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Early Diagnosis of Damage to Automatic Injection Motorcycles Using a Decision Tree Algorithm Based on Mobile Application

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Abstract

Indonesia is the country with the most motorcycle users, where nearly a third of the population owns motorcycles. Automatic motorcycles are the most widely used type because of their agility and ability to save fuel. However, if there is sudden damage, it can hamper activity. In addition, most users do not know the cause of the damage they are experiencing. The purpose of this research is to develop a mobile-based application to help users of automatic injection motorcycles in diagnosing earlier the problems they are experiencing. All data related to damage and its solutions were obtained based on interviews with experts and conforming to existing theories. The research method used is to develop applications using the System Development Life Cycle (SDLC) and the artificial intelligence algorithm used is the Decision Tree. Decision Tree has become one of the popular algorithms for diagnosing damage to various systems and devices, including in this context for diagnosing damage to automatic injection motorcycles. This method is used because it is a key path for identifying damage that has rules. The Decision Tree is a technique of exploring data into a branch to produce a solution. The results of this study are that the application is fully functional, both from the user and admin side. In addition, through the application of the Decision Tree Algorithm with an accuracy rate of 100% without any discrepancies. Finally, we can also confirm that the application can be used by users to assist in solving damage problems by accommodating maintenance actions or also choosing repair services.

Keywords: artificial intelligence, decision tree, injection motorcycle, motorcycle damage.

1 Introduction

In the Asian region, including Indonesia, is the country with the highest number of motorcycle users [1]. For this reason, various types and variants of motorcycles have been circulating, including the generation of injection engine motorcycles that have begun to appear. The presence of a motor with this type of injection engine is nothing but to support low levels of exhaust emissions and also fuel efficiency [2]. Automatic injection motorcycles have become one of the most popular motorized vehicles in recent years. Its reliability, fuel efficiency and ease of use make it an attractive choice for many. However, like other motorized vehicles, automatic injection motorcycles are also prone to damage and technical problems. Diagnosing damage to an automatic injection motorcycle is a complex challenge. Damage can be caused by a variety of

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factors, including worn mechanical components, electronic faults and fuel problems. Accurate and efficient identification and troubleshooting are important factors in maintaining the performance and service life of automatic injection motorcycles.

In the last few decades, Artificial Intelligence (AI) has progressed rapidly and has become a very relevant research area in various industries. The application of AI in diagnosing damage to automatic injection motorcycles offers great potential in increasing the efficiency and accuracy of the diagnostic process. One of the AI algorithms that can be used is the Decision Tree. A Decision Tree is a predictive model that uses a tree structure to map a series of decisions based on a given attribute and attribute value [3]. This Decision Tree Algorithm is very simple and easy to use when compared to a Random Forest. A Decision Tree combines several decisions, whereas a Random Forest combines several Decision Trees. So it's a slow process, although time-consuming. Besides that, the accuracy of the Decision Tree Algorithm is better [4].

In the context of diagnosing damage to an injection automatic motorcycle, Decision Trees can be used to identify patterns and relationships between symptoms and signs of damage with possible causes. The application of AI, especially Decision Trees, in diagnosing damage to injection automatic motorcycles has several advantages. First, the use of Decision Trees can speed up the diagnostic process by providing the technician or mechanic with clear instructions on the steps to be taken. Second, it can assist in identifying complex faults by breaking them down into a series of simpler, easier-to-follow steps. Third, the use of AI can reduce human errors in diagnosing damage, because AI models are based on well-defined rules and patterns [5]. In conclusion, the application of AI, such as Decision Trees, for diagnosing damage to automatic injection motorcycles has great potential in increasing diagnostic efficiency and accuracy. The use of this technology can help technicians or mechanics quickly identify the cause of a breakdown and provide the right solution, which in turn can reduce repair time and associated costs.

