\frac{\text{mean}(y)}{\max(x_j)} + \frac{\text{mean}(y)}{\text{mean}(x_j)}}{\text{mean}(y)(\text{no. attributes})} = \frac{2.4}{17} + \frac{2.4}{16} = 0.02 \quad (9)$$

Table 6

Predicted fuzzy values for p_i^j for Rule 1

	age x_1	sex x_2	marstatus x_3	location x_4	time x_5
$\text{mean}(y)$			2.4		
$\max(x_j)$	17	1	1	4	3
$\text{mean}(x_j)$	16	1	1	4	3
no. of attributes			5		
$\frac{\text{mean}(y)}{\max(x_j)} + \frac{\text{mean}(y)}{\text{mean}(x_j)}$	p_1^1	p_1^2	p_1^3	p_1^4	p_1^5
$\text{mean}(y)(\text{no. attributes})$	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:

$$c_1 = y_1 - p_1^1 x_1 + p_1^2 x_2 + p_1^3 x_3 + p_1^4 x_4 + p_1^5 x_5$$

$$c_1 = 2.7 - ((0.02)(17) + (0.40)(1) + (0.40)(1) + (0.11)(4) + (0.15)(3))$$

$$c_1 = 0.67 \quad (10)$$

Table 7

Predicted fuzzy value for p_i^j, c_i

	p_1^1	p_1^2	p_1^3	p_1^4	p_1^5	c_i
Rule 1	0.02	0.4	0.4	0.11	0.15	0.67
Rule 2	0.02	0.23	0.21	0.13	0.15	0.49
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

IV. RESULT AND DISCUSSION

In this paper, 75 datasets cases sentenced by fines were collected and trained with ANFIS where new 30 datasets were collected to be tested with ANFIS. Table 8 shows the ANFIS result of some selected cases and also given the values for the linguistic variables that represent the degree of fines amount. The result shows seven cases out of 30 cases are 100% accurate between human judgment and ANFIS result, and the highest gap is only 0.2 or RM 200 difference. Fig. 2 shows that there is a very minimal difference between human judgment and ANFIS result and the average of difference is about 0.1 or RM100 which is acceptable for fine estimation. Since there were different judges involved in judging the cases, the difference is expected. Moreover, in the training data, there are some cases that have same values of input but different output. As example, case no 11004-143-0068-2015 and case no 11001-143-0023-2015 has same values but the human judgement result shows a very big gap of output as shown in Table 9. The gap was also expected because of the criteria used in this study is based on case fact which was collected before the trial where the real amount was decided after the trial which may have additional criteria that had been considered during the trial. Unfortunately, these additional criteria are not jotted down or recorded. As a result, there are only five criteria in the case fact can be collected for the research. Based on the few factors above, it can be concluded that the gap is reserved for the unknown criteria/s.

Table 8
Result comparison between human judgement and ANFIS

Case No	Human Judgement	ANFIS	Difference
11008-143-0025-2016	3.0	3.0	0.0
11005-143-0029-2016	2.7	2.7	0.0
11008-143-0014-2016	3.0	3.0	0.0
11003-143-0004-2016	3.0	3.0	0.0
11005-143-0044-2016	2.9	2.9	0.0
11008-143-0018-2016	2.9	2.9	0.0
11009-143-0006-2016	2.9	2.9	0.0
11008-143-0055-2016	2.8	2.7	..0.1
11005-143-0047-2016	2.7	2.8	0.1
11001-143-0017-2016	2.5	2.6	0.1

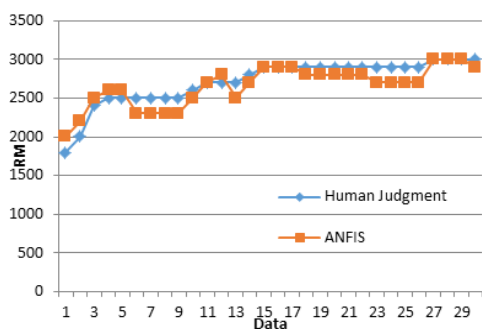


Figure 2: Testing data result compared to human judgment

Table 9
Difference of judgement in training data

Case No	age x_1	sex x_2	mar status x_3	location x_4	time x_5	fines y (x1000) RM	gap
11004-143-0068-2015	33	2	3	3	3	3.0	1.0
11001-143-0023-2015	40	2	3	3	3	2.0	

V. CONCLUSION

This paper proposed ANFIS 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 is an efficient way to estimate the fines and help the judge make a preliminary judgment at once. However, there is still a little difference between human judgments and ANFIS which is related to the weight of each input and the additional criteria during the trial to produce the estimated amount. A weight of each input in the linear equation of ANFIS will be considered in the future work.

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