



Optimization Neuro Fuzzy using Genetic Algorithm for Diagnose Typhoid Fever

Muhamad Nasrul Fata¹, Riza Arifudin², Budi Prasetyo³

^{1,2,3}Computer Science Departement, FMIPA, Universitas Negeri Semarang, Indonesia
Email: ¹nasrul10fata@gmail.com, ²riza.arifudin@gmail.com, ³budipras@mail.unnes.ac.id

Abstract

Neuro Fuzzy is one method in the field of information technology used in diagnosing an disease. The application of Neuro Fuzzy is to identify disease. Genetic algorithms can be used to find solutions without paying attention to the subject matter specifically, one of which is an optimization problem. Typhoid or typhoid fever is a disease caused by Salmonella enterica bacteria, especially its derivatives. The diagnosis of typhoid fever is not an easy thing to do. This is because some of the indications experienced by patients also appear in other diseases. The number of patients with typhoid fever that requires accuracy in diagnosing typhoid fever based on indications caused. Based on this background this study aims to assist in the diagnosis of typhoid fever with 11 indication variables. This study uses medical record data for typhoid fever in 2017 Tidar Magelang Hospital. The method used is Neuro Fuzzy which optimizes the value of the degree of membership with genetic Algorithms. Then the value of the degree of neuro fuzzy membership is more optimal. The results of this optimization are the diagnosis of typhoid fever based on the variable of indications entered. From the research results obtained from the neuro fuzzy method get an 80% accuracy value and neuro fuzzy optimization results with genetic algorithms with a value of pc 0.5, pm 0.2 and max generation 25 the value of accuracy increases to 90%. Suggestions from this study, need to add more specific indication variables.

Keywords: Neuro Fuzzy, Genetic Algorithm, Typhoid Fever, Diagnosis, Optimization, Accuration

1. INTRODUCTION

In the subdivision of information technology there are several methods that can be used to help everyday life, one of which is to diagnose an disease. One way of diagnosing disease, fuzzy logic can be used to present the linguistic truth values of a set of members [1] and alternative ways of thinking that can model complex systems using knowledge and experience that have logic starting as a study of language in argumentation and persuasion [2]. One of the fuzzy methods used in diagnosing an disease is Neuro Fuzzy. One application of this method is in Neuro Fuzzy research to diagnose Schizophrenia. In the study obtained a diagnosis with a percentage of 100% based on expert judgment on system trials [3]. The application of Neuro Fuzzy into

information systems that can identify diseases, will greatly assist in the process of diagnosing activities quickly and precisely. Methods that combine fuzzy logic and artificial neural networks are commonly called hybrid systems [4]. Compared with reverse propagation neural networks, the ANFIS learning process only requires a few tens of epochs [5].

Genetic algorithms do not require much mathematical concepts, and can treat all forms of objective functions and constraints. The problem of optimization of constrained functions with integer coding, can be solved by genetic algorithms. So that the value of the function of reliability, cost and weight of a system can be produced [6]. Genetic algorithm (GA) is employed to search the optimal solution on the response surfaces modeled [7].

Typhoid fever or abdominal typhus is an acute infectious disease of the digestive tract that has the potential to be a multisystemic disease caused by *Salmonella typhi* [8]. Indication include high fever, malaise, headache, nausea, loss of appetite, constipation or diarrhea, pink spots on the chest (Rose spots), and enlargement of the spleen and liver [9].

Typhoid fever is a health problem in the world especially in developing countries such as those found endemic throughout Africa, South America, East Asia and especially in South Asia [10]. Typhoid or typhoid fever is a disease caused by *Salmonella enterica* bacteria, specifically its derivatives, *Salmonella typhi* [11]. This disease can be found all over the world, and is spread through food and beverages that have been contaminated by feces [12]. Typhoid can cause septicemia, and reported an average incidence of around 2,500 per 100,000 population [13].

The diagnosis of typhoid fever is not an easy thing to do. This is because some of the indication experienced by patients also appear in other diseases. Typhoid basil, the main indication of typhoid fever is continuous high heat for 2 weeks [14]. This fever can be followed by other non-typical indication such as diarrhea, anorexia or coughing [15].

