Electric Motorcycle Damage Detection System Using Tsukamoto's Fuzzy Inference System

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Abstract

With the development of technology today, there are more and more users of electric motorcycles because electric motorcycles are a cheap, affordable and environmentally friendly means of transportation. The number of electric motorcycle users is not proportional to the level of understanding of the damage and the symptoms of the damage. To overcome this, this research creates a system that can help detect damage to electric motorcycles based on the answers to symptoms experienced by customers at the Bogi Power workshop. With this system the repair process becomes fast and efficient. This study uses 21 questions with answer choices (Yes, Sometimes, No) which are assigned a value to determine the weight. In order to make the right decisions in this research, the Tsukamoto Fuzzy Inference System method is used with the rules that have been used then look for the zscore and conclusions about the damage to the electric motorcycle.

Keywords*: Electric Motorcycle, Fuzzy Inference System Tsukamoto*

1. Introduction

Electric motorcycles are a means of transportation that is currently widely used by several groups of people. Provide information to consumers when buying a used motorbike, there are input criteria that must be considered, including complete documents, engine condition, body condition and price [1]. A system is needed on the vehicle that has a function to avoid collisions between motor vehicles and objects in front of them. By using distance and speed detection between motor vehicles and objects in front of them, ultrasonic sensors will be used as distance parameters, hall effect to measure the speed of motor vehicles. Determination of the output value will be processed using the fuzzy logic method which is processed using a microcontroller [2]. The growth of electric motorcycles is very rapid in line with the level of need and the community's economy for cheap, affordable and environmentally friendly means of transportation. Damage to automatic motorbikes is one of the problems that users often face, so it is not uncommon for users to immediately take the vehicle to a repair shop [3]. Through this system, users can monitor the performance of 3-phase motors accurately and take necessary actions in case of disturbances or abnormal conditions. This system also allows optimization of energy use by adjusting the motor speed according to application needs [4]. Detecting damage to electrical components of automatic injection motorbikes is a system to make it easier for motorbike owners to detect damage to their motorbikes, so that owners can find out early about damage to their motorbikes and can take initial action before being followed up by mechanics [5].

However, the more electric motorcycle users there are, not many people understand the damage they experience and how to overcome it, in terms of business, there are still not many who open electric bicycle service or repair shops to repair electric motorcycles.By implementing Fuzzy Inference System with Mamdani method for detecting electrical damage on motorcycles, it can simplify the process of detecting electrical damage on motorcycles [6]. With a damage detection system on this electric motor, it can help to detect damage to the electric motor, so that it can make it easier to handle damage to the electric motor. The problem encountered with motorbikes is because motorbikes have complicated engine components and the time to predict the level of damage to the motorbike takes a long time [7]. The development of environmentally friendly vehicle technology has encouraged the increasing use of electric motorbikes as an alternative transportation that is energy efficient and has low emissions. Fuzzy Logic Application: The use of fuzzy logic in controlling solar panels for DC motors can increase the efficiency of energy use. Fuzzy logic allows the system to adjust the power generated by the solar panels adaptively according to environmental conditions and the needs of the DC motor [8]. However, electric motorbikes still have the potential to experience various types of damage, both in the electrical system, motor, battery,

and other electronic components. This damage can cause decreased performance or even vehicle failure if not immediately identified and handled. The Sugeno fuzzy logic method acts as a water pump speed controller based on the speed of water discharge entering the reservoir, then the total water and speed of water flow entering the reservoir will be displayed on the LCD display [9].

In practice, the process of diagnosing electric motorbike damage still depends heavily on the expertise of technicians or user experience. This is a challenge in itself because not all symptoms of damage have a definite pattern, and often involve information that is uncertain or vague. Therefore, a system is needed that can help the diagnosis process quickly and accurately even with incomplete or vague data. One approach that can be used to overcome this problem is a Fuzzy Inference System (FIS)-based system. The fuzzy method can accommodate uncertainty and imitate the way humans make decisions based on experience. In particular, the Tsukamoto method in FIS provides results in the form of crisp values that are suitable for diagnostic systems. By combining a number of symptoms inputted by the user, this system can determine the level of damage logically and systematically. The application of the Fuzzy Inference System method Mamdani through a process that begins with Fuzzification Input load settings and sensor load input then performs inference consisting of implication functions with the min method and composition between rules with the max method which ends with the centroid method defuzification process can help optimize the 3-phase induction motor speed control system so that the motor speed can be constant even though it gets a variable load from 0.5 Nm to 1.75 Nm with a load optimization level of 75% from previous research [10].