2 Related Works

Numerous studies have explored the use of AI in diagnosing motorcycle damage. The following are some examples of related research including [6][7][8] which utilizes an Expert System Method with the type of Forward Chaining to diagnose damage to automatic injection motorcycles based on Android, the application has been implemented for users and can function, but this application does not have a request for repair feature as a service and only provides solutions to overcome the damage. In addition, research from [9][10] each of which builds desktop and website-based applications as a means of diagnosing damage to automatic motorcycles that utilizes the Expert System Method with the Forward Chaining type, but the request for repair feature does not exist and only provides repair solutions just.

The research conducted by [11] built an application for diagnosing automatic motorcycle engine damage by utilizing the Certainty Factor Algorithm, the result is that the accuracy of using this algorithm must always be evaluated with the help of experts, besides that there is no feature to propose repairs. Furthermore, research from [12] utilizes the C4.5 Algorithm in the web-based Honda and Vario motorcycle damage diagnosis application, where the test results when using the algorithm obtained an accuracy of 86.7%. Besides that, the evaluation of this study was that there was a discrepancy in the diagnostic results, required acquisition of continuous knowledge from experts, and there is no feature to propose improvements.

Based on the several studies that have been described, the research being conducted now is to complement the shortcomings of previous research which include trying to improve modeling based on the acquisition of appropriate experts and the existence of proposed improvement features. So that the resulting application can help significantly and not only provide a solution in the description, but can also provide direct repair services by taking the motorcycle to a garage or having a service at home. It also tries to maximize its accuracy.

3 Research Methodology

The software development method used is the Software Development Life Cycle (SDLC) which consists of six stages, namely Analysis, Design, Development, Testing, Deployment, and Maintenance. This model can be used to create systems that have artificial intelligence interactions, including machine learning [13]. In detail, the steps taken are explained as follows:

(1) Analysis: at this stage, the software development team interacts with users or other stakeholders to understand the business and functional requirements that must be met by the software to be developed, namely an early diagnosis system for automatic injection motorcycle damage, besides that communication is also needed with experts to explore related fault symptoms and proposed solutions. The result of this stage is a requirements analysis document that contains clear specifications regarding what is expected of the software to be built;

(2) Design: This stage involves activities in designing the overall software structure. This design includes system architecture design, user interface and interaction design, database design, module or component design that will be used in the software, and modeling rules that will be used as Decision Trees which will also be integrated with the software. The result of this stage is a design document that contains a detailed description of the structure and function of the software;

(3) Development: The development stage involves writing software code based on the designs that have been made, this involves Front-End Developers and Back-End Developers. The development team uses appropriate programming languages and development tools to implement the required features. The result of this stage is software that is ready to be tested;

(4) Testing: The testing phase is the stage where the software is tested to ensure that it can function according to predetermined specifications. The test is carried out by comparing the expected results with the actual behavior of the software. If there are errors or failures, they are noted and corrected by the development team. The tests carried out in this study focused on functional testing using the Black-Box Testing technique. In Black-Box Testing, the primary focus is on the inputs and outputs generated by the software, as well as the functional behavior of the software. Where testing is done by testing the software from outside, such as end users. Testers only have access to software specifications and requirements, without knowing the implementation details in them. The purpose of Black-Box Testing is to identify errors, defects, or discrepancies between the expected functionality and the actual behavior of the software [14].

(5) Deployment: This stage involves installing the software into the production environment. The software is a mobile device application for early diagnosis of damage to automatic injection motorcycles with a Decision Tree Algorithm that has been tested and approved ready for use by end users. At this stage, data migration (if needed), user training, and necessary infrastructure

preparation are carried out.

(6) Maintenance: This stage involves monitoring, fixing, and updating the software after it has been launched. Maintenance can include bug fixes, performance improvements, adding new features, and handling problems that arise during the use of the software.

Next, the role of the Decision Tree Algorithm in this system is explained, namely as a means to find patterns of a symptom that occurs as an initial diagnosis of damage to an automatic injection motorcycle which will form a Decision Tree model that will direct between symptoms that occur as conditions towards conclusions as decisions are formed through appropriate rules [15]. The processes in the Decision Tree Algorithm are (1) Changing the form of data (tables) into a Decision Tree model; (2) Turning Decision Tree models into rules; (3) Simplifying the rules (Pruning) [16].