Based on the problem of the number of typhoid fever sufferers and requires accuracy in diagnosing typhoid fever based on indication caused, it is necessary to use the Neuro Fuzzy method which will then be optimized again using Genetic Algorithms and implemented into the system. The proposed system is built with the aim of providing a decision support which adopts genetic algorithm technique to optimize the performance of a neuro-fuzzy diagnostic method platform with the capability to aid medical practitioners in administering efficient diagnosis outcome for patients [16]. So that it is expected to help speed up the diagnosis of typhoid fever that may be suffered. Therefore this study applies the Neuro Fuzzy method optimized with Genetic Algorithms for the Diagnosis of Typhoid Fever based on indication variables obtained from medical record data on typhoid fever in Tidar Hospital Magelang in 2017.

2. METHODS

Data processing is done by calculating the results of diagnosis with the Neuro Fuzzy method first. Then calculate the diagnosis with the Neuro Fuzzy method and optimize the Genetic Algorithm. Calculate the accuracy value of each diagnosis result with actual diagnosis data. The following is the flowchart of the Neuro Fuzzy method shown in Figure 1. In the neuro fuzzy optimization process with genetic algorithms performed on fuzzy membership degree values. The optimization process can be seen in the flowchart of the Neuro Fuzzy method with Genetic Algorithms as in Figure 2.

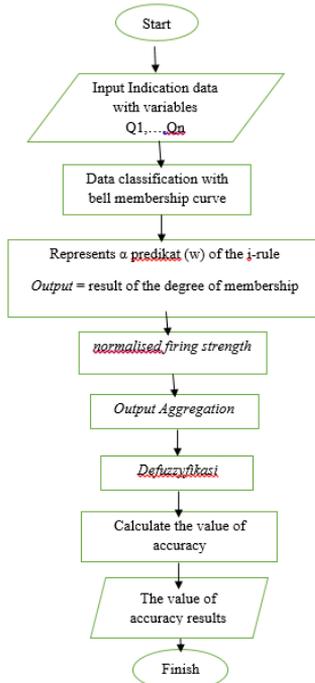


Figure 1. Flowchart of the Neuro Fuzzy Method

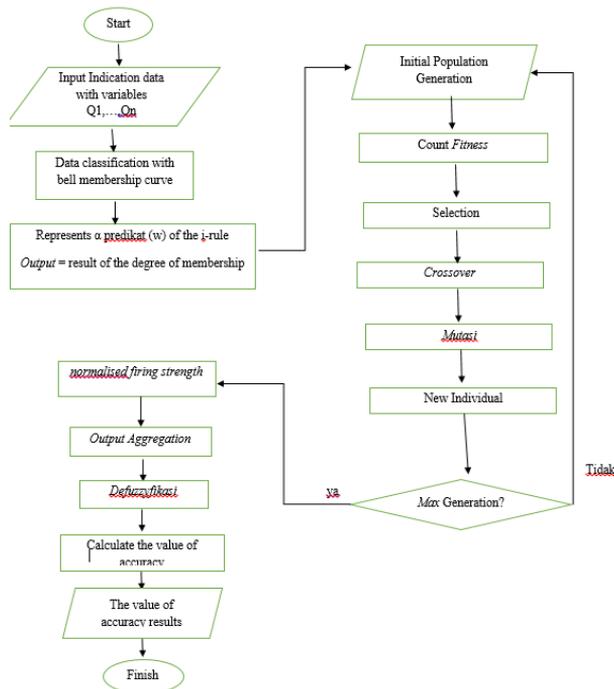


Figure 2. Flowchart of the Neuro Fuzzy Method with Genetic Algorithms

3. RESULTS AND DISCUSSION

The data used in this study is the medical record data of typhoid fever patients in Tidar Hospital Magelang in 2017. The data taken amounted to 100 medical record data and contained indications of typhoid fever. Indication variables taken amounted to 11 consisting of physical indications: fever, pain, dizziness, diarrhea, nausea and temperature. Whereas in the lab results the blood lab results are taken which consists of: hemoglobin, leukocytes, erythrocytes, hematocytes, and platelets. Based on the data and literature obtained, the value of the indication variable can be seen in Table 1.

