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Development of an expert system for fault diagnosing of washing machines using Delphi 7

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ABSTRACT

An expert system is a system that tries to adopt human knowledge into washing machines, so that users can solve problems as experts usually do, and a good expert system is designed to be able to solve a particular problem by imitating the work of experts. Currently handling customer complaints to technicians about fault of washing machines takes quite a long time, and for each handling it takes quite a long time. This system aims to diagnose fault and provide information on repair solutions that can be carried out. This expert system uses the forward chaining method and literature study in Delphi. Based on testing this expert system, it shows that this expert system is able to help solve problems effectively.

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1. INTRODUCTION

An expert system is a system that tries to adopt human knowledge into a computer system, so that users can solve problems as experts usually do, and a good expert system is designed to be able to solve a particular problem by imitating the work of experts (Hartati & Iswanti, 2008). Expert systems are a branch of artificial intelligence that learns how to "adopt" the way an expert thinks and reasons in solving a problem, and making a decision or drawing conclusions from a number of existing facts. The basis of an expert system is how to transfer the knowledge possessed by an expert to a computer, and how to make decisions or draw conclusions based on that knowledge (Fadli, 2003). Expert systems provide added value to technology to help in dealing with the increasingly information age advanced (Wardani et al., 2021).

The concept of an expert system includes expertise, experts, transfer of expertise, inference engines, rules and the ability to provide explanations (Ramadhan et al., 2020). Meanwhile, expertise is in-depth knowledge about a particular thing. Where expertise can be obtained from experience or education, training and reading from book sources (Fadli, 2003). With this expert system, ordinary people can be helped in solving their problems or simply looking for quality information that can only be obtained from experts in their field (Sihombing & Ayub, 2010).

There are two types of knowledge, namely knowledge from expert sources and knowledge from non-expert sources. Knowledge from expert sources can be used to make decisions quickly and accurately (Rananavare & Chitnis, 2024). An expert is a person who has

expertise about a certain area of the case at a certain level. A system programmed in a computer is called an expert system because its function and way of working resembles an expert who has years of knowledge and experience, so that it can solve a problem or problem quickly (Hartati & Iswanti, 2008).

The main components of an expert system are: (1) a knowledge base, which is a substitute for human knowledge, (2) an inference machine which functions to store the rules for drawing conclusions, both of these are entered into memory, (3) working memory, and (4) user interface (Wardani et al., 2021). This mechanism will analyze certain problems and then look for the best answer or conclusion (Jashnabadi et al., 2023).

A washing machine is a machine created to wash all kinds of clothes (Dwilestari, 2021). In principle, the process of washing clothes in a washing machine consists of two parts, namely the washing and drying of clothes. Washing machines have become a special need for households. Washing machines can also dry clothes quickly without depending on weather conditions (Dewi et al., 2018).

Washing machine components are the main parts that regulate the function of the washing machine, including: (1) Dryer and washer motor which functions to rotate the drum in a certain direction, (2) Dryer and washer timer which is useful for regulating the length of washing time, (3) Gearbox which functions to transmit movement from the motor to the washing tube, (4) Fan belt which functions to connect the motor with the washing machine gearbox, so that the motor movement can be transmitted to the washing tube, and (5) Water drain hose which functions to remove water laundry residue after washing. Some washing machine components often experience fault/wear due to use (Septiana, 2015).

At this time, handling the problem of fault to the washing machine by a technician takes quite a long time (Dewi et al., 2018). Even technicians often delay handling due to the large number of faults. Coupled with the fact that handling requires quite a long time, this causes the waiting time to repair faultd washing machines to take a long time (Nashiruddin & Hidayat, 2022).

So that problem components in washing machines can be known in more detail, an application is needed that can provide detailed information to washing machine users. So that users can find the right solution to the problems they face so that the problems can be resolved. This system aims to diagnose washing machine fault and provide information on repair solutions that can be carried out. The way the expert system works adopts the forward reasoning method (forward chaining) with the Delphi programming language.

