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Development of a mobile expert system for the diagnosis on motorcycle damage using forward chaining algorithm

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Development of a mobile expert system for the diagnosis on motorcycle damage using forward chaining algorithm

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ABSTRACT

Indonesia is an ASEAN country with the most motorcycle users, where one-third of its population own motorcycles. The automatic motorcycle is the most widely used type due to its agility and fuel-efficient abilities. Sudden motorcycle damage could hamper the users' activities. However, most of the users do not know the reason for the damage. This paper presents the development of expert system for diagnosing the damage of motorcycle using forward chaining method. This system was implemented in mobile application. Through a mobile application, a solution for these users can be obtained. This application immediately discovers the damaged location and repair process. Furthermore, it acts as the first solution before motorcycle repair is carried out in a shop. In this study, the forward chaining method was implemented. It is based on a pattern-matching algorithm whose primary objective is to match facts (input data) with appropriate rules from the rule base. Various test results showed that the diagnostic application used for automatic motorcycle damages 100% worked.

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1. INTRODUCTION

Automatic motorcycle types are widely used in the world. The unique physical characteristics are that it is slim and sporty. It also adopts a 110-cc engine to obtain attractiveness and agility. Furthermore, this type of motorcycle is environmentally friendly and easy to use. All motor vehicles experience various damages, an example of the most common damage is the engine being unable to turn on. This confuses users that do not know the reason for the damage, which is solved afterward by meeting motorcycle service experts. Furthermore, the use of an expert system for diagnosing motorcycle damage is also a potential user solution.

Although information technology (IT) is increasingly powerful and sophisticated, human intelligence and expertise still play a decisive role in many situations. Limited user knowledge often affects the levels of performance in various areas of responsibility. Furthermore, expert system development based on recent year's expertise provides a solution that enables ordinary users to carry out expert roles. These systems which began to commercialize a few years ago experienced dramatic progress in the development of applications for businesses and industries [1]–[7]. Furthermore, mobile applications were implemented in the agricultural and medical fields for diagnosis and treatment [8]–[11]. Therefore, it was built to act as a decision support system [12]–[15]. These applications were also developed for the implementation of mobile learning systems, especially during the COVID-19 pandemic [16], [17].

There are high expectations from the areas of development for expert systems. Human expertise is transferred for easy access through these built knowledge-based expert systems. Furthermore, knowledge and skill often need to be assessed and constantly updated through various testing processes, which maintains the system's expert performance. An inference mechanism also exists for analysis and assessment. Therefore, this allows for easy-to-use interfaces which allow the system to operate without extensive training for non-technical users [5], [6]. Various systems also explain the output generated or suggest alternatives to choose from as requested by the user [18].

Furthermore, expert systems are constructed to judge incomplete or futile information for practical use. It is a scientific artificial intelligence that helps humans solve problems. It also works to adopt the knowledge of an expert which is integrated into a computer system. This means it is designed to solve a problem like an expert in a particular field. Expert systems are beneficial for users trying to solve an unfamiliar problem without directly meeting experts [19]. Furthermore, this system works due to its problem analysis and solution discovery abilities through interviews and respondents' data collection results. It obtains weights and calculations, which conclude on an answer with the highest score [20].

The inference method is a part of an expert system that provides a mechanism for the function of thinking and patterns of reasoning used by an expert. This approach discovers the best answers and conclusions for question analysis following the database rules based on facts [5], [6], [9], [21], [22]. Expert systems for clustering the damage to an autonomous motorcycle have been developed in prior studies utilizing the K-means method and the findings of decision tree-based rules (decision tree) [23]. Many components of an automatic motorcycle are linked to one another. This study was carried out to develop an expert system for detecting automatic motorcycle damage using the Forward Chaining Method. The application can be executed on android-based phones, through which the expert system identifies automatic motorcycle users on cellphones.

2. METHOD

The study method is closely linked to the methods, techniques, tools, and projects used. Also, the design used matched the selected approach, while the techniques and instruments employed were also consistent with the established study methods. Furthermore, a "qualitative approach" that integrated various situations and phenomena with the author as an instrument for carrying out the study was utilized. There were steps implemented to design for complex realities, observation data collection techniques and interviews. The following are the study projects, literature, data gathering, analysis of systems, development, and reporting, which is similar to previous studies on this topic [24], [25].

To identify the problem in the field, a literature study was carried out. Afterward, the theoretical basis, support and comparison of various book reviews related to the problem were obtained from the internet, observations and interviews at the official service center for motorcycles. Therefore, the aim was to strengthen this data and understand how to diagnose motorcycle damage appropriately at these service centers through observational techniques carried out directly by experts. Furthermore, interviews with technicians, staff, and mechanical workers at the motorcycle service center were carried out. This led to an understanding of diagnosed automatic motorcycle damages. Documental analysis was also used in the qualitative study for observation and interview methods. The conceptual framework of this system was shown in Figure 1.

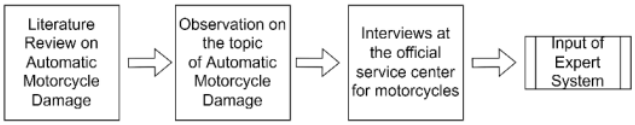

Figure 1. The conceptual framework of the system

In the system analysis phase, the analysis of current problems was carried out during the diagnosis process of damages. The waterfall or classic life cycle method was used for development due to the practical advantages while reflecting the technical features that preserve software quality through structured and supervised development. Furthermore, reports were based on study results using primary and secondary data collection techniques and appropriate topic-driven study methods [25].

2.1. Forward chaining method

Currently, the results of expert systems in various fields are due to several development methods such as forward chaining. This method arrives at a conclusion based on data or facts that lead to it. Forward chaining also discovers answers with the if-then algorithm using known facts. After obtaining desired facts, the system adjusts results obtained from the IF algorithm section using if-then rules. Furthermore, provided these facts follow the appropriate section, the system will convert it into an output which is the problem solution. However, for facts that are not appropriate, the system will continue to search for the then algorithm section until it discovers the right solution as output [26], [27].

Various system requirements were achieved through the above phases and study framework which include Input form, user data, damage types in the motorcycle, issues relating to symptoms of a motorcycle user, rules, and checks for motorcycle damage. The process requirements include admin, user, motorcycle damage type, questions, rules, inspection, and results. Furthermore, the output requirements were for the diagnosis of motorcycle damage [28], [29]. Table 1 and Table 2 described the list of the inference questions and the list of the damage in the motorcycle. The data rule was a schema concerned with the method used by systems to carry out the production of a solution or diagnostic result based on data constraints regarding motorcycle damage, shown in Table 3 below.

Table 1. List of inference questions of symptoms

Code	Symptoms
K01	The engine spins, however it does not start.
K02	DTC (Diagnostic Trouble Code).
K03	MIL (Malfunction Indicator Lamp).
K04	The engine spins or will not start (There is no working fuel pump sound for a turned ON ignition).
K05	The engine shuts down continuously.
K33	Poor performance at high speed or underpowered.
K34	The leaking of Oil.

Table 2. List of the damage in an automatic motorcycle

Code	List of the damage
A01	Programmed Fuel injection PGM-FI system malfunction.
A02	Damage to the ignition system.
A03	Damage to Electric Starter.
A04	Damage to the lubrication system.
A05	Damage to Cylinder Head or valve/Cylinder/Piston.
A10	Damage to Final Reduction or transmission.
A11	Damage to Carburettor.

Table 3. The rule of the data

No.	Rule	Data
1.	Rule 1	IF there are two symptoms from K01 AND K02 OR K03 THEN A01.
2	Rule 2	IF there is a symptom from K04 OR K08 OR K11 OR K12 OR K13 THEN A01.
3	Rule 3	IF there are 3 symptoms from K05 AND K06 AND K07 THEN A01.
4	Rule 4	IF there are 2 symptoms from K09 AND K10 OR K13AND K14 THEN A01.
5	Rule 5	IF there is a symptom from K15 OR K16 OR K17 THEN A02.
6	Rule 6	IF there is a symptom from K18 OR K19 THEN A03.
7	Rule 7	IF there are symptoms from K20 AND K21 THEN A04.
8	Rule 8	IF there is a symptom from K22 THEN A04.
9	Rule 9	IF there are symptoms from K23 AND K06 OR K24 OR K25 THEN A05.
10	Rule 10	IF there is a symptom from K26 OR K27 OR K07 THEN A05.
11	Rule 11	IF there is a symptom from K28 THEN A06
12	Rule 12	IF there are symptoms from K29 AND K30 THEN A07.
13	Rule 13	IF there is a symptom from K31 THEN A08.
14	Rule 14	IF there is a symptom from K32 OR K33 THEN A09.
15	Rule 15	IF there is a symptom from K34 THEN A10.
16	Rule 16	IF there is a symptom from K04 AND K14 THEN A11.
17	Rule 17	IF there are symptoms from K32 AND K6 AND K7 THEN A11.

The following steps should be carried out to create a rules-based forward chaining system: i) problem (including problem selection of the domain and knowledge acquisition) and data input system definition which requires initial information to initiate inference; ii) defining the structure of data control; iii) initial coding to determine the system's ability to effectively capture the field of knowledge within a proper structure of rules; iv) system tests carried out with several rules to test the running system, v) interface design,

and the creation of a knowledge base, vi) systems development that includes adding system prototype interfaces and knowledge, and vii) assessment of the system in the form of a real problem test. Redevelopment is carried out provided that the system does not work properly.

3. RESULTS AND DISCUSSION

Various damages existed in different motorcycles. An expert system was developed in Java on Android Studio with MySQL as a database system using the forward chaining method to detect these damages in a mobile-based application, especially those that are android based. Furthermore, this developed system assisted the user to identify the symptoms of motorcycle damage and obtain the initial treatment method for overcoming it. The flowchart of the system is shown in Figure 2. The process commences with a user login and is directed to the main page of the expert system. On this main page, there is a diagnostics button, which could be pressed by users that want to diagnose the damage. Afterward, users are instructed to choose several symptoms according to those experienced by the motorcycle. After all the symptoms are selected, the system will search for damage according to the constraints experienced by the user's motor.

The use case diagram is introduced for modelling or describing the system's limitations and its primary functions. This diagram shows the operation of a system from the user's user point of view. Furthermore, it illustrates regular interaction between users and the system through system utilization explanations. The use case identification and scenario are the two main aspects of the use case diagram. Here, menus exist in the android application where users log in, carry out damage diagnosis based on symptoms, displays damage history, delete history, view a list of motor components with videos on repairing a motorcycle, and accesses application notes. Admins or experts also add, modify, or delete constraint, crash, and rule data as shown in Figure 3.

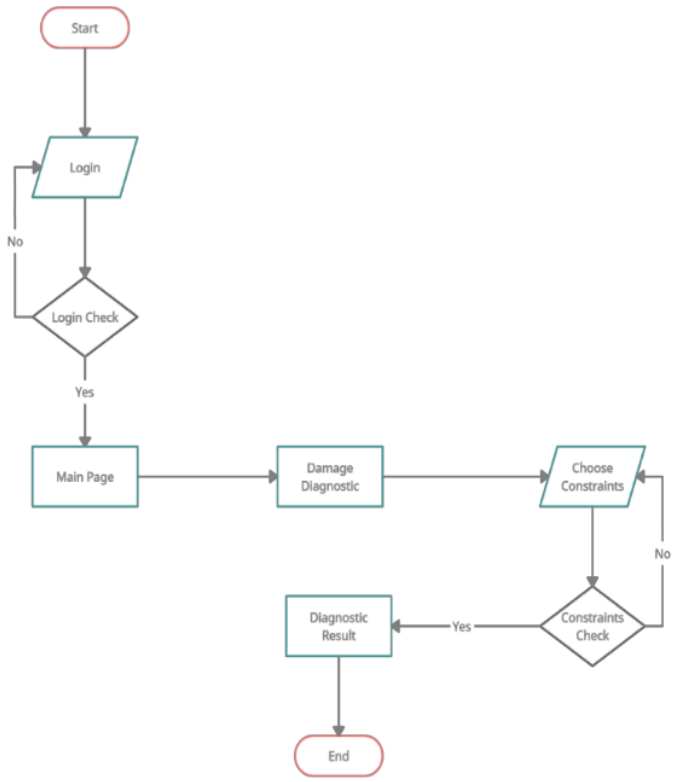

Figure 2. The flowchart of the system

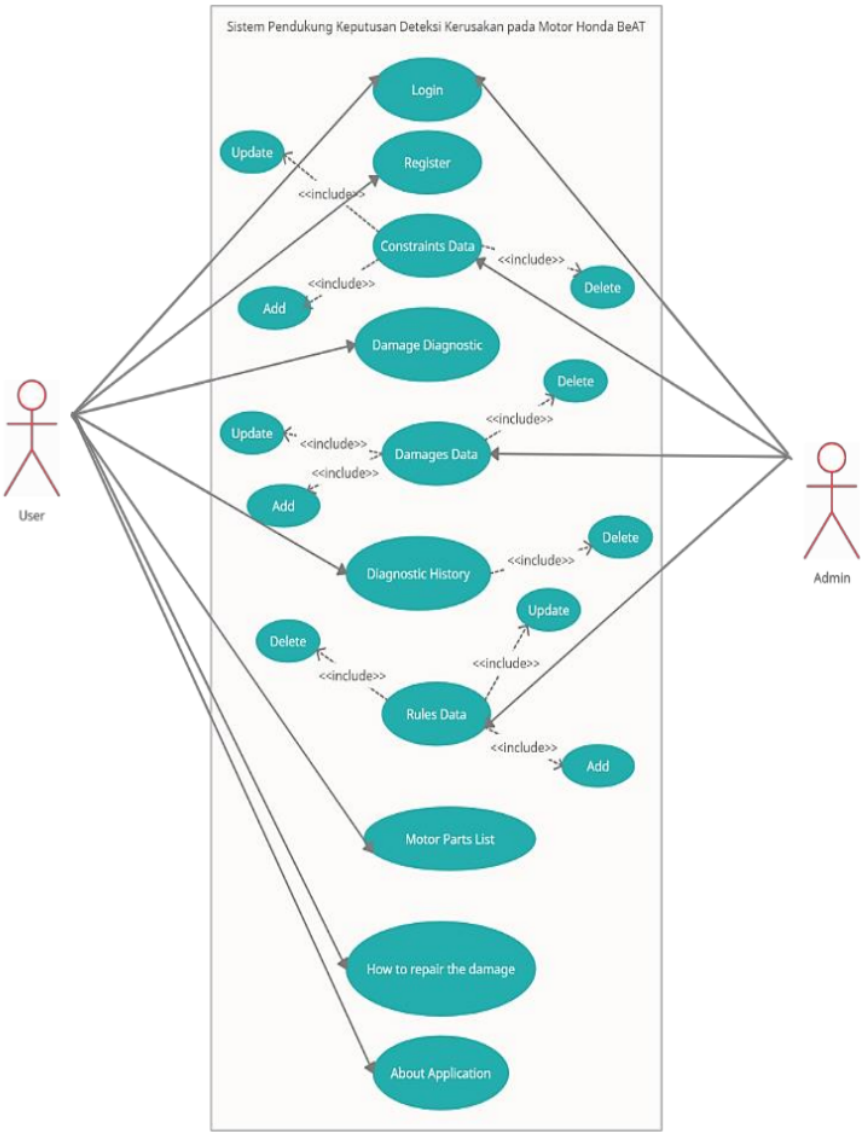

Figure 3. Use case diagram of the system for both of user and admin

The mobile application is installed on a smartphone or tablet. Android is the mobile operating system of choice in this scenario. We used the Java programming language and the extensible markup language (XML) to create the application. To enable access to the MySQL database where the symptoms and the damage list are maintained. In hypertext preprocessor (PHP) code, structured query language (SQL) queries are written in the form of strings that are processed by the MySQL database server [30], [31]. Figure 4 presented the graphical user interface of the mobile expert system. The interface of the application was developed, with a system built on Android OS and executed or uploaded in Google Play Store. Furthermore, black box testing which involves observing the results of execution through test data and checking of software functionality was carried out. Table 4 shown the black box testing results from the system's function after functionality testing of several menus that were applied in the application.

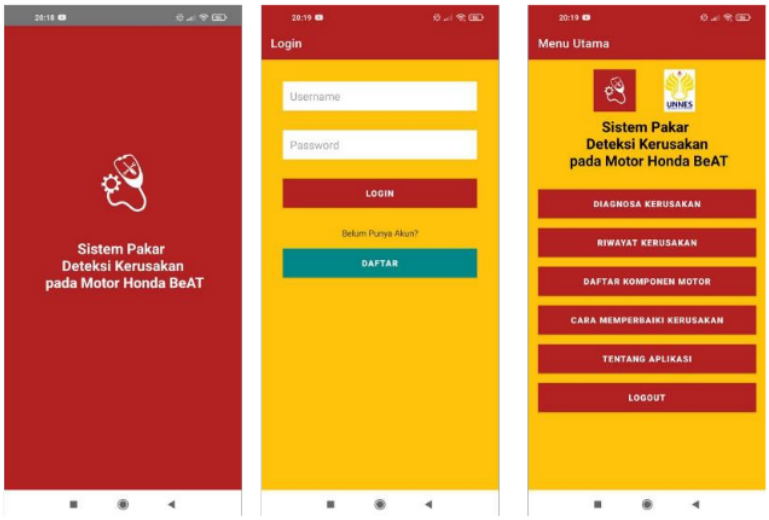

Figure 4. The graphical user interface of the system

Table 4. The result of black box testing of the system

Code	Menu testing	Testing scenario	Result		Detail
			Success	Failed	
User					
Test01	Page Registration	Display the registration form.	V		The application shows the form.
Test02	Page Registration	Carry out registration.	V		Users can carry out the registration.
Test03	Login Page	Display the login form.	V		The application shows the form login.
Test04	Login Page	Carry out the login process.	V		Users can carry out the login.
Test05	Main Page	Display the main page.	V		The application shows the main page.
Test06	List of Symptom Page	Display the question of the symptoms.	V		The application asks for the symptoms.
Test07	List of Symptom Page	Display the next question of the symptoms.	V		The application asks for the symptoms.
Test08	List of Damage Page.	Display the result of the diagnosis.	V		The application asks for the diagnosis result.
Test09	List of detailed damage	Display the detailed damage information.	V		The application shows the damage description and solution.
Test10	History of the damage	Display the damage history.	V		The application shows the damage history.
Test11	History of the damage	Delete the damage history.	V		The application deletes the damage history.
Test12	List of motorcycle parts.	Display of motorcycle's part.	V		The application shows the list of motorcycle parts.
Test13	How to fix the damage.	Display information on how to fix the damage.	V		The application shows the maintenance system page.
Test14	About the Application.	Display the information of the application	V		Application can show the detail information of the system
Admin					
Test15	List of the Symptoms.	Admin carries out the CRUDE function (Create, Update, Delete)	V		Admin can carry out the CRUDE function.
Test16	List of the damage.	Admin carries out the CRUDE function (Create, Update, Delete).	V		Admin can carry out the CRUDE function.

Based on Table 4 the discoveries of black-box testing determined that functionally built applications provided expected outcomes. Selecting the symptoms of the damage was also one of the factors that influenced the rule-based forward-chaining results. Using a mobile application, an expert system may identify certain symptoms of an automatic motorcycle and then determine the cause of the problem [14]. Furthermore, an

android-based expert system was used to diagnose damage for the automatic motorcycle through the forward chaining method [26]. It was anticipated that this will make it easier for users to understand the symptoms of damage detection and how early treatment is required to quickly overcome these symptoms. The required detection procedure can be carried out at any time and from any location. This research described the development of mobile expert system that can be implemented for daily uses.

4. CONCLUSION

Based on the results and discussion, it can be concluded that: i) the development of an expert system using mobile applications was successfully executed because it obtained 100% in each test; ii) the forward chaining method had an excellent level of accuracy, which was 100% when diagnosing motorcycle damage, especially automatic types; iii) the forward chaining method also required users to answer every question asked by the system to the last question even though the constraint data already match one type of damage; and iv) the user was greatly assisted by an expert system in deciding treatment information and methods that were consistent with the diagnosis of the motorcycle damage.

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