Table 1. Variable value indications of typhoid fever patients

Variable	Name of Indication	Criteria		
		Low	Moderate	High
Q1	Fever (Day)	< 3 Day	3 s.d 7 Day	> 7 Day
Q2	Pain	No Pain (1)	Light pain (2)	Stomach/Abdomen (3)
Q3	Headache	No Headache (1)	Light Headache (2)	High Headache (3)
Q4	Nausea	No Nausea (1)	Nausea (2)	Nausea and Retch (3)
Q5	Diarrhea	No Diarrhea (1)	Diarrhea 1-3 (2)	Diarrhea > 3 (3)
Q6	Temperature (°C)	< 36°	36° s.d. 39°	> 39°

Variable	Name of Indication	Criteria		
		Low	Moderate	High
Q7	Hemoglobin (gram/dL)	< 13	13 s.d 18	> 18
Q8	Leukocytes (sel/mm ³)	< 4	4 s.d 11	> 11
Q9	Erythrocytes (sel/mm ³)	< 4.5	4..5 s.d 6.5	> 6.5
Q10	Hematocytes (%)	< 40	40 s.d 54	> 54
Q11	Platelets (sel/mm ³)	< 150	150 s.d 450	> 450

The value of the diagnosis variable can be seen in Table 2.

Table 2. The diagnostic variable value of patients with typhoid fever

Level of Risk	Value
Low	< 1
Moderate	1 s.d. 2
High	> 2

Indication data of typhoid fever patients in 2017 Tidar Hospital Magelang obtained and will be processed are shown in Table 3.

Table 3. Indication data on typhoid fever patients in Tidar Magelang Hospital in 2017

No	Physical indication						Blood test						Result
	Fever	Pain	Headache	Nausea	Diarhea	Temperature	Hemoglobin	Leukocytes	Erythrocytes	Hematocytes	Platelets		
1	34-42	5	3	3	3	3	36.5	13.2	7.6	4.6	38.1	317	High
2	35-42	7	2	3	2	1	36.5	9.6	6.2	4.5	28.4	204	High
3	01-42	8	2	2	3	2	36.5	14	6.5	5.2	40.6	145	Moderate
4	10-42	7	2	2	2	2	37.5	15.6	6.9	5.3	43	87	Moderate
5	34-48	5	3	2	2	2	40	10.1	5	4.3	29.8	187	High
6	32-36	8	3	2	2	2	36	11.8	10.8	4.2	33.2	225	High
:	:	:	:	:	:	:	:	:	:	:	:	:	:
10	02-15	4	1	2	2	1	38	14.5	3.7	5.7	43.3	196	Moderate

This data will be processed with neuro fuzzy process and optimization process with genetic algorithm method to get the diagnosis of typhoid fever.

The steps in the neuro fuzzy optimization process with genetic algorithms can be described as follows:

1) Layer 1

Determine the membership function of indication data by using the bell membership function curve which can be seen in Figure 3 and will be calculated with the following equation:

$$\mu(A) = \frac{1}{1 + \left| \frac{A-c}{a} \right|^{2b}} \quad (1)$$

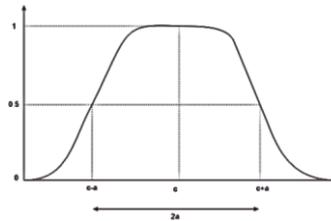


Figure 3. Membership Function Curve

From this curve the premise parameter c is the data center point, the premise parameter a is the center point width to the smallest or largest data, while the premise parameter b is the value of the coefficient that is worth 1 to determine the value of the bell membership not reversed.

Based on the above calculations, the membership function and membership degrees are obtained as follows, which can be seen in Table 4.

Table 4. *Membership function*

Q1			M	Q2			M	..	..	Q11			MF
R	S	T	F	R	S	T	F	..	..	..	R	S	T
0.1	1	0.31	1	0.04	0.1	0.5	0.5	0.03	1	0.16	1

In layer 1 the degree of membership function is obtained from the indications of typhoid fever.

2) Optimization Membership function using Genetic Algorithm

In this process an optimization process is carried out on the degree of neuro fuzzy membership with genetic algorithms. The optimization process with genetic algorithms is as follows:

a. Initial Population Formation (Initialization)

The initial population formation is done according to the popsize parameter is 3, the crossover probability (P_c) is 0.5 and the probability of mutation (P_m) = 0.2. The initial population generated with 3 random or random numbers or chromosomes (k) can be seen in Table 5.

Table 5. Initial Population

Chromosoms									
k1	0.74	0.25	0.063	0.52	0.22	0.19	0.81	...	0.803
k2	0.88	0.48	0.092	0.5	0.07	0.85	0.4	...	0.013
k3	0.85	0.25	0.885	0.99	0.89	0.87	0.15	...	0.162

b. Calculation of Fitness Value Evaluation

Fitness evaluation value is

fitness [i] = Gen Gen value [i] can be seen in Table 6.

