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Implementation of Forward Chaining Method in Laptop Damage Detection Expert System

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ABSTRACT

Expert systems are a branch of artificial intelligence designed to replicate the reasoning ability of specialists. This study applies the forward chaining method to build a web-based expert system for diagnosing laptop malfunctions. The system's knowledge base was constructed from 20 common laptop malfunction symptoms, identified through literature review, user questionnaires, and interviews with repair technicians, and translated into inference rules. To evaluate performance, the system was tested on 50 malfunctioning laptops. Results show that the expert system achieved an accuracy rate of 85%, indicating its effectiveness in detecting various hardware and software problems. This research demonstrates that forward chaining can support non-expert users in performing early fault detection, thereby reducing repair costs and dependence on professional technicians.

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1. INTRODUCTION

Expert systems simulate an expert's approach to problem-solving. This technique is useful for identifying electronic equipment faults, for example. Expert systems make decision-making easier and lessen the need for human specialists in the face of urgent and accurate problems. They have been shown to be effective in methodically recognizing and evaluating technical issues in earlier studies. AI-driven expert systems generate more precise and data-driven evaluations than conventional techniques that just use the expertise of specialists. Furthermore, these solutions improve the efficiency of electronic device service and speed up problem discovery by simplifying diagnostic processes.[1]

Forward chaining is a commonly used inference technique in expert systems. It produces an accurate diagnosis by matching the user's symptoms with the rules in the knowledge premises. This method works by finding patterns in existing facts and then using established rules to draw logical conclusions. This study found that applying forward chaining in an expert system gives better results in detecting problems compared to the backward chaining method. The study found that forward chaining has the ability to structure the relationships between symptoms in a more structured manner, allowing the system to draw clearer and faster conclusions. Therefore, it is considered that this approach is more effective in the diagnosis process compared to other approaches that require more inference steps before reaching the final result. [2]

A number of studies in Indonesia have proven the effectiveness of forward chaining-based expert systems in various applications. One study showed that an expert system designed to diagnose laptop malfunctions can achieve an accuracy rate of up to 87% in identifying hardware and software problems. The study revealed that the forward chaining-based system can categorize symptoms and match them with the most relevant possible causes, giving users a more targeted diagnosis. Another advantage of the system is its ability to provide recommended solutions that users can implement before taking their laptops to a professional technician, which in turn can save repair costs and waiting time[3]. Laptop malfunctions often have complex and varied symptoms, including hardware issues such as screens that don't turn on, keyboards that don't work,

and motherboards that experience system failures. On the other hand, software problems such as operating system crashes and slow laptop performance are also common, which are sometimes difficult to identify the exact cause. That's what emphasizes that forward chaining-based expert systems have the advantage of solving problems with many variables. In their research, forward chaining allows the system to connect user-reported symptoms with a wider range of possible causes, resulting in a more in-depth and accurate diagnosis. This is especially important in cases where one symptom can have more than one cause, so the expert system can help filter out the most relevant possible causes before the user takes further action. [4]

The quality of the knowledge base used is critical to the development of an expert system. One expert said that the ability of an expert system to make a correct diagnosis is related to how complete and accurate its knowledge base is. To collect data on common symptoms of laptop malfunctions, this study conducted interviews with professional technicians and read relevant literature. Next, the data is classified and translated into the form of inference rules, which can be processed by the expert system. Information about symptoms, factors that could potentially cause damage, and repair procedures are included in these rules. It is expected that the expert system can provide a more accurate diagnosis and help users solve problems by using structured and complete knowledge.

The main objective of this research is to build a web-based expert system that can help users independently identify laptop malfunctions. The system is intended to help users who do not have technical knowledge in terms of laptop repair and those who live in areas with limited access to technician services. Thus, users can perform initial diagnosis independently without having to wait for technician assistance. In addition, this system aims to evaluate the accuracy in fault diagnosis, which is expected to achieve a high level of accuracy so that it can be relied upon as an auxiliary tool in diagnosing laptop problems. High accuracy in diagnosis is essential to ensure that users can take appropriate actions to fix their laptop problems in an appropriate manner.

