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Smart System for Diagnosing Motorcycle Damage Using Adaptive Neuro-Fuzzy Inference System for Future Transportation

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***Abstract*—Motorcycle is one of popular vehicles in Indonesia and predicted the use will continually increase. Indonesian Motorcycle Industries Association states that in 2016, the total sales of motorcycle nationally was 5.931.285 units. The more sophisticated the motorcycle machine, the more precise maintenance needed. One of the ways is damage diagnosing ability on motorcycle. The motorcycle damage may be diagnosed based on the motor sounds heard. The aims of the current research were (1) producing the smart system product of ANFIS (Adaptive Neuro Fuzzy Inference System) to diagnose the motorcycle damage through the motor sound. (2) Analyzing the accuracy level of smart system using ANFIS. Smart system application was built using prototype development model. ANFIS built for this application consisted of 5 inputs and 1 output, with 243 rules. The lowest RSME score was 1.1056e-08, obtained from the evaluation result of Data Training and Data Testing using MF Triangular (trimf) and Trapezoidal (trapmf), Hybrid optimization method, error tolerance 0.0001 and epoh was 30. The result of Alpha Test was 4.7 and including into Very Good category. Meanwhile, the total score obtained from the Beta Test was 4.6 and including into the Very Good category.**

Keywords: ANFIS, sound identification, motorcycle damage, mobile, android

I. INTRODUCTION

Motorcycle is one of popular vehicles in Indonesia and predicted the use will continually increase because until now it still become the most economic vehicle. It may be used by all social classes and its role is important in transportation in Indonesia. Moreover, in Indonesia there is no (still in development stage) *Mass Rapid Transit* (MRT) that can go fast and comfortably as applied in developed countries. According to Statistic Center [1], motorcycle has highest development in 10.54 percent per year. Indonesian Motorcycle Industries Association says that in 2016 the total sales of motorcycle nationally were 5.931.285 units [2]. The more sophisticated the motorcycle machine, the more precise maintenance needed. There are some ways for maintaining motor, one of them is the rider or mechanic/workshop technician may diagnose the damage through the motor sound. The motorcycle damage may be diagnosed through the motor sound heard by the mechanic/ workshop technician. In digital signal management, motorcycle sound can be identified and changed into digital signal. From this signal the motorcycle damage may be identified using artificial intelligence method.

In the other side, people are faced by the sophisticated science of technology and information that may distribute quickly in the entire world including Indonesia. It may cause various change either in small scale or large scale. The emerged change tends to facilitate human for interaction and communication in various fields. It is directly proportional to the users of communication tool of phone cell, particularly the android type [3].

The android users since April 2016 until May 2017 have increased. Even, android is in the first rank with the average percentage of users of 75% out of the total cell phone users in Indonesia. It indicates the high number of people dependency on the development of

information technology [4]. The development of technology and information reach the transportation field. However, is there an online application that may help people in diagnosing their motorcycle independently? Particularly when the congestion occurs and the access to the workshop is too far.

Neuro-fuzzy is one of branches of popular artificial intelligence science and mostly applied to solve various daily problems particularly to classify, predict, and image processing. This system is the combination of two systems of fuzzy logical system and artificial neural network. Neuro-fuzzy system is based on the fuzzy inference system trained using learning algorithm deified from the artificial neural network. Therefore, neuro-fuzzy system has all advantages owned by the fuzzy inference system and artificial neural network system. The combination of artificial neural network and fuzzy logic essentially may implement the human's mastery, thus may be used in the process of decision making. From its ability to learn then neuro-fuzzy system is often called as ANFIS (*Adaptive Neuro Fuzzy Inference System*) [5,6]. ANFIS has largely used in various fields some of them to predict the heart disease [7], detect and classify the error in transmission line [8], and motor movement of robot [9], and to predict the cash flow of bank [10].

The present research is aimed to (1) produce smart system product using ANFIS with proper combination of Artificial Neural Network and Fuzzy Inferency Method to diagnose the motorcycle damage (2) analysing the accuracy level of smart system using ANFIS to diagnose the motorcycle damage. In this research, ANFIS will be used to determine the type of motorcycle damage based on the sound entered. It is expected that the smart system produced may help the rider and mechanic/workshop technician in diagnosing the motorcycle damage with high accuracy level as an expert.