Table 6. Evaluation of Fitness Value

No	Chromosoms										Result	
k1	0.74	0.25	0.063	0.52	0.22	0.19	0.81	0.047	0.0017	...	0.803	13.60187
k2	0.88	0.48	0.092	0.5	0.07	0.85	0.4	0.92	0.2594	...	0.013	14.7202
k3	0.85	0.25	0.885	0.99	0.89	0.87	0.15	0.165	0.6619	...	0.162	15.46656

c. Chromosome Selection

Used the Roulette Wheel method with the following stages:

1) Inverse with $Q [i] = 1 / \text{fitness} [i]$

2) The relative probability / fitness of each individual with the equation $P [i] = Q [i] / \sum Q [i]$

d. Crossover

Opportunity for crossover (P_c) = 0.5, it is expected that the total chromosome will experience a crossover by means of $3 * 0.5$ the result is 2 offspring. Generate random numbers [0 1] as many as 3 pieces.

Select the number to be crossed over by selecting a random value that is less than the p_c value, for the p_c value = 0.5. The crossover process with the two cut point crossover crossing method where selecting 2 points and the crossover is between the cut points. So the results of the crossover can be seen in Table 7.

Table 7. New Population of Crossover Results

New population											
k1	0.85	0.25	0.89	0.99	0.895	0.8746	0.15	0.165	0.66	...	0.162
k2	0.74	0.25	0.06	0.52	0.221	0.1887	0.81	0.047	0	...	0.803
k3	0.88	0.48	0.09	0.5	0.068	0.8511	0.4	0.92	0.26	...	0.013

e. Mutasi

Calculate the length of genes in the population by feeling $\text{anjangLength Gen} = \text{popsize} * \text{enGen} [i]$ by calculating Gen Gen

Length = 3 * 11 = 33. Choosing the position of the mutated gene by generating random numbers of 33 genes
 With pm = 0.2, the number of genes to be mutated is pm * ΣGen [i] = bit result value. Group random numbers that have been raised based on chromosomes. Next select the gene value of each chromosome that is less than the value of pm = 0.2.
 The process of mutation by exchanging selected chromosome genes is mutated by randomizing the values of these genes to form new genes. The results of the mutation process can be seen in Table 8.

Table 8. New population results of mutations

	New population <i>Mutasi</i>								
k1	0.8549	0.25	0.561	0.77	0.76	0.87	0.15	...	0.162
k2	0.7389	0.25	0.063	0.01	0.22	0.19	0.81	...	0.803
k3	0.584	0.48	0.092	0.37	0.07	0.85	0.73	...	0.225

f. Solution Evaluation

The process in generation 1 generated is calculated as the fitness value formed. Select the highest fitness value with maximum generation. Then a more optimal new degree of membership will be formed. Before getting a fitness value approaching 1 or a maximum of generation, the process will return to the crossover and so on.

3) Layer 2

In the second layer, which is counting the values of W1, W2, W3 on each membership function value obtained from table 8. The following equations are used in the calculation:

$$W_1 = \mu_R(Q_1) * \mu_R(Q_2) * \mu_R(Q_3) * \mu_R(Q_4) * .. * \mu_R(Q_{11}) \tag{2}$$

$$W_2 = \mu_S(Q_1) * \mu_S(Q_2) * \mu_S(Q_3) * \mu_S(Q_4) * .. * \mu_S(Q_{11}) \tag{3}$$

$$W_3 = \mu_T(Q_1) * \mu_T(Q_2) * \mu_T(Q_3) * \mu_T(Q_4) * .. * \mu_T(Q_{11}) \tag{4}$$

Then the calculation for data -1 is obtained as shown in Table 9.

4) Table 9. Layer 2

W ₁	W ₂	W ₃
3.65095E-11	7.81037E-06	1.03012E-09

5) Layer 3

In layer 3, each neuron in this layer in the form of a neuron is still the result of calculating the ratio of firing strength i (wi) to the total of firing strength in the second layer, the equation for calculating is as follows:

$$\bar{w}_i = \frac{w_i}{w_1+w_2}, i = 1,2 \tag{5}$$

For the calculation of the 1st data, it is as follows

$$W_1^- = \frac{W_1}{W_1 + W_2 + W_3} \quad (6)$$

$$W_2^- = \frac{W_2}{W_1 + W_2 + W_3} \quad (7)$$

$$W_3^- = \frac{W_3}{W_1 + W_2 + W_3} \quad (8)$$

Then the calculation results in the third layer with the first data can be seen in Table 10. This result is known as normalized firing strength.