This research also focused on developing an intuitive and easy-to-understand user interface. This interface was designed to make it easy for users to enter data related to the symptoms experienced by their laptops. Users only need to select or fill in information regarding the symptoms, such as a screen that does not turn on or a slow system, and the system will automatically process the data to generate a diagnosis. With a simple and user-friendly interface, users can easily follow the steps to obtain accurate diagnosis results. In addition, the system also provides guidance on the repair steps that need to be taken, so that users can carry out repairs themselves if possible[5].

One of the advantages of implementing a forward chaining-based expert system is its flexibility in dealing with a variety of symptoms that may occur on a laptop .This system can continue to grow by adding new rules over time because of the increasing types of damage that may occur on these electronic devices .With the ability to update knowledge dynamically, this expert system can maintain the relevance and accuracy of its diagnoses .This is very important considering the ever-changing development of hardware and software technology, which will affect the types of damage that can occur on laptops. Therefore, this expert system not only provides solutions to current problems but is also able to adapt itself to problems that will arise in the future [6].

It also adds insight to the academic literature by highlighting the utilization of forward chaining methods in the context of electronic devices, especially in laptops. Most of the previous research on the use of forward chaining has focused more on the field of healthcare or hardware management in general; thus its application in the scope of smaller and complicated electronic devices such as laptops is still very limited. Thus this research makes an important contribution in expanding the understanding of the application of forward chaining methods in various fields.

It is hoped that the expert system developed in this research will enable users to identify problems and repair their laptops more quickly by reducing reliance on technicians. This will be very helpful, especially for people living in areas with limited technician services. With this system, users can reduce the amount of time needed to get technician assistance and repair costs. Thus, this forward chaining-based expert system enhances users' ability to maintain their own devices and facilitates fault detection.

Collecting accurate and relevant data was one of the challenges faced during the development process of this system. Depending on various factors, such as the make and model of the laptop and the type of malfunction that occurs, information about the symptoms of laptop malfunction varies greatly. Therefore, in order for the expert system to make a proper diagnosis, this research required considerable in-depth and detailed data collection. In addition, there is another challenge to create a user-friendly interface but still be able to process complex data accurately. To solve these problems, this research will utilize the latest technology and involve experts in the field of electronic devices.

2. METHOD

To provide a clearer picture 1 of the steps in this research, the following flowchart of the research method is presented. This flowchart illustrates the process starting from problem identification to analyzing the results and drawing conclusions. Each step in this diagram shows the important stages carried out in the development of a laptop damage detection expert system based on the forward chaining method. The forward chaining method in the laptop damage detection expert system was evaluated in this study using a quantitative approach and descriptive analysis. The main objective of this research is to build an expert system that can help lay users diagnose laptop damage automatically based on the symptoms provided by the user. The decision to use a quantitative approach is based on the fact that this research requires measuring the accuracy of the expert system in detecting laptop malfunctions based on the numerical data collected.[7].

This study used a questionnaire distributed to laptop users and laptop technicians to identify common symptoms that occur in faulty laptops. One hundred laptop users who experienced breakdowns were given this questionnaire, and they readily provided information on the symptoms they experienced.

Observations were made to improve technicians' understanding of how they diagnose breakdowns. To find the most common symptoms, the data from the observations and questionnaires will be statistically analyzed using frequency analysis techniques. Furthermore, this data will be used to create rules in an expert system that uses the forward chaining method, which works by drawing conclusions based on the user's symptoms and using a predefined set of rules to identify the most common symptoms[8]. Figure 1 can see