The present research was inspired by research on voice recognition that had been done previously by the research team, which is how to understand sentence words and the types of sounds that have been included for diagnosis and decision making [11]. Hasanah [12] has also built an application of voice recognition to navigate presentation slides to facilitate the instructor in the learning process with the Backpropagation Artifical Neural Network (ANN) method. Based on these research, this research aims to develop an intelligent system in which the way it works is also based on voice recognition, with the domain of the problem being the diagnosis of motorcycle damage. While the method used is ANFIS, which is a combined method of Backpropagation ANN and Fuzzy Logic. This ANFIS method is expected to provide better results because it works based on the advantages possessed by Backprogation ANN and Fuzzy Logic.

II. RESEARCH METHOD

A. *Development Model*

The research method used is research and development conducted to develop the product prototype or new product design. The current research and development will produce a product of software and hardware prototype. According to Pressman [13], this method has 3 elements should be considered in software development namely users need (motorcycle rider, mechanic, and workshop technician), developer, and user's test drive (mechanic and workshop technician). In general it can be seen on Figure 1.

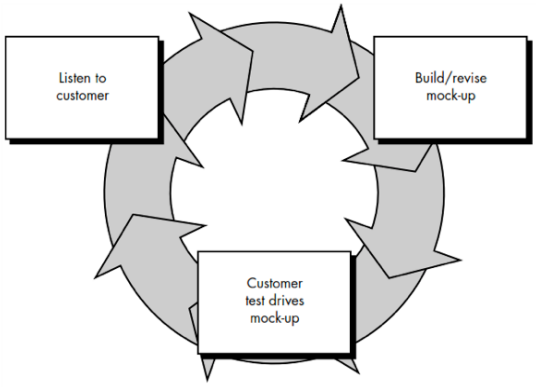

Fig. 1. Prototype Model [11]

Prototype method is software development method modeling the work system of incomplete software from the user side (motorcycle rider, mechanic, and workshop technician). The developers have coordination and meeting intensively with the users to accommodate the information that will be the base of design. Prototype of software produced is presented by the user, and the user have chance to give suggestions thus the software produced is greatly in accordance with the customers need and expectation.

B. *Development Procedure*

This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations. This research includes into the R&D procedure because the research result is oriented to the product. This software development method is started by collecting the requirements. Prototyping model approach is used if the user only defines the software in general without classifying the suggestion need, processing and output, whereas the developer not sure with the efficiency of algorithm, operating system adaptation, or interface form of human-machine should be taken. The scope of activities of prototyping model consists of (1) Defining the objective in whole and identifying the known need (2) Having design properly as the basic for prototype making (3) Testing and evaluating the prototype and give addition and improvements on the prototype made.

Ideally the prototype functions as a mechanism for identifying the software need. If the running prototype

is developing, developer should use fragmentation of the program existed or implement the assisting tools that enable the running program emerge quickly.

1. Listen to Customer

   This phase have observation and interview with the users those are the rider, mechanic, and workshop technician of motorcycle, to analyze the weakness of diagnoses process of motorcycle damage.

2. Build/revise Mock Up

   In this phase, software is getting started for pre-processing (feature extraction) that is FFT. It is continued by the software design and implementation of ANFIS algorithm for sound pattern learning and testing. Commonly this application system follow the line as depicted in Figure 2.

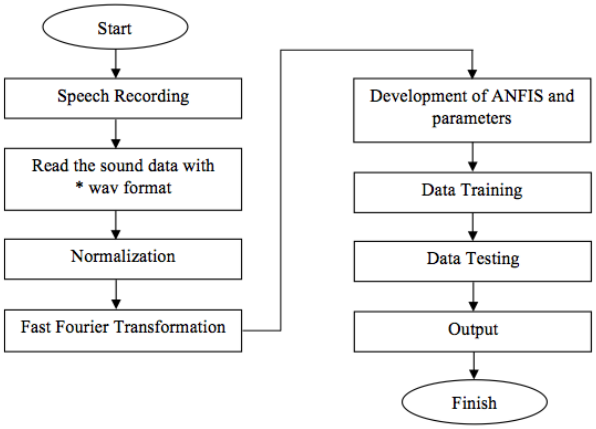

Fig. 2. Flow Chart of System

3. Costumer Test Drives Mock Up

   This phase is evaluation phase that is the activity of collecting, processing, and analyzing information systematically to obtain the real score of problem solving. Evaluation phase is conducted by collecting information from the users (rider, mechanic, and workshop technician) who have used the application developed.

   a) Alpha Test

      Alpha test aims to identify and eliminate as much as possible the problem before finally reach the users. The test is conducted after the application finish to be developed by the developer. The instrument of Alpha test is required for guarantying the validity of application performance result. The experts assigned in alpha test consist of; software development expert and practitioner.

   b) Beta Test

      Beta test is completely conducted by the user using instrument by chosin three categories potential user, average user, and slow learner user. The user is provided with the information of beta test procedure, then asked to give score on the application to collect data. The result of beta test will be the revision material of application product. The instrument of beta test is used after confirmed by the software development expert.