Table 1 and Table 2 describe a list of questions from the symptoms experienced by users and a list of damage from injection automatic motorcycles.

Table 1: List of Symptom Inference Questions

Id	Question
G000	What type/brand of injection automatic motorcycle do you have?
G001	Is the injection lamp flashing or calibrating?
G002	Does the engine not start at all?
G003	Does the spark plug fire?
G004	Is there a red, irregular flame coming out of the spark plug?
G005	Is it losing compression or is it losing pressure when cranking?
G006	Does the appearance of rust on the spark plug cap?
G007	Does it not start when the engine is started, but when cranked does it start?
G008	Is the motorcycle difficult to start or halting?
G009	Does a rough sound occur in the cylinder?
G010	Do you experience hiccups when the motorcycle is running and experience a momentary shutdown?
G011	Will the motorcycle stall when the gas lever is low?
G012	Does the motorcycle feel heavy, but the engine still sounds good?
G013	Are all the lights on the speedometer display off?
G014	Is there no sound at all when turned on with the electric starter?
G015	Do you experience a machine that stutters and then suddenly turns off?
G016	Are the spark plugs black?
G017	Is the motorcycle engine unable to slow down?
G018	Do you experience a lack of response to gas pull or a discrepancy between the kilometer value and the gas pull conditions?

G019	Is there a weak pulp sound?
G020	Does it lose power when it's on early, middle, and full throttle?
G021	Is white smoke coming out of the exhaust?
G022	Is there no fire coming out of the coil?

Table 2: List of Demage Conditions

Id	Demage Conditions
KMil	Damage Incurred is Specific to Mile Codes
K000	Malfunction Not Detected
K001	Cylinder Block
K002	Spark Plug
K003	Valve Spark Plug
K004	Idle Screw
K005	Throttle Position Sensor
K006	Setting Valve
K007	Coil
K008	Throttle Body
K009	Pulp
K010	Injector, Pulp Filter
K011	Fuse
K012	Valve
K013	Accu
K014	Trigger Valve
K015	Continuously Variable Transmission
K016	Switch Rem
K017	Short-Circuit or Damage to the Cable

In addition, Table 3 shows in detail the solutions and descriptions of the solutions offered. Table 4 is the rule data that will be entered into the system so that it will also form a decision tree which can be seen in Figure 1. This is all based on the results of discussions with experts who are involved in dealing with damage to automatic injection motorcycles, while also adopting theories and events that have occurred.

Table 3: List of Solutions and Detailed Descriptions

Id	Solutions	Detailed Descriptions
K000	Malfunction not detected. Please enter the damage experienced by your motorcycle.	Malfunction not detected. You can submit and fill out a complaint on the submission record form so we can evaluate the damage to your motorcycle.
K001	If the cylinder block is damaged, namely the inner cylinder wall is scratched or worn, then the way to fix it is to change the cylinder (change the size of the hole).	0.25 means that the oversize is 0.25 mm, namely the cylinder is changing for the first time; 0.50 means that the oversize is 0.50 mm, that is, the cylinder has changed for the second time; 0.75 means that the oversize is 0.75 mm, that is, the cylinder has changed for the third time; 0.100 means that the oversize is 0.100 mm, that is, the cylinder has changed in size for the fourth or last time. Once in a 0.100 oversize cylinder, the cylinder cannot be cortered anymore, and the corrective action is to replace a new cylinder block or shock the old cylinder block again. The job of over-sized cylinders or cylinder shocks is done by a lathe workshop.
K002	In case of emergency clean the spark plug with a wire brush, it is recommended to replace the spark plug with the original one.	Clean the spark plug with a wire brush until it is completely clean and clean using gasoline. Avoid getting soaked in gasoline. Replace the spark plug with a new and original one according to the type of vehicle and adjust the length or shortness of the thread size or the size of the spark plug.
K003	Do the cleaning with gasoline and dry it after that do the installation again as before.	If the spark plug valve starts to break down (not tightly attached to the spark plug), you want to tighten it but it still doesn't work, then it must be replaced with a new one. Replace the spark plug valve according to the type of motorcycle. Because every motorcycle has a different shape.
K004	It's easy to set, just turn the knob using a screwdriver plus. If you turn it to the left it will enlarge the incoming air and to the right to reduce the incoming air.	Remove the idle screw by looking at the end, if it looks dirty it means that the throttle body is also dirty, then clean the idle screw. After that, put the idle screw back in to its original place, turn the idle screw knob to the right until it is fully rotated, then start the motorcycle, pull the gas lever a little so the motorcycle doesn't turn off, and turn the knob to the left until it feels stable.
K005	By shifting and only done by mechanics. If the damage is too severe then it can be replaced with a new Throttle Position Sensor.	Usually accompanied by a flashing Malfunction Indicator Lamp (MIL) 8 times, but some are not detected.
K006	First please open the valve cover on the front of the engine, align the magnet rotor to the top position, and shake the valve, the rocking valve then do the adjustment, the valve is prohibited from being too tight and also to rocking.	It is recommended to be supervised by a mechanic or leave everything to a mechanic or workshop when carrying out routine service.