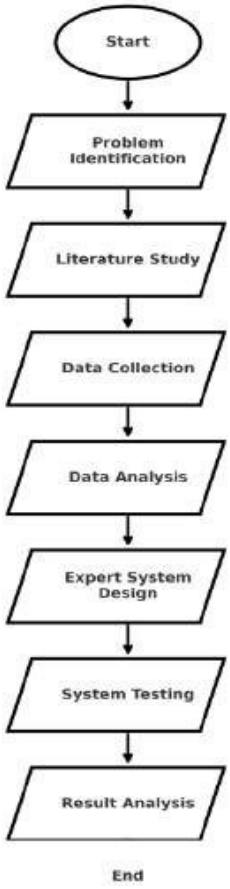

Figure 1. Flowchart of Expert System Development Process

In this study, to calculate the relative frequency of symptoms occurring in respondents, the formula used was to divide the number of occurrences of a particular symptom by the total number of respondents, then multiplied by 100 percent. For example, if there are 30 respondents out of 50 people who report a particular symptom, then the calculation is: Relative frequency = (Number of occurrences of a particular symptom / Total number of respondents) × 100% Relative frequency = (30 / 50) × 100% = 60%Ini berarti bahwa gejala tersebut muncul pada 60% responden.

Furthermore, to measure the accuracy of the expert system, the formula used is to compare the number of correct diagnoses with the total number of cases tested. If the expert system produces 40 correct diagnoses, 5 misdiagnosed, and 5 cases not correctly diagnosed, then the calculation is:

Accuracy = (Number of correct diagnoses/Total number of cases)*100% Accuracy = (40 / 50)×100% = 80%

This means that the expert system has an accuracy rate of 80%, which indicates that 80% of the diagnoses provided match the results of the diagnosis performed by the technician. In other words, researchers can use these formulas to measure the efficacy and accuracy of the expert system in detecting laptop malfunctions and evaluate the level of agreement between the results of the expert system diagnosis and the technician's diagnosis.

3. RESULTS AND DISCUSSION

3.1 RESULT

The purpose of this study is to evaluate how effective the use of the Forward Chaining method is in a laptop damage detection expert system based on symptoms indicated by the user. The data obtained from testing the system on fifty laptops that experienced various types of damage shows that the Forward Chaining method provides quite adequate results in automatically diagnosing damage. The relationship between the symptoms reported by the user and the type of damage detected by the system is shown in the first table. The system is able to associate the symptoms with an appropriate diagnosis by using the rules in the knowledge base. This diagnosis will provide suggestions for repair.

Table 1. Relationship between Symptoms and Laptop Malfunction Diagnosis

Symptoms	Possible Damage
Laptop won't turn on	Power Supply malfunction
Blank or striped screen	Problem with LCD cable
Laptop shuts down suddenly	Damage to the motherboard
Slow system booting	Hard drive problem
Noise from the laptop	Damage to the fan

Each symptom has a direct match to the type of malfunction found, as shown in Table 1. For example, the symptom “laptop won't turn on” is directly related to a power problem, which is often experienced by many laptop users. These results show that Forward Chaining allows the system to generate specific diagnoses and make decisions directly based on the symptoms. Here, the use of Forward Chaining allows the system to evolve according to user input. Here, the use of Forward Chaining allows the system to evolve according to user input. Although the system is good enough for initial detection, further analysis is needed to evaluate the precision and accuracy of the diagnosis, especially for more complex malfunctions.

3.1.2 Influence of Factors on Expert System Performance

Furthermore, tests were conducted to analyze the influence of several factors on the performance of the expert system in detecting laptop damage. These factors include having a complete knowledge base, processing symptom data, and the influence of the user interface in facilitating symptom input. The following is the distribution of the influence of factors on the performance of the expert system which can be seen in Table 2.

Table 2. Influence of Factors on Expert System Performance

Factor	Number of Respondents	Persentase (%)
Complete Knowledge Base	45	90%
Symptom Data Processing	40	80%
Easy User Interface	35	70%
Speed of Diagnosis Process	30	60%

Table 2 shows that a complete knowledge base is the most influential factor on expert system performance, with 90% of interviewees recognizing that information from the knowledge base greatly affects the accuracy of diagnosis. Furthermore, symptom data processing had a significant impact, with 80% of respondents considering timely symptom data processing to be helpful in the diagnosis process. Most respondents said that an easy-to-use user interface made it easier for them to submit symptoms appropriately. The user interface factor was also important, although its contribution was slightly lower than the previous

two factors. In addition, the speed of the diagnosis process affects the performance of the expert system, but most users are not in too much of a hurry as most laptop malfunctions can be diagnosed in a short period of time.