In addition, a web called NAMI will be created to monitor the state of the sea. The web aims to make it easier for the public to participate in seeing the latest marine conditions. NAMI is developed on a web service with the Laravel 8 framework, while data processing uses the Fuzzy Tsukamoto Algorithm [11]. The expert system can diagnose washing machine damage and is able to provide convenience for washing machine users to be able to know early about the symptoms of washing machine damage so that they can handle washing machine damage more quickly and precisely [12]. IoT enables real-time data collection from various sensors installed in the field, enabling smarter and more timely decisions. However, to optimize management of rice fields, a method is needed that is able to manage sensor data well, and the Tsukamoto fuzzy method is one method that is able to provide this solution [13]. This method was chosen because it can handle data uncertainty in clinical symptoms. To determine the diagnosis results, the system consists of five main stages, namely collecting data on symptoms and disease characteristics, data fuzzification, rule formation (rule base), fuzzy inference process, and defuzzification [14]. In fuzzy logic there is a Fuzzy Inference System (FIS) and the method used is the Tsukamoto method. The Tsukamoto method has 3 important stages, namely: 1. Fuzzification to determine variables, sets, and domain values, 2. Inference for the process of forming rules and Min implication functions, and 3. Defuzzification using the weighted average method [15]. This study uses the Tsukamoto Fuzzy Inference System (FIS) method with 3 input variables, namely income, collateral, and the character of the prospective borrower. The output variable in this study is the feasibility in the form of a percentage of the Tsukamoto FIS calculation results [16].

Therefore, this study aims to design and implement an electric motorcycle damage detection system using the Tsukamoto method of Fuzzy Inference System, as a solution to support an efficient, flexible, and reliable damage diagnosis process.

2. Method

This study uses the Tsukamoto fuzzy method which forms a rules-based or rule base in the form of "cause and effect" or "if-then". The calculation steps in using the Fuzzy method are as follows:

1. The first step in calculating the Tsukamoto Fuzzy method is to create a fuzzy rule.
2. The next step is to calculate the degree of membership according to the rules that have been made. After the membership value of each fuzzy rule is known, the alpha value of the predicate can be determined by using fuzzy set operations. The linear function is down, namely the fuzzy set starts from the value of the region with the highest degree of membership on the left side, then moves down to the domain value that has a lower degree of membership.

The set in each variable is calculated based on the answer to the selected damage question. With the provisions of the answer choices YES (Value 60-100), the value Sometimes (30-70), and the answer no (0-40). Furthermore, the inference calculation process and finally the deffuzification process with the z-score calculation. The following is a picture of a fuzzy set in the damage detection system on an electric motorbike which can be seen in Figure 1.

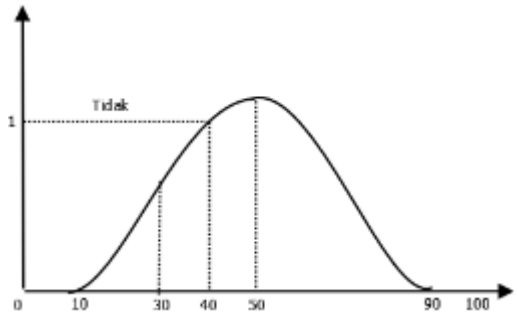

Figure 1. Curva Beta

$Yes = 1 / (1 + ((Z(i) - 80)/10)^2)$
$Sometimes = 1 / (1 + ((Z(i) - 50)/10)^2)$
$No = 1 / (1 + ((Z(i) - 20)/10)^2)$

Description:
Value i = Input value based on answer choices from damage symptoms
The knowledge base applied in this study uses fuzzy logic, especially fuzzy Inference System with the Tsukamoto method. The input value used is the original data that is processed. The input variable used is the variable of damage symptoms of this electric motorbike which can be seen in the following table 1.

Table 1. Symptom Variables

Symptom Code	Symptom Name
GJL01	Molis is powerless
GJL02	Battery drains quickly/leaks
GJL03	When charged, it immediately fills up quickly
GJL04	The engine is limping
GJL05	The motor can rotate when assisted at the start
GJL06	The engine sound is rough and lacks power
GJL07	The engine rotation is slow and jerky
GJL08	The BLDC motor spins for a moment then stops due to improper installation
GJL09	Hall sensor malfunction
GJL10	3 phase motor failure
GJL11	Damage to the seat assembly
GJL12	Axle damage

Symptom Code	Symptom Name
GJL13	Carrying load that is too heavy
GJL14	A short circuit occurred in the 3 phases of the motor
GJL15	When the condition is ON, but the motor does not want to turn when the gas is pressed, there is a small "tick" sound from the controller
GJL16	When the motor is rotated manually, it feels jerky/stuttering
GJL17	Micro damage to the controller
GJL18	Gas handle damage
GJL19	Voltage too low or too high
GJL20	Unequal phase voltage
GJL21	One of the phases is broken

Table 2. Damage table

Damage Code	Damage Name
KR01	Battery Damage
KR02	BLDC Motor/Dynamo
KR03	Controller
KR04	Supply Network

3. Result and Discussion

This research and damage detection system on electric motorcycles was created as a medium to help bogi power workshops so that handling of damage to their electric motorcycles is faster. The admin inputs data based on the symptoms experienced by the customer's electric motorcycle. The system will show what damage is experienced after that the customer can submit it to the workshop mechanic to repair the damage directly. The calculation in this system begins when the admin inputs an answer based on the symptoms given by the customer (Answer Choices Yes, Sometimes, No). The value of the answer Yes (60-100), Sometimes (30-70), No (0-40). An overview of the questions can be seen in figures 2 to 4.