K007	Check the coil whether there is a short circuit or out of electric current. If it happens then replace the coil.	It is recommended to replace the coil with the original product according to the type of motorcycle. Loss of ignition can occur when the coil, accu, magnetic spool, body cable is shorted, or the Capacitor Discharge Ignition is in a weak condition.
K008	Perform routine servicing by cleaning the throttle body using an injector cleaner fluid.	It is recommended to be supervised by a mechanic or leave everything to the mechanic. The throttle body does not work optimally if there is dirt attached to the throttle body wall. This dirt is caused due to the duration of vehicle usage and airborne dirt sticking to the throttle body.
K009	Carrying out routine service, and replacing the pulp is recommended with original products that match the type of motorcycle.	Damage to the pulp occurs due to the age of use or the habit of leaving the fuel tank almost empty, it could be due to lack of maintenance on the pulp filter because it can reduce the performance of the pulp itself.
K010	Replace the injector with an original product that matches the type of motorcycle. Meanwhile, the filter can be replaced and it is recommended to use the original product.	The cause of the less than optimal performance of the injector is because one of the holes is clogged with dirt. When the injector is damaged or dirty, the gasoline that is released can be less or too much. A dirty fuel pump filter is usually caused by water getting into the gas tank.
K011	Replace the fuse which is usually located near the accu. Replace the fuse according to the size listed.	The main cause that often occurs is an excess of electricity passing through the fuse. This will cause the fuse to break and break, even where the fuse can burn and melt. If it has happened like that, the fuse must be replaced quickly.
K012	The trick is to open the spark plug, put the oil into the spark plug hole with a size of 1.5 ml, crank with the contact off and without the spark plug, then attach the spark plug.	Usually occurs because the valve is too tight. If this solution cannot be done, it is advisable to make repairs directly at the workshop.
K013	Replace the accu with the original and known for its durability.	The vehicle cannot start because the accu is weak. After all, it cannot push the magnetic rotation and pump the pulp.
K014	Disassemble the machine to make a replacement.	The engine sounds due to the age of use or the delay in changing the engine oil. If you hear a noise on the motorcycle, take immediate action so it doesn't spread to other spare parts.
K015	Carry out routine servicing of side machines.	A transmission work system in a motorized vehicle in which the gear shifts are carried out automatically and continuously. The use of Continuously Variable Transmission is a characteristic of automatic motorcycles, such as Freego, Mio, Fino, and Soul motors and their variants.
K016	Replace the brake switch at the repair shop.	It is recommended to be supervised by a mechanic or leave everything to the mechanic or workshop when carrying out routine service.
K017	Disassemble all vehicle bodies and do an electrical check using a multitester.	It could be due to the starter line's electricity or the starter button not working.