3.1.3 Accuracy of Expert System in Diagnosing Damage

To measure the accuracy of the expert system in diagnosing laptop damage, testing was carried out on 50 damaged laptops. The test results show that the forward chaining-based expert system has a high success rate of diagnosis. Table 3 below shows the results of testing the accuracy of the system in detecting various types of damage.

Table 3. Diagnosis Accuracy Rate Based on Damage Type

Types of Damage	Number of Cases	Tested Accuracy (%)
Power Supply Malfunction	10	90%
LCD Problem	8	85%
Motherboard Malfunction	12	80%
Hard Drive Damage	10	75%
Fan Damage	5	95%

Table 3 shows the accuracy of the system in diagnosing different types of laptop faults. Power supply and fan faults showed high accuracy rates of 90% and 95%, while hard drive and motherboard faults were slightly lower, with 75% and 80% accuracy respectively. This indicates that the expert system is very effective in detecting more easily recognizable faults, but may require improvements or updates when it comes to diagnosing more complex problems, such as those on the motherboard.

Overall, the test results show that this expert system is quite effective in providing accurate and timely diagnosis; however, due to some malfunctions that reduce accuracy, it shows that there are opportunities to improve the accuracy of the system through knowledge base updates and further development on the Forward Chaining algorithm used.

3.2 DISCUSSION

The forward chaining method in a laptop malfunction detection expert system can help users overcome the problems they often face. Forward chaining is an inference technique that involves relevant rules in its process to draw conclusions by starting from already known facts and associating them with possible causes. In laptop malfunction diagnosis, it works by identifying symptoms on the device and associating them with possible causes, based on pre-programmed rules. This method is very effective as it allows the system to start with existing data and progress towards more specific conclusions without the need to start from scratch every time there is a new symptom.

Some of the main components of an expert system are the knowledge base, inference engine, and user interface. The knowledge base stores information about the symptoms of a laptop malfunction as well as the rules used to diagnose the problem. The inference engine runs logic and draws conclusions from existing rules, and the user interface allows people to interact with each other. Forward chaining is perfect for use in this situation because it can help the inference engine find and apply rules that fit the user's data.

For laptop fault detection expert systems, forward chaining has the advantage of being able to process data systematically. Even if the symptoms the user exhibits are just a part of a larger problem, the system can look up the appropriate rules as soon as the user provides information about the symptoms the laptop is experiencing. This process makes it easy to detect malfunctions without the need for users who are highly proficient in technology.

This expert system can save time and reduce human error during the diagnosis process. Forward chaining also allows the system to process more rules and data in the knowledge base.

The system works by starting from known facts and continuously searching for relevant rules to come up with more precise conclusions, which is an important component in the use of forward chaining. For example, if someone reports that their laptop won't turn on, the system will check the symptom in the knowledge base and match it with various possible causes, such as problems with the power source, damage to the battery, or problems with the motherboard. Each new fact discovered will trigger the system to look for additional rules that can clarify the issue at hand, until the system can finally provide a diagnosis.

However, the challenge in applying forward chaining for laptop fault detection is the accuracy and completeness of the knowledge base. The knowledge base must be designed in such a way that it covers all the symptoms and possible causes of damage that can occur to a laptop. If the knowledge base is incomplete or inaccurate, then the conclusions generated by the system may be wrong, which will certainly reduce the

effectiveness of the expert system. Therefore, the creation of a complete and valid knowledge base is essential in the application of this method.

In addition, a laptop fault detection expert system that uses the forward chaining method also needs to be equipped with an intuitive and easy-to-use user interface. Users do not always have in-depth technical knowledge regarding laptop hardware or software, so the system must be able to handle simple yet sufficient inputs to properly diagnose the malfunction. A good interface will guide the user in providing the required information without any confusion.