Table 10. Layer 3

\bar{W}_1	\bar{W}_2	\bar{W}_3
4.67385E-06	0.999863453	0.000131873

6) Layer 4

In the fourth layer the W_{if_i} value will be calculated to calculate the output of the fuzzyfication process with the following equation:

$$W_{if_i} = W_i^- * \Sigma f_i \quad (9)$$

Then the results of calculations in the fourth layer of the first data can be seen in Table 11.

Table 11. Layer 4

$\bar{W}_i f_i$
364.2584886

7) Layer 5

In this layer you will get results from calculations with neuro fuzzy. The results of this calculation are a diagnosis of the indication data entered. To calculate the results using equations:

$$Y = \bar{W}_i f_i / \Sigma \text{ parameter } c \quad (10)$$

So that the calculation is obtained in the first data

$$Y = 364.2584886 / 155.5 = 2.342498319$$

Neuro fuzzy calculations are carried out with training data of 60% or as many as 60 data records for the training process, while 40% data or as many as 10 data records for the data testing process. In the neuro fuzzy process after the defuzzyfication process, the accuracy value of typhoid fever is 80% with the number of data records corresponding to the actual value of 32 data from the total 40 data records.

Then genetic algorithm optimization is carried out in the process of forming the degree of neuro fuzzy membership. After optimization with genetic algorithms resulted in an increase in accuracy from 80% to 90% with the number of data records that correspond to the actual value of 36 data from the total 40 data records. The table of results of neuro fuzzy optimization using genetic algorithms for the diagnosis of typhoid fever can be seen in Table 12.

Table 12. Results of Neuro Fuzzy Optimization using Genetic Algorithms for Diagnosis of Typhoid Fever

No	Physical indication							Blood test					Actual	Algen+ Neuro Fuzzy
	M /F	Fe ver	Pa in	Head ache	Na use a	Diar rhea	Tempe rature	Hemo globin	Leuko cytes	Erythr ocytes	Hematr ocytes	Plat elets		
34-42-42-35-20-42-01-88-42-10-23-.42-34-48-32-36-05-22-36-37-12	M	5	3	3	3	3	36.5	13.2	7.6	4.6	38.1	317	High	High
	M	7	2	3	2	1	36.5	9.6	6.2	4.5	28.4	204	Moderate	Moderate
	M	8	2	2	3	2	36.5	14	6.5	5.2	40.6	145	Moderate	Moderate
	M	7	2	2	2	2	37.5	15.6	6.9	5.3	43	87	Moderate	Moderate
	F	5	3	2	2	2	40	10.1	5	4.3	29.8	187	Moderate	Moderate
	F	8	3	2	2	2	36	11.8	10.8	4.2	33.2	225	Moderate	Moderate
	M	10	1	2	3	2	36	14	5.1	5.5	41.4	250	Moderate	Moderate
:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
34-40-59	F	7	3	1	1	1	38.7	11.3	13	4.3	32.8	213	Moderate	Moderate

In this study, the results of accuracy are increased when the value of the degree of membership in the first neuro fuzzy layer process is optimized with genetic algorithms.

4. CONCLUSION

Neuro fuzzy optimization using Genetic Algorithm occurs in layer 1 which is a process of fuzzyfication and results in the value of the degree of membership from the variable input of typhoid fever indications. The optimization process with genetic algorithms is done to produce a more optimal value of membership by generating a randomized value of membership, then determining the fitness value. Repeat the crossover process with popsize = 3, the pc is 0.5 and the mutation with pm is 0.2 to get the desired fitness value with max generation 25. So that the value of the new membership degree is more optimal. Layers 2 and 3 are normalized firing strength and aggregation processes while layer 4 is defuzzyfication. In layer 5 it produces the output of the diagnosis with neuro fuzzy. If the output value between 0 and 1 results is Low risk, the value of 1 to 2 results is Medium risk and the output value is more than 2 High risk results. The results of the accuracy of typhoid fever diagnosis after being optimized using genetic algorithms with training data of 40 data records for typhoid fever indications resulted in 80% accuracy for fuzzy neuro and after being optimized with genetic algorithms the accuracy increased to 90%.

5. REFERENCES

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