The data analysis method used in the case of answering the problem design which then clasified in the research question is analysisi technique of quantitative descriptive and evaluative. This technique is used because in R&D research not conducted the hypothesis test. The research evaluate the feasibility of application product with descriptive analysis technique conducted to determine the product feasibility in its function.

III. Results

A. ICT Literacy

The first step of this research was Listening To Costumer or having communication with the customer/prospective user. The interview was conducted with customer, mechanic, and workshop technician of Mulia Jaya Motor Yogyakarta and Motorcycle workshop of Automotive Engineering Education of Engineering Fcaulty of UNY. The interview was discussion and answering question focused on the problem faced in diagnosing the motorcycle damage through the sound. The following are problems found as well as the solution gathered from the result of answering question with the user.

1. Customer unable to understand the problem occurred in motorcycle. Customer not have knowledge about motorcycle thus unable to understand correctly the type of motorcycle damage occurred, either visually or sound. Only the mechanic that able to diagnose the type of motorcycle damage based on the sound. The solution expected is the existence of a system/application that can diagnose the type of motorcycle damage based on the sound that can be operated by unexpert in motorcycle.
2. Costumer cannot find workshop near with the location and not know the contact number of workshop can be called. Sometime, the customer have trouble on his motorcycle in the location far from the workshop. Some customers location also far from the motorcycle workshop, thus require much time and power to push motorcycle. The proper solution is building a system/application that able to diagnose the type of motorcycle damage based on the sound with unlimited time and space.
3. Some types of motorcycle damage on such brand have similar damage sound thus difficult to be diagnosed and the presence of human error due to the fatigue factor causes the diagnose result not accurate. The solution is building a system/application that able to diagnose the type of motorcycle damage based on the sound automatically, quickly, accurately, and

consistently although the sound diagnosed have high similarity of sound with other sounds.

4. Sometime, difficulty in concentrating while listening the sound because disturbed by other sounds such as other motor. Mechanic and technician can detect the dmaage from the sound, but sometime disturbed by other motorcycle sounds or other machines in or outside of the workshop. The solution is building a system/application that able to diagnose the type of motorcycle damage based on the sound with high noise of sound.

The next step was analysing the requirement of process based on the problem and solution will be applied.

1. The process of taking sound sample for the the basis of network knowledge. In this process, the researcher took data of motorcycle damage sound from workshop of Mulya Jaya Motor Yogyakarta and Motorcycle workshop of Automotive Engineering Education Program of Engineering Faculty of UNY. The process of sound sampling was conducted on May 2018. The data of motorcycle sound taken was 350 sounds infile format of .wav. this sound then was entered to ANFIS as the basis of knowledge to be the basis of decision making. The tool used to take the sound was Digital Voice Recorder. The damage type from the sample of motorcycle sound was 4, namely (1) Coupling Rubber House (2) Compact Chain (3) Loose Valve Gap (4) Damage on Locker Bearing / Dearing / Noken As, and also Normal sound.
2. The process of taking sound sample for testing. After taking motorcycle sound sample as the knowledge basis of ANFIS, the next step was taking sound for network testing. The data of sound taken for the test was 150 sounds.
3. The process of type determination of motorcycle damage entered.

B. Design Result of Build and Revise Mock-up Stage

1. Interface Design

   Interface design for application Smart System Application of Diagnosing Motorcycle Damage using *Adaptive Neuro-Fuzzy Inference System* can be seen on Figure 3.