Table 4: The Rule of The Data

Id	Rules
R1	IF **G001** THEN **G000**
R2	IF **G009** AND **G021** THEN **K001**
R3	IF **G002** AND (**G022** OR **G002**) AND **G003** AND (**G004** OR **G008**) AND **G015** AND **G016** THEN **K002**
R4	IF **G002** AND **G006** THEN **K003**
R5	IF **G008** OR **G011** THEN **K004**
R6	IF **G008** AND **G015** AND **G020** THEN **K005**
R7	IF **G008** AND **G015** THEN **K006**
R8	IF **G002** THEN **K007**
R9	IF **G008** AND **G015** AND **G017** AND **G018** THEN **K008**
R10	IF **G008** AND **G015** AND **G019** THEN **K009**
R11	IF **G008** AND **G015** AND **G017** THEN **K010**
R12	IF **G007** AND **G013** THEN **K011**
R13	IF **G002** AND **G003** AND **G005** THEN **K012**
R14	IF **G002** AND **G003** THEN **K013**
R15	IF **G009** THEN **K014**
R16	IF **G012** THEN **K015**
R17	IF **G007** AND **G014** THEN **K016**
R18	IF **G007** THEN **K017**

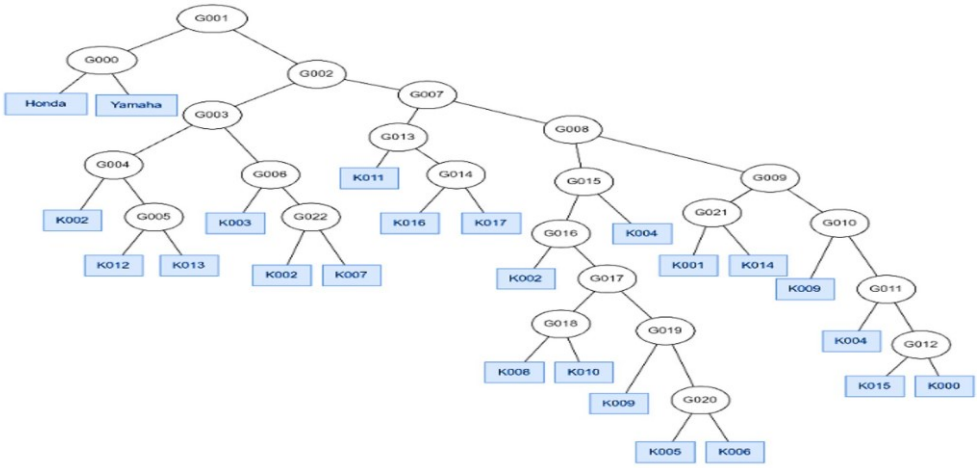

Figure 1: Decision Tree Models

Based on Figure 1, the Decision Tree model is formed by determining the selected nodes and then constructing a tree model. To determine the selected node, then use the Entropy value of

each criterion with the specified sample data. The selected node is the criterion with the smallest Entropy. If the node and leaf have been successfully formed, then it is modeled into a rule and this is assisted by experts which can be seen in Table 4.

4 Results and Discussion

In building this application, software such as the Android Studio IDE is used to do programming in building mobile-based applications which are also supported by IntelliJ IDEA, MEmu is used as an Android emulator, and Firebase as a real-time database because it supports internet connections. The application that has been built has two sides, namely the admin and user interfaces. From the admin side, it acts to validate incoming data, manage, edit, and delete data in the system. In addition, the admin is tasked with validating the application for improvement where it can select the action of the submission being processed, the application is approved, and the submission being accepted (see Figure 2). If the application is accepted, the workshop can provide repair services as requested (come directly to the workshop or home service).