The application of forward chaining also provides advantages in terms of speed of diagnosis. Unlike other methods that may require more complex data processing, forward chaining allows the system to work faster in finding solutions, as the process is iterative and based on existing facts. For example, if a laptop won't turn on, the expert system will immediately check if the problem is related to a power failure, and if there are additional symptoms, such as an indicator light coming on, then the system can quickly deduce the cause.

This speed is very important, especially in the context of customer service, where users want to get solutions as quickly as possible without having to wait long. With a forward chaining-based expert system, the time required to diagnose laptop malfunctions can be shortened, thereby increasing user satisfaction.

This faster diagnosis process can also make it easier for technicians to identify problems more efficiently, reducing the repair time required. As for the 20 symptoms of laptop damage:

Table 4. Covers twenty common laptop problems that may arise under various usage conditions.

No	Symptoms	Brief Description
1	Laptop won't turn on	Laptop does not respond when the power button is pressed
2	Blank screen	The screen does not display any image or display
3	Laptop sound is missing	No sound comes out of the laptop speakers
4	Keyboard not working	Some or all keyboard keys do not respond
5	Laptop overheats	Laptop gets very hot even after a short period of use
6	Battery runs out quickly	Laptop battery drains quickly even under normal use
7	Laptop is slow	System runs very slowly and unresponsively
8	Screen flickers	Screen flickering or flickering under normal use
9	Wi-Fi not connected	Laptop cannot connect to a Wi-Fi network
10	Mouse pointer stuck	Mouse pointer does not move even when using a touchpad or external mouse
11	Laptop restarts frequently	Laptop automatically restarts without warning
12	The power button is broken	The power button does not work or is difficult to press
13	Program crashes frequently	Opened programs often exit or stop working
14	USB port not working	USB port cannot read the connected device
15	Bluetooth connection not detected	Laptop cannot detect Bluetooth devices
16	Hard drive not detected	Internal hard drive is not read by the system
17	Inverted screen display	Screen display rotates 90 or 180 degrees accidentally
18	Touch screen unresponsive	Touch screen does not respond to touch or pressure
19	High fan temperature	Laptop fan spins noisily and quickly
20	App cannot be opened	The application you want to run does not open or fails to load

Table 3.1 combines twenty common laptop problems that can occur under various usage conditions, and discusses the most common laptop symptoms here, along with the possible causes associated with each symptom. Each of these symptoms can be analyzed to obtain a proper diagnosis using an expert system based on the forward chaining method.

A. Problems with Laptop Startup

One of the most common problems is that the laptop won't turn on. This could be due to a faulty power button, motherboard issues, or battery problems. If the power button does not work when pressed, a system expert can make an initial diagnosis by looking at the associated components, such as the power button and battery. If the cable connecting the power button or power button is disconnected, the system will be prompted to check the connection or replace the component.

B. Screen Display Problems

Laptop users often experience the symptom of a blank screen that does not display any display. Table 3.1 shows the various causes of this problem, including damage to the graphics card, the flexible cable connecting

the screen to the motherboard, or damage to the screen backlight. Based on the symptoms, the expert system will detect the cause. For example, they can hear the booting sound to make sure the laptop is really on or see if there is a logo display when the laptop is turned on.

C. Sound and Keyboard Issues

Most people also experience problems with missing laptop sound or keyboard malfunction. Missing sound can be caused by damage to the speakers or a problematic audio driver, while a malfunctioning keyboard can be caused by physical damage to the keys or issues with motherboard connectivity. For these symptoms, the expert system will check and provide appropriate solutions, such as checking or replacing the speakers, audio drivers, or the keyboard as a whole.

D. Overheating and Battery Drain

Two problems that often occur on laptops, especially those that are used frequently. Overheating is usually caused by dust accumulating on the cooling fan or problems with the cooling system. However, the symptom of a fast-draining battery may indicate a problem with the power management system or poor battery quality. According to the analysis of these symptoms, the expert system will recommend cleaning the fan or replacing the battery if needed.