This expert system uses the Delphi 7 program. Delphi is the next generation of Turbo Pascal. Delphi programming is designed to operate under Windows systems (Edwana et al., 2017). Delphi is a programming language that has a wide range of capabilities and is very sophisticated. Various applications can be created with Delphi including applications for processing text, graphics, database numbers and web applications (Chu & Hwang, 2008). Delphi is a programming language that has a broad and sophisticated range of capabilities. Various types of applications can be created with Delphi including applications for processing text, graphics, numbers, databases and web applications (Mandailina & Pramita, 2016).

To make programming easier in creating application programs, Delphi provides very complete programming facilities. Programming facilities are divided into two groups, namely objects and programming languages. In summary, an object is a component that has a physical form and can usually be seen (visually) (Jatnika et al., 2023).

This research is different from previous research conducted by (Wamiliana et al., 2013) entitled Development of a Mobile Web-Based Expert System to Identify the Causes of Cell Phone Damage Using the Forward and Backward Chaining Method, where this research uses the Delphi 7 program as expert system creation software, using the

method fprward chaining expert system database funds namely washing machine damage. Choosing Delphi 7 as expert system creation software has the advantage of being user interactive and having an attractive appearance.

With this expert system, it is hoped that it can increase knowledge about expert systems and also help the public understand more about handling damage to washing machines. So that when a Cuvi engine failure occurs, the cause and solution to the damage can be immediately identified.

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2. RESEARCH METHOD

In this research, an expert system is used for knowledge base handling procedures for diagnosing fault to washing machines. According to (Trianto, 2018) There are 3 stages in creating an expert system, namely: tracking stage, search stage and decision tree creation stage. The stages of creating this expert system are as follows:

a. Tracking Stage

In the process of diagnosing washing machine fault, the tracking method used is the forward chaining method. By using this method, a search is carried out to detect all symptom data and rules to obtain diagnostic results for washing machine fault.

b. Search Stage

The search method used is the best first search method. This search method will check all the destination nodes (washing machine fault type) that have been collected. By using this method the search process will be more effective.

c. Decision Tree Stage

Making a decision tree used in making an expert system for diagnosing washing machine fault uses a tree diagram. A decision tree diagram is a design in the form of a tree that is used to build an expert system (Zhou et al., 2023). With the Decision Tree diagram, it will make it easier to compile a collection of rules needed to determine the certainty factor for diagnosing washing machine fault based on existing symptoms (Ayu et al., 2017)

d. Method of collecting data

The data collection method in this research uses literature study. Literature study is conducting a review of previous research related to research carried out to obtain sources of expert system knowledge base information (Ayu et al., 2009). In this research, a literature study was carried out by collecting data on symptoms and types of washing machine fault through previous research studies.

3. RESULTS AND DISCUSSIONS

The process of forward chaining method of reasoning is used by displaying several convincing symptom data to reach a final conclusion or fault (Ahmad, 2020). Forward chaining is also usually called data driven search (Hidayat & Maulana, 2022). The implementation of forward chaining inference starts from identifying symptoms on the washing machine experienced by the customer. The next process is to accommodate the input that has been entered by the user as a rule in the system. The system will check again based on the input that has been accommodated to then display the type of fault

found in the washing machine and the solution to resolve the fault. In line with research (Syarif et al., 2021) which states that a forward chaining based expert system for household goods damage (washing machine, ac & refrigerator) has valid and effective results. In line with research (Kusbianto et al., 2017)which states that the implementation of a forward chaining expert system for identification and treatment of facial acne with results of 83% (effective).

In this expert system for diagnosing washing machine fault, existing symptoms are matched with the if parts of if-then. If there are symptoms that match the if part, then the rule will be executed. Each rule can only be executed once and the matching process stops when there are no more rules that can be executed. Knowledge about the symptoms that have been obtained will be substituted into the knowledge engineer which then becomes the system knowledge base. This is also in line with research) which states that the implementation of the system draws conclusions based on existing facts using the forward chaining method to produce valid conclusions based on tracing the existing rules one by one until the tracing is stopped because the last condition has been met (A et al., 2009).