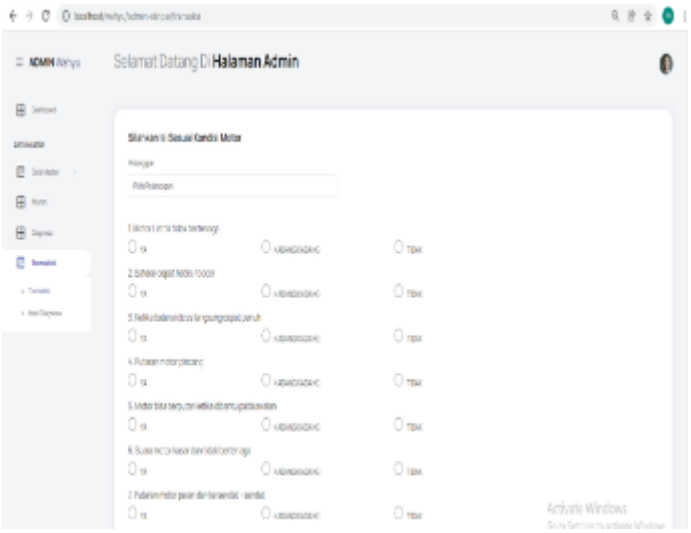

Figure 2. Question 1

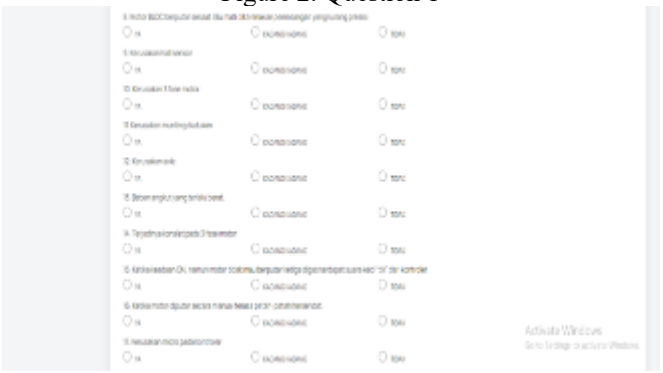

Figure 3. Question 2

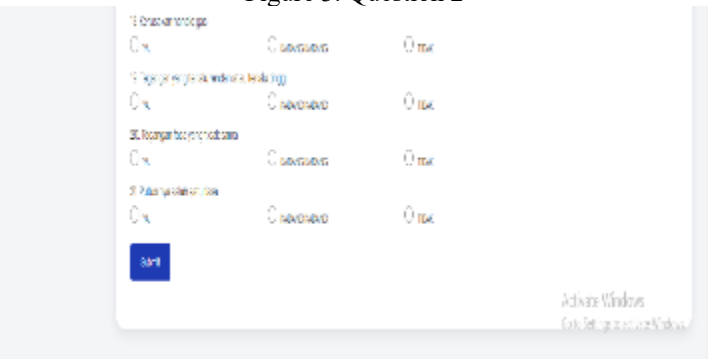

Figure 4. Question 3

Next, the weight calculation is carried out using the following formula:
Weight (a) = $1 / (1+((Z(i)-M_e)/(10)^2))$

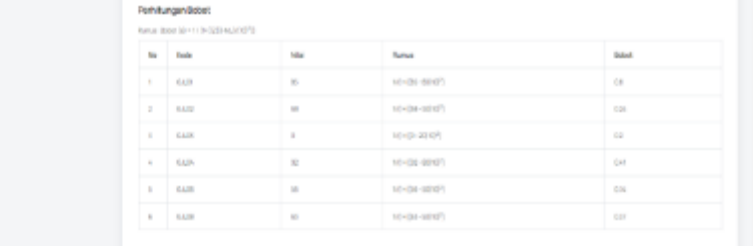

Figure 5. Weight calculation

The next step is the defuzzification calculation and the last zscore calculation, then the conclusion of the damage to the electric motorbike is drawn. The Z formula is as follows:

$Z = z_1 * a_1 + z_2 * a_2 \; z_n * a_n \; / \; a_1 + a_2 + a_n$

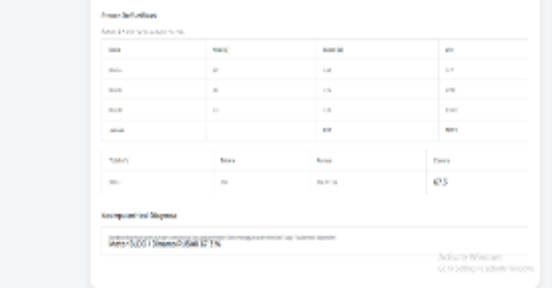

Figure 6. Defuzzification Calculation

4. Conclusion

Based on the results of this study, the following conclusions can be drawn:

1. The electric motorcycle damage detection system uses 21 questions with answer choices (Yes, Sometimes, No) which are given a value and then converted into weight.
2. The system that has been designed by implementing the Tsukamoto Fuzzy System method can be proposed for use in decision making in the damage detection system on electric motorcycles.

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