Meanwhile, on the user side, they can access the diagnostic page by first logging in to start exploring the system by selecting which symptoms are experienced, then get a fix solution and a detailed explanation of the fix solution. Apart from that, there is also a feature to submit repairs directly to the workshop or the mechanic can come directly to the user's address as a home service. The damage diagnosis page arrives at a solution, which is an interaction of the results of the Decision Tree Algorithm model that has been embedded in the system. Some examples of the user interface of this mobile-based application can be seen in Figure 2 and Figure 3.

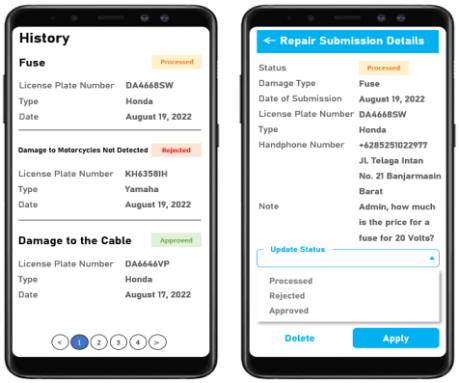

Figure 2: User Interface from Admin Side

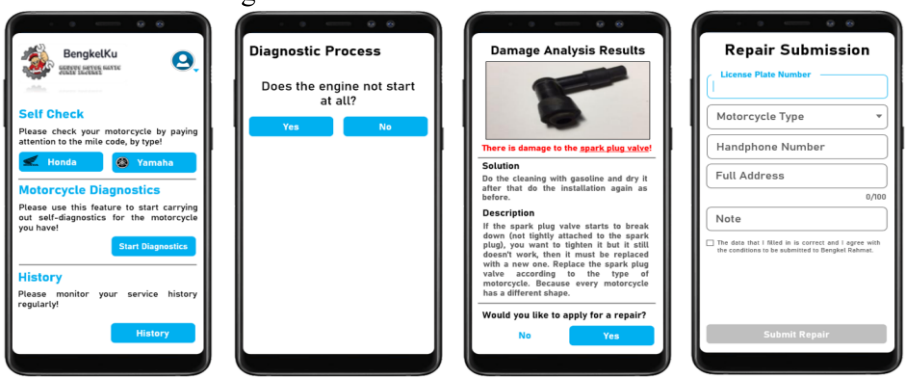

Figure 3: User Interface from User Side

In the interaction from the user side (see Figure 3), the user can access the Diagnose button feature to start diagnosing the initial damage experienced, then the user will be led by the application to find a decision or solution if the symptoms comply with the rules based on the Decision Tree model. Where this interaction is to run rule number four with rule id: R4.

In addition, if the solution to the symptoms of damage is successfully diagnosed, the user will also receive a detailed solution in the form of a description as material for the user to be able to repair it himself. If you can't handle it yourself, a Submit a Repair button feature is provided where the user will be directed to the submit a repair page. The damage experienced and the date of submission of repairs are recorded automatically when the user accesses the Submit Repair button. In applying for this repair, the choice is given whether the motorcycle is taken to the workshop to be repaired or the workshop sends a mechanic as a service directly to the house when the application has been processed by the admin.

Then testing was carried out using the Black-Box Testing technique with the results presented in Table 5. The testers who tested the application were several prospective users and were accompanied by a team of developers.

Table 5: Application Testing Results

Id	Test Cases	Expected Results	Test Result
Main Display Before Login Page			
T001	Accessible Information Button	The system displays an application information page and users can access it.	Accepted
T002	About Button	The system can display pages about and users can access it.	Accepted
T003	Whatsapp Hyperlink	The system can connect directly to the Whatsapp application so users can communicate directly with the repair shop.	Accepted
T004	Maps Hyperlink	The system can connect directly to the google maps site and users can access it.	Accepted
Login Page Display			
T005	Login Button	If the username and password are correct, then the login will be successful.	Accepted
Main Page Display (After Login)			
T006	Name Hyperlink	The system can display the admin or user name.	Accepted
T007	Logout Button	The system can logout from the account that is currently active.	Accepted
T008	Honda Button	The system can display the Honda MIL code page and the user can access it.	Accepted
T009	Yamaha Button	The system can display the Yamaha	Accepted

		MIL code page and the user can access it.	
T010	Start Diagnostics button	The system will direct the user to go to the diagnostic process page.	Accepted
T011	Yes Button or No Button	Yes Button in the diagnostic process to go to the next symptom or even go to the solution as a conclusion. No Button in the diagnostic process goes to the next symptom or even to the solution as a conclusion. Yes Button to agree to a thing. No Button to reject an item.	Accepted
T013	History Button	The system can display the history of repair requests on the admin page side or the user page side.	Accepted
T014	Submit Repair Button	The system will record the repair data that has been filled in by the user, and then the admin will process the submission on a different page.	Accepted
Display of Data Input, Delete Data, and Update Data Pages			
T015	Input Button	Admin can access the input button to enter the appropriate data.	Accepted
T016	Delete Button	Admin can access the delete button to delete the corresponding data.	Accepted
T017	Update Button	Admin can access the update button to update the appropriate data.	Accepted
T018	Save Button	Admin can access the save button to save the appropriate data.	Accepted
T019	Apply Button	Users can access the apply button to submit repairs.	Accepted

Based on the results of Black-Box Testing (see Table 5), it can be concluded that all the features provided by the application can function fully and are following the expected results.

Next, we will discuss the results of testing for accuracy by validating the results of conformity detection of the system through the logic of the rules that have been made, which compares the results expected by the rules adopted from experts with the results of the system that has been programmed. The validation results are presented in Table 6, the data is taken from observations of 30 users when interacting with the application.

Table 6: Accuracy Validation Results

Data	Symptoms	Conclusion Results Should Be (Expert Judgment)	System Detection Results	Conformity Value (0 = No and 1 = Yes)
1	IF **G001**	**G000**	**G000**	1

2	IF **G009** AND **G021**	**K001**	**K001**	1
3	IF **G002** AND (**G022** OR **G002**) AND **G003** AND (**G004** OR **G008**) AND **G015** AND **G016**	**K002**	**K002**	1
4	IF **G002** AND **G006**	**K003**	**K003**	1
5	IF **G008** OR **G011**	**K004**	**K004**	1
6	IF **G008** AND **G015** AND **G020**	**K005**	**K005**	1
7	IF **G008** AND **G015**	**K006**	**K006**	1
8	IF **G002**	**K007**	**K007**	1
9	IF **G008** AND **G015** AND **G017** AND **G018**	**K008**	**K008**	1
10	IF **G008** AND **G015** AND **G019**	**K009**	**K009**	1
11	IF **G008** AND **G015** AND **G017**	**K010**	**K010**	1
12	IF **G007** AND **G013**	**K011**	**K011**	1
13	IF **G002** AND **G003** AND **G005**	**K012**	**K012**	1
14	IF **G002** AND **G003**	**K013**	**K013**	1
15	IF **G009**	**K014**	**K014**	1
16	IF **G012**	**K015**	**K015**	1
17	IF **G007** AND **G014**	**K016**	**K016**	1
18	IF **G007**	**K017**	**K017**	1

Based on the results of Table 6, it will be processed using the accuracy formula, namely Total Appropriate Data / Total Test Data * 100% = 18 / 18 * 100% = 100%. From the accuracy results obtained, it can be concluded that using the Decision Tree Algorithm has been successfully implemented in application interactions which are following the models and rules that have been designed with an accuracy level of 100% and are superior when compared to previous studies. Finally, this application can help users to diagnose early symptoms and damage from injection automatic motorcycles and can make it easier for users to make submissions with the repair services that have been provided.

5 Conclusion and Future Work

This paper has confirmed the results of this study, namely that the application is fully functional, both from the user side and from the admin side, and can be used by users to solve damage problems, so that it can make it easier for users to diagnose the initial symptoms experienced by injection automatic motorcycle users so that may take maintenance action or carry out corrective activities. Future work is to add the payment for repairs feature directly to the application, be able to improve accuracy further with Confusion Matrix validation and use other combinations of algorithms to improve performance.

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