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An Expert System for Diagnosing Laptop Hardware Failures Using a Web-Based Certainty Factor Method

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Abstract

Rapid technological developments are driving the increased use of laptops in various activities, which indirectly increases the potential for hardware damage. In laptop repair services, the damage identification process generally relies on the technician's experience, resulting in subjective and potentially inconsistent decisions. This situation demonstrates the need for a system capable of providing structured and measurable diagnostic support. The approach used is the Certainty Factor method to represent the level of confidence in diagnostic results. The developed web-based expert system allows users to identify damage based on selected symptoms, then produces output in the form of the type of damage along with a confidence value as a percentage. Evaluation is carried out by comparing the system's diagnostic results with those of experts in a number of test cases. The test results show a good level of agreement, so the system can be used as an aid in the initial diagnosis of laptop hardware damage.

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1. Introduction

Rapid technological advancements have driven the increasing use of laptops in various activities, both for academic and professional needs (Apriyanti & Munti, 2022). This high reliance on these devices is accompanied by an increased risk of hardware damage, which can hinder user productivity if not addressed promptly. (Mijaswari & Sulindawaty, 2020) In practice, the process of diagnosing laptop damage at repair services is still largely conducted manually, relying on the technician's experience. This approach tends to result in subjective decisions and may lead to inconsistencies, especially when the symptoms are complex or interrelated (Widianto et al., 2025).

This situation highlights the need for a more systematic and measurable approach to support the fault identification process. Expert systems can serve as a solution by incorporating an expert's knowledge and decision-making patterns into a computer-based system. With a knowledge base and inference mechanisms (Kurnia & Haidir, 2024), the diagnostic process can be conducted more consistently and reduce reliance on individual subjectivity.

The Certainty Factor method is applied to represent the level of confidence in each possible failure. (Mulyono et al., 2020) This approach enables the system to handle uncertainty in a manner similar to the reasoning process performed by an expert. The development focuses on a web-based expert system for diagnosing laptop hardware failures by integrating the Certainty Factor method. The resulting system is capable of providing information regarding the identified type of failure along with its confidence level. The primary contribution lies in providing a structured and measurable diagnostic tool, thereby supporting the initial identification of failures and aiding decision-making in laptop repairs.

2. Research Methodolgy

2.1 Knowledge Acquisition

Knowledge acquisition is performed through interviews to obtain a list of symptoms, types of malfunctions, the relationship between symptoms and malfunctions, and expert confidence scores. This knowledge is then organized into a knowledge base in the form of IF-THEN rules. In this study, the system is limited to six types of laptop hardware malfunctions commonly encountered in the field. This limitation is imposed to ensure that the diagnostic process remains focused and does not include software malfunctions.

Table 1. Data on Types of Damage

Code	Types of Damage
K01	Laptop Battery
K02	SSD
K03	Cooling System or Fan
K04	Headphone Jack or Charging Port
K05	RAM
K06	CMOS Battery

The selection of these six types of malfunctions is based on considerations of their frequency in the field, the urgency of resolution, and the ease of identification through symptoms that users can observe without special diagnostic tools.

The knowledge base contains thirty symptoms. These symptoms are grouped based on their tendency to be associated with each type of failure. This grouping helps the system search for rules in a more structured manner.

Table 2 Types of Symptoms Associated with Failures

Symptom Code	Symptom Name
G01	Laptop won't turn on at all
G02	Battery drains quickly
G03	Battery percentage fluctuates abnormally
G04	Laptop shuts down when the charger is unplugged
G05	Battery doesn't charge fully
G06	Laptop is slow
G07	Frequent read/write errors
G08	Laptop fails to boot into the operating system
G09	Files are frequently corrupted
G10	Laptop frequently restarts on its own
G11	SSD enters read-only mode
G12	SSD not detected in BIOS
G13	Laptop powers on but does not enter the system
G14	Laptop overheats quickly
G15	Laptop fan makes loud noises
G16	Laptop shuts down when temperature is high
G17	Laptop performance decreases when overheated
G18	Laptop only charges when the cable is moved

G19	Charging indicator frequently turns on and off
G20	Laptop shuts down when the charger is bumped
G21	Charger works normally when used with another laptop
G22	Battery does not charge even when the charger is connected
G23	System performance is very unstable
G24	Frequent errors when installing applications
G25	Applications frequently close on their own (crash)
G26	Blue Screen of Death (BSOD) appears
G27	Frequent beeping sounds
G28	Date and time settings frequently change
G29	"CMOS battery failure" error message appears
G30	"F1" appears during Windows boot

2.2 Rule Base Construction

The rule base is structured in IF-THEN format. The IF part contains a combination of symptoms, while the THEN part contains the conclusion in the form of a damage type. Each relationship between a symptom and a damage type is assigned a confidence weight based on expert assessment. In general, the rule structure used is as follows:

IF symptom_1 AND symptom_2 AND ... AND symptom_n THEN damage_type with a specific expert CF value.