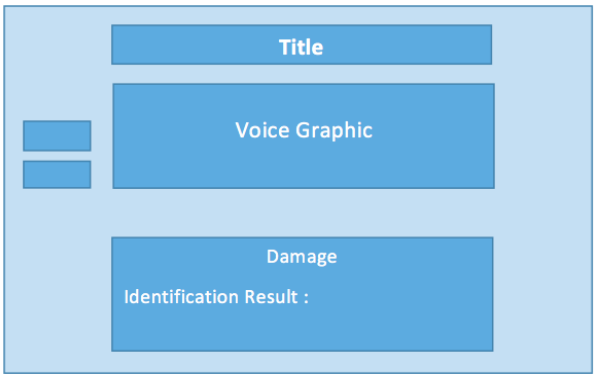

Fig. 3. Interface Design of Motorcycle Damage Diagnoser Application

2. Interface Implementation Result

   Application interface depict on Figure 3. To obtain the proper result as expected, the use of this application should in accordance with the following steps:

   a) Take the data using botton “Open File” and chose the file will be diagnosed the damage. After the data chosen, to indicate that the data has entered the system then the column of “File Name” will be filled with the name of file chosen as well as the graphic of “Amplitude” will be filled with amplitude graphic of the data.

   b) After ensure that the data has successly entered the system, we can push the botton “Play” to listen the data of motorcycle sound.

   c) Push the botton of “Predict” to have presses diagnosis using ANFIS method.

   The diagnosis process not require much time. The diagnosis result is depicted on column “Prediction Result” containing the name of motorcycle damage.

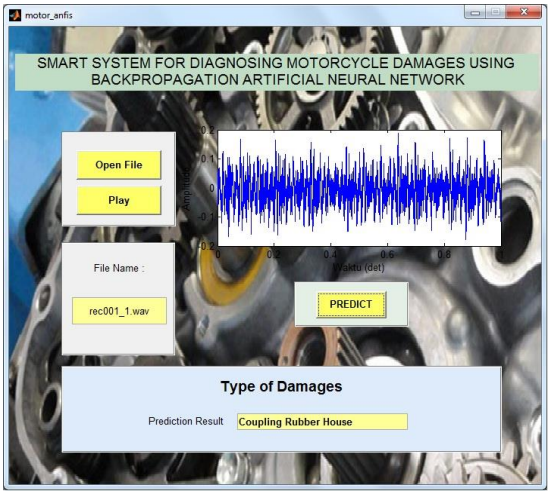

Fig. 4. Application Diagnose Result

C. The Result of Costumer Test Drives Mock-up

The first step of this research was Listening To Costumer or having communication with the customer/prospective user. The interview was conducted with customer, mechanic, and workshop technician of Mulya Jaya Motor Yogyakarta and Motorcycle workshop of Automotive Engineering Education of Engineering Faculty of UNY. The interview was discussion and answering question focused on the problem faced in diagnosing the motorcycle damage through the sound.

1. Alpha Test

   The experts assigned in alpha test consist of the experts of software development. The total score obtained from the result of instrument filling of Alpha test was 4**.7** and including into category of **Very Good**.

2. Beta Test

   The users who have test was potential user. They were provided by the beta test procedure, then required to give score on the application to gain the data. The result of beta test will be the revision material of application product. The total score obtained from the instrument filling of beta test was **4.6** and including into category of **Very Good**.

IV. Discussion and Results

The present research used two types of data namely the data for training (Training Data) of 300 and data for testing (Testing Data) of 100.

1. **Load Data** Stage

   In this stage, the data was loaded into ANFIS Editor GUI. The data loaded was Training Data then continued by Testing Data. The result of Training Data loaded was depicted on Figure 5 figured by the small circles with hole.

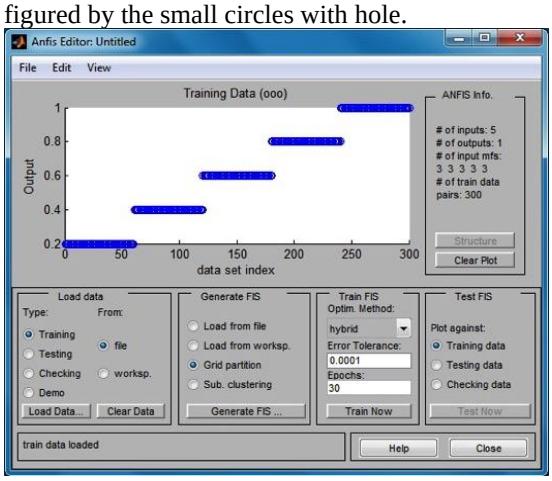

Fig. 5. Training Data

Meanwhile, the result of Testing Data loaded was displayed on Figure 6 figured by filled small circles. Both of data type loaded was file of sounds compilation with extension of .dat.