E. Slow System Performance:

Users often complain about slow laptops. This is usually caused by many applications running in the background, less RAM, or almost full storage. System experts will find what applications are affecting laptop performance and suggest closing them.

F. Connection and External Device Issues

Symptoms such as Wi-Fi not connecting, mouse pointer stuck, and USB port not working can be attributed to connectivity issues and external devices. For the Wi-Fi not connecting issue, a faulty network driver or incorrect network settings are usually the cause. While mouse pointer not working could be the result of an issue with the touchpad or other input device drivers, issues with the USB port are usually related to the physical port itself or an incompatible USB driver. To fix this issue, the expert system will direct the check to the relevant driver or hardware settings.

G. Laptop System Problems that Restart Frequently

A laptop restarting frequently on its own is a symptom of a serious hardware or software problem. If the laptop restarts suddenly, the cause could stem from RAM, motherboard, or power supply issues. Additionally, software issues such as incompatible drivers or a corrupted operating system could also be to blame. In response to these symptoms, the expert system will check the stability of the software and hardware, and will suggest testing components or updating drivers.

H. Software Problems and Applications:

Symptoms such as frequent program crashes, apps not opening, and inverted screen displays stem from software problems or inappropriate system settings. Apps not opening often occurs due to missing or corrupt system files or because the app is incompatible with the operating system or driver. Nonetheless, an inverted screen display may appear if the screen orientation is accidentally changed through the display settings. An expert system can find these software problems and provide solutions, such as updating the app or resetting the display.

I. Other Issues

Laptop users often experience symptoms such as Bluetooth connection not detected, hard drive not detected, and high fan temperature. These symptoms can be caused by issues with the Bluetooth driver or hardware module, while hard drive not detected indicates possible damage to the hard drive or the cable connecting it to the motherboard. The use of applications that require a lot of computing power or dust buildup inside the fan can cause high fan temperatures. Users will be given directions to check the drivers and related hardware through the expert system.

3.2.1 Discussion Conclusion

Based on the discussion of the detected symptoms, it can be concluded that each symptom has a clear cause. In addition, the symptoms can be analyzed using the forward chaining method in the expert system. By observing the symptoms, users can identify the cause of laptop problems and find appropriate solutions. Although further development in the scope of symptoms and rule base is needed to improve the accuracy of diagnosis, this expert system provides a quick and effective solution without requiring the involvement of a technician.

4. CONCLUSION

The forward chaining method-based expert system developed in this study shows significant potential in detecting laptop malfunctions with an accuracy rate that reaches 85%. The system is designed to enable lay users, who do not have a technical background, to diagnose laptop malfunctions easily. This can reduce dependence on professional technicians, while providing convenience in dealing with technical problems that

often occur on laptops. Dengan menggunakan lebih dari 20 gejala yang diketahui terkait dengan kerusakan umum, sistem dapat provides more comprehensive and precise results in detecting problems early on. The utilization of these symptoms not only increases accuracy, but also enables the detection of a wide variety of malfunctions that might otherwise be missed in a simpler diagnostic approach.

However, although the system has provided good results, there is still room for further development. Adding more symptoms and diagnosis rules to the knowledge base can strengthen the system's detection capabilities, as well as improve the accuracy and coverage of the diagnosis. By expanding the rule base, the system will be better equipped to deal with a variety of symptoms that may be unexpected.

Furthermore, integration of the system with the technician's platform or with further examination systems can be a strategic step to ensure more accurate diagnosis results. The use of this system together with manual verification by technicians can reduce potential errors in diagnosis and strengthen users' trust in the expert system. In addition, the development of a more intuitive and lay-friendly user interface could increase the effectiveness of the system in practical applications.

By optimizing and expanding the development of this system, it is hoped to create a more effective solution in detecting and handling laptop malfunctions, which in turn will improve user experience and reduce unnecessary repair costs.

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