These rules are used by the inference engine to determine damage candidates. If the symptoms selected by the user satisfy the IF part of the rule, the rule becomes active, and the damage type in the THEN part becomes a candidate for the diagnostic result. (Sirait, 2023)

2.3 Certainty Factor Method

The Certainty Factor is used to calculate the level of confidence in the damage candidates obtained from the tracing process (Mijaswari & Sulindawaty, 2020). The CF value indicates how strong the relationship is between the symptom and the damage hypothesis according to the expert. The basic formula for the Certainty Factor is as follows:

$$CF(H,E) = MB(H,E) - MD(H,E)$$

Explanation: CF(H,E) is the certainty factor of hypothesis H based on fact E, MB(H,E) is the measure of increased confidence, and MD(H,E) is the measure of increased doubt (Wibowo, 2022). If there is more than one symptom pointing to the same damage, the CF values are combined using the equation:

$$CFcombine = CF1 + CF2 \times (1 - CF1)$$

The final CF value is then converted to a percentage. The type of damage with the highest CF value is designated as the primary diagnosis, while other candidates may be displayed as supporting information.

Table 3: Confidence Scale

Confidence Level	CF
Not sure	0,2
Somewhat sure	0,4
Fairly sure or maybe	0,6
Sure	0,8
Very sure	1,0

2.4 System Design and Implementation

The system was designed using the Unified Modeling Language (UML) approach, specifically Use Case Diagrams, Activity Diagrams, and Class Diagrams. UML was used to describe functional requirements, diagnostic process flows, and relationships between data within the system (Arif et al., 2020; Destriana Rachmat et al., 2021). The system has two main actors: users and administrators. Users can seek consultation by selecting the symptoms they are experiencing, while administrators manage symptom data, damage data, and the rule base. The system is web-based, allowing access via a browser and making it easier for non-technical users to use.

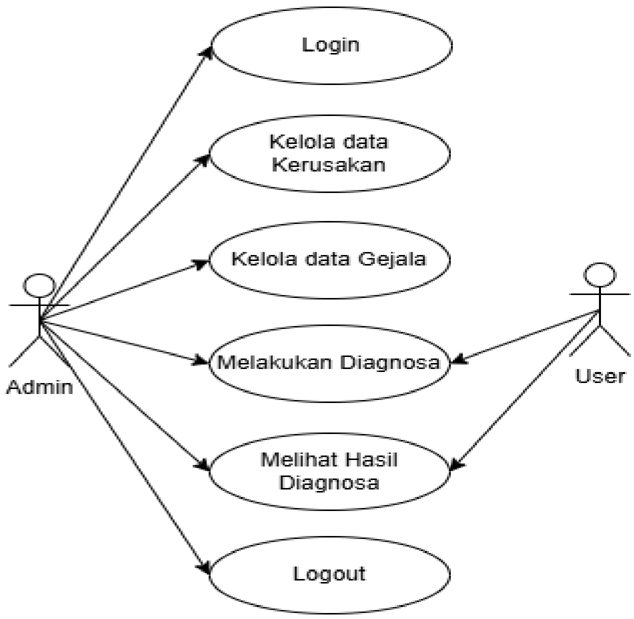

Figure 1. Use Case Diagram

2.4 System Testing

Testing was conducted using two approaches. First, Black Box Testing was used to ensure that every main function operates as intended without directly reviewing the program code. Second, the accuracy of the diagnostic results was tested by comparing the system's results with those of experts across five test cases. The accuracy rate was calculated using the following formula:

Accuracy = (Number of matching data points / Total test data) × 100%

3. Results and Discussion

3.1. System Implementation Results

The expert system developed features a main page, a login page, a consultation page, a consultation results page, an admin dashboard, a symptom data page, a damage data page, and a rule base page. On the consultation page, the user selects the symptoms experienced by the laptop, after which the system performs a reasoning process using Forward Chaining. Once potential causes of damage are identified, the system calculates the Certainty Factor and displays the diagnostic results in the form of the type of damage along with its confidence percentage.

On the admin side, the system provides facilities for managing damage data, symptom data, and the rule base. These facilities are important because the expert system's knowledge can be updated when new symptoms arise or expert assessments change. Thus, the system functions not only as a consultation application but also as a structured medium for documenting technicians' knowledge.