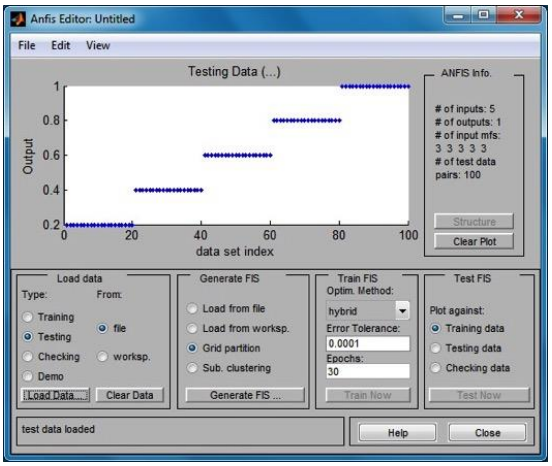

Fig. 6. Testing Data

2. **Generate FIS** Stage Test

   The next stage was generating the FIS. In input, the number of membership function (MF) used was 3 3 3 3 while the type of MF yang was Triangular (trimf), Trapezoidal (trapmf), Generalized Bell (gbellmf), and Gaussian (gaussmf). In output, type of MF chosen was constant.

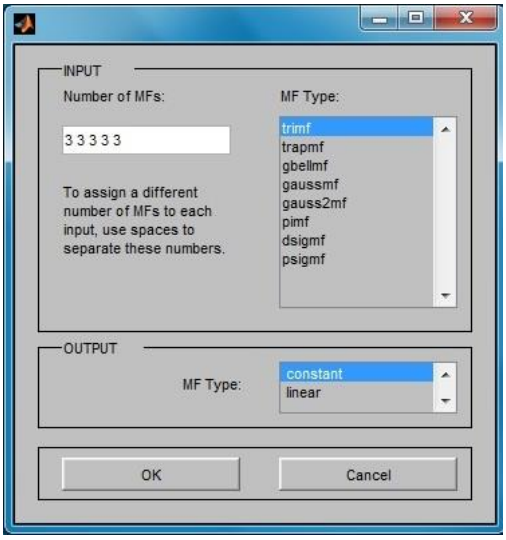

Fig. 7. Generate FIS

3. **Training FIS** Stage Test

   After FIS generated, next was training the FIS. The optimization method used was hybrid and back propagation. The Error tolerance was 0.0001 while epoh used was 30.

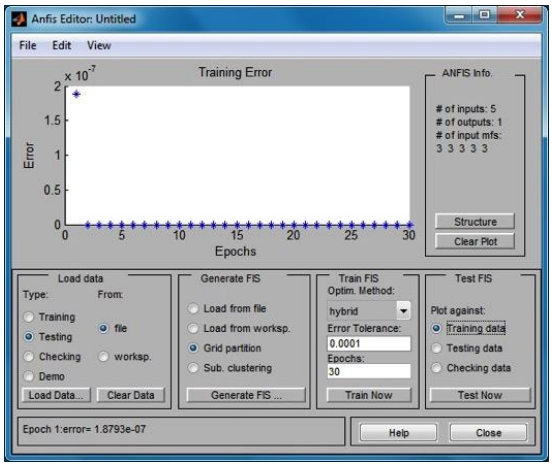

Fig. 8. Train FIS

Figure 8 indicated the FIS training stage using hybrid and trimf method. The score of Root Mean Square Error (RMSE) obtained was 1.8793e-07.

4. **Test FIS** Stage Test

In this stage the test is conducted using FIS design made before the Training Data which continued by evaluation of Testing Data. This evaluation was conducted with four types of MF namely trimf, trapmf, gbellmf, gaussmf. Meanwhile, the optimization methods were hybrid and back propagation. Figure 9 indicated the evaluation result of Training Data using trimf and hybrid optimization method. The score of RMSE obtained was 1.1056e-08.