In this stage, a search and collection of data and knowledge obtained from an expert is carried out. There is data on symptoms, fault, solutions and decisions from the expert system for diagnosing fault to washing machines. Where the data can be seen as follows:

Table 1. Symptoms on the Machine

Symptom	Code
The washing machine is completely dead	GM 1
Noise	GM 2
The washer motor suddenly stops	GM 3
Scratched body contact	GM 4
There is a smell of scorched/burnt cables	GM 5
Abnormal vibration	GM 6
The washing process is problematic	GM 7
The drying process is problematic	GM 8
The machine emits a smell	GM 9
Water drips into the drying dynamo	GM 10

Data on symptoms of washing machine damage is divided into 2, which is seen from the symptoms of damage to the machine and to the washing machine tube. Table 1 above, is data on symptoms of damage to washing machines obtained through literature studies and interviews with washing machine damage experts. Where for data on symptoms of washing machine damage to the machine there are 10 symptoms, such as The washing machine is completely dead which is given code GM 1 and so on up to Water drips into the drying dynamo with code GM 10.

Table 2. Symptoms on the Tube

Symptoms	Code
Drain doesn't come out	GT 1
The washer drum does not rotate	GT 2
The dryer drum cannot rotate	GT 3
The washer drum rotates very slowly	GT 4
The dryer drum rotates very slowly	GT 5
Cannot fill water	GT 6
Water cannot be emptied	GT 7

Table 2 above contains symptoms of washing machine damage in the washing machine tub. Where there are 7 symptoms of damage with the code. The database of

symptoms of damage to washing machines in the drum section starts from Drain doesn't come out with code GT1 to Water cannot be emptied with code GT7.

Table 3. Washing Machine Fault

Fault/Failure	Code
The motorbike connecting rope/belt is faultd	K1
Broken capacitors, dirty timers, loose belts	K2
The washing machine dynamo is broken	K3
Van Belt faultd/loose, heater faultd	K4
Faultd gear box, loose van belt, capacitor, weak dynamo motor, or low voltage	K5
The position of the washing machine is tilted, the clothes in the drum are irregular	K6
Too many clothes in the tube	K7
The drain hose is faultd	K8
Water pressure too low	K9
A dirt blockage occurred	K10
Rinsing is not clean, detergent is often excessive, cleaning is rarely done	K11
The water seal is faultd	K12
There is dirt in the tube	K13

By entering the symptoms of washing machine damage on the machine and tube parts into the expert system, a conclusion will be obtained on the type of washing machine damage. Where the database of types of washing machine damage in this expert system contains 13 types of damage. The damage data is from The motorbike connecting rope/belt is faulted which is given code K1 to There is dirt in the tube with code K13.

Table 4. Causes and Solutions to Fault

Code	Reason	Solution
K1	The clothes spinner axle cannot rotate	Check the connecting rope/belt. If it is faultd, replace it with a new one
K2	The clothes spinning tube rotates slowly	Check the capacitor, timer and connecting belt
K3	There is a washing machine component that is not working	Replace the washing machine dynamo
K4	Washing machine components don't work	Check the van belt, check the engine heater/dryer
K5	Some components of the washing machine are loose	Replace faultd gear box, check van belt, replace capacitor, replace dynamo motor, check voltage
K6	The washing machine bolts are loose	Adjust the washing machine feet, arrange the clothes in the drum, check the washing machine bolts
K7	Clothing capacity doesn't match the program	Reduce clothes in the washing drum, set the appropriate program
K8	The dryer tube is not working	Close the washing machine, adjust the position of the drain hose (height 80-120cm)
K9	Faultd valve, leaking or clogged water hose	Check water pressure, check water hose for leaks
K10	The water hose is kinked	Check the water hose, make sure the hose is not kinked, check the water hose for leaks
K11	The washing machine isn't kept clean	Open the cover after use, rinse thoroughly, avoid excessive detergent, clean the machine
K12	Washing machine performance is reduced	Replace the water seal with a new one
K13	Water drainage problems	Check the channels, if there are blockages, clean them