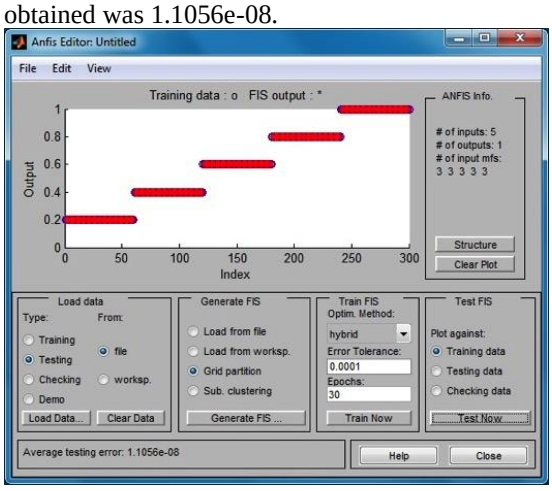

Fig. 9. Evaluation Result of Training Data

In addition, the figure 10 indicated the evaluation result of Testing Data. The score of RMSE obtained was 1.1056e-08.

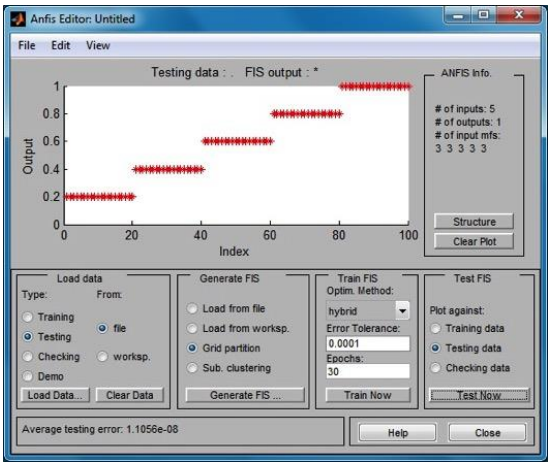

Fig. 10. Evaluation result of Testing Data

Table 1 showed the comparison of RSME score obtained from the evaluation result of Training Data and Testing Data using four types of MF (trimf, trapmf, gbellmf, and gausmf) and two optimization methods (hybrid and backpropagation).

TABLE I. COMPARISON RESULT OF RSME SCORE

Root Mean Square Error (RMSE)				
MF	Training Data		Testing Data	
	Hybrid	Backpropagation	Hybrid	Backpropagation
Trimf	**1,1056e-08**	0,395	**1,1056e-08**	0,395
Trapmf	**1,1056e-08**	0,395	**1,1056e-08**	0,395
Gbellmf	4,0612e-08	0,42905	1,1107e-06	0,42905
Gausmf	5,6515e-08	0,40958	1,6555e-06	0,40958

The researcher may conclude based on the Table 1 that the smallest result of RMSE was **1.1056e-08**, obtained from the evaluation result of Training Data and Testing Data using **trimf** and **trapmf** with **hybrid** optimization method. Figure 11 showed the structure of ANFIS model used. ANFIS consist of 5 inputs and 1 output with 243 rules.

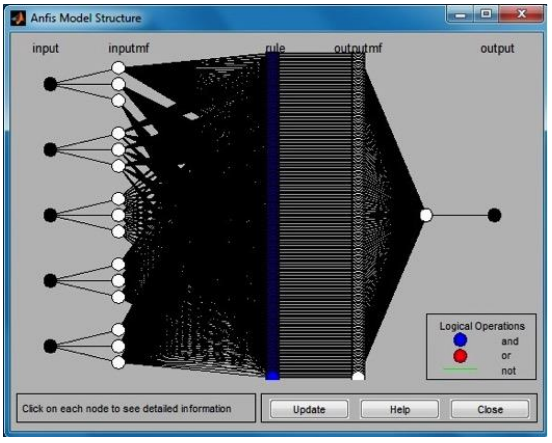

Fig. 11. ANFIS Model Structure

V. RESULTS

Based on the results of the research and discussion, the conclusions obtained from the research are:

1. Smart System Application of Diagnosing Motorcycle Damage Using Adaptive Neuro-Fuzzy Inference System is developed using Prototype development model. ANFIS built for this application consist of 5 inputs and 1 output with 243 rules.
2. In the stage of ANFIS development, it has been tested by some architecture of ANFIS with different MF type and optimization method. The smallest score of RSME is **1.1056e-08**, obtained from the evaluation result of Training Data and Testing Data using **MF Triangular (trimf)** and **Trapezoidal (trapmf)**, **Hybrid** optimization method, error tolerance 0.0001 and epoh of 30.
3. The total score obtained from the filling result of Alpha test instrument is **4.7** and including into category of **Very Good**. Moreover, the total score obtained from the filling result of Beta test instrument is **4.6** and including into category of **Very Good**.

ACKNOWLEDGMENT

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