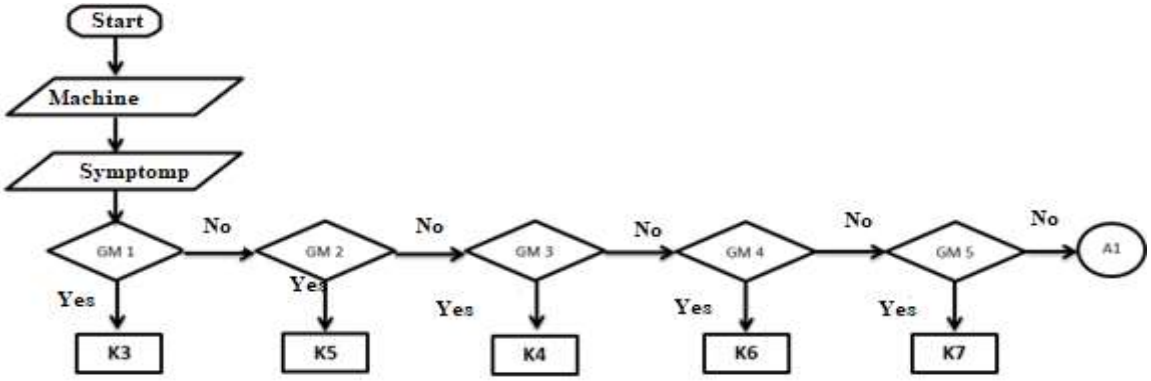
After knowing the type of damage to the washing machine, the next step is to find out the causes and solutions for this type of damage. Table 4 above contains 13 data on the causes and solutions for the washing machine damage. Starting from code K1 with

the cause of damage The clothes spinner axle cannot rotate and Solution Check the connecting rope/belt. If it is faulted, replace it with a new one, up to K13 with causes of Water drainage problems and Solutions Check the channels, if there are blockages, clean them.

Table 5. Decision/Conclusion

Fault/Failure	Symptoms on Machines	Symptoms on Tube
Broken motorbike connecting rope/belt (K1)		GT 2, GT 3, GT 5
Defective capacitor, dirty timer, loose belt (K2)		GT 2, GT 3, GT 4
Fault washing machine dynamo (K3)	GM 1	
Van Belt faultd/loose, heater faultd (K4)	GM 3	
Faultd gear box, loose van belt, capacitor, weak dynamo motor, or low voltage (K5)	GM 2	
The position of the washing machine is tilted, the clothes in the drum are irregular (K6)	GM 4	
Too many clothes in the tube (K7)	GM 5	
Faultd drain hose (K8)	GM 6	GT 1
Water pressure too low (K9)	GM 8	
There is a dirt blockage (K10)	GM 7	
Rinsing isn't clean, detergent is often excessive, cleaning is rarely done (K11)		GT 6
Fault water seal (K12)	GM 10	GT 7
There is dirt in the tube (K13)	GM 9	

Based on table 5 above, the performance of the expert system for diagnosing fault to washing machines uses the if rule with the rule if – then. In describing the flow, the author makes a decision tree, where this decision tree is in the form of a flowchart. The decision tree can be seen below as follows:



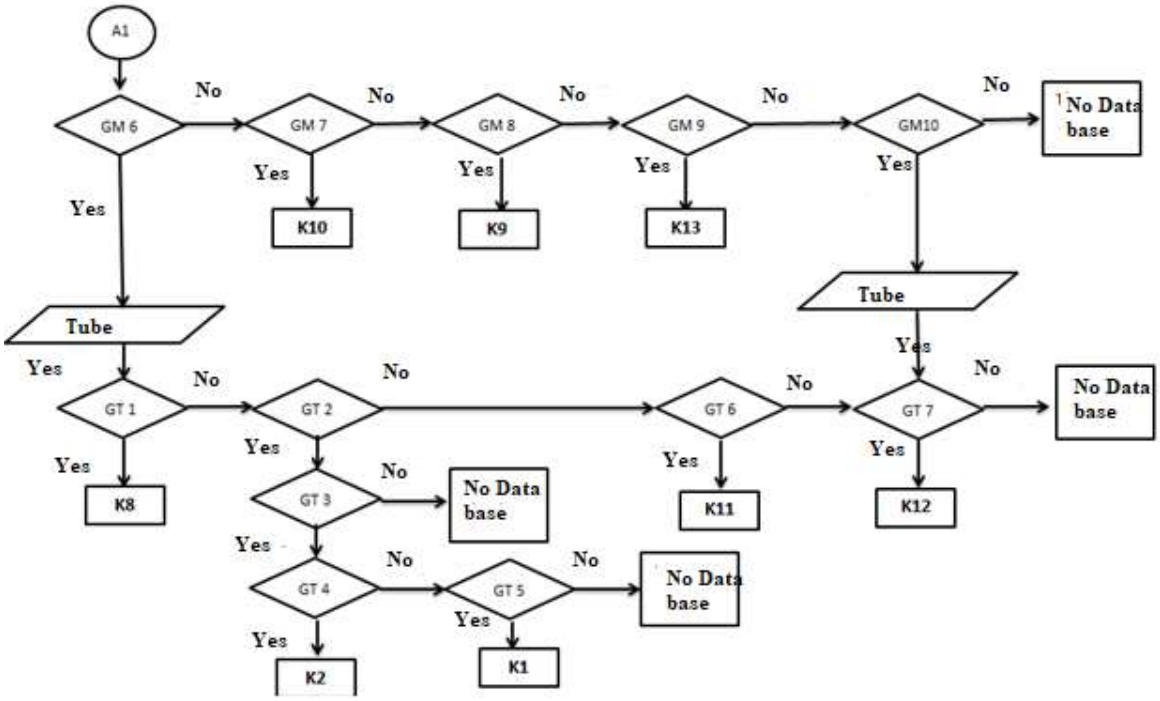


Figure 1. Washing Machine Fault Diagnosis Expert System Decision Tree

Based on the decision tree above, it can be seen that the expert system for diagnosing washing machine fault uses the forward chaining method. Where the customer will determine the facts in the form of symptoms experienced which then these facts will be executed, and after being processed by the system it will produce the type of fault or conclusion according to the input entered. This is in line with research from (Cahyono & Ainur, 2018) which states that a weld defect detection expert system using Delphi-based ultrasonic testing can determine the correct defect type conclusion according to the defect indication data entered. In line with research (Dewi et al., 2018), the expert system for diagnosing washing machine damage using the fuzzy mamdani method works effectively and can diagnose washing machine damage and is able to make it easier for washing machine users to find out earlier about the symptoms of washing machine damage. So it can be concluded that the expert system for diagnosing types of washing machine damage is running well and effectively. The weakness of this expert system is that there are only 13 types of damage in the database. To develop this expert system, it is necessary to add a database of types of washing machine damage, which can be obtained from literature studies from related journals or books. Apart from that, it can also be obtained through direct interviews with washing machine experts.

4. CONCLUSION

In developing a Delphi-based expert system for diagnosing washing machine errors which is capable of diagnosing 13 types of damage to washing machines based on the input symptoms of damage. This system was developed using the Delphi language by adopting the forward chaining method. The weakness of this expert system is that there are only 13 types of damage in the database. To develop this expert system, it is necessary to add a database of types of washing machine damage, which can be obtained from literature studies and direct interviews with washing machine experts. The results of this research can be used as a program that helps people who use washing machines when they

experience damage so that they can find out the type of damage as well as the cause and the right solution. So by using this expert system, washing machine damage can be handled more quickly and efficiently. The washing machine damage database that can be detected using an expert system is only 13 types of damage with 2 types of damage symptoms to the engine parts and washing machine tube. So it is necessary to add a database of symptoms and types of washing machine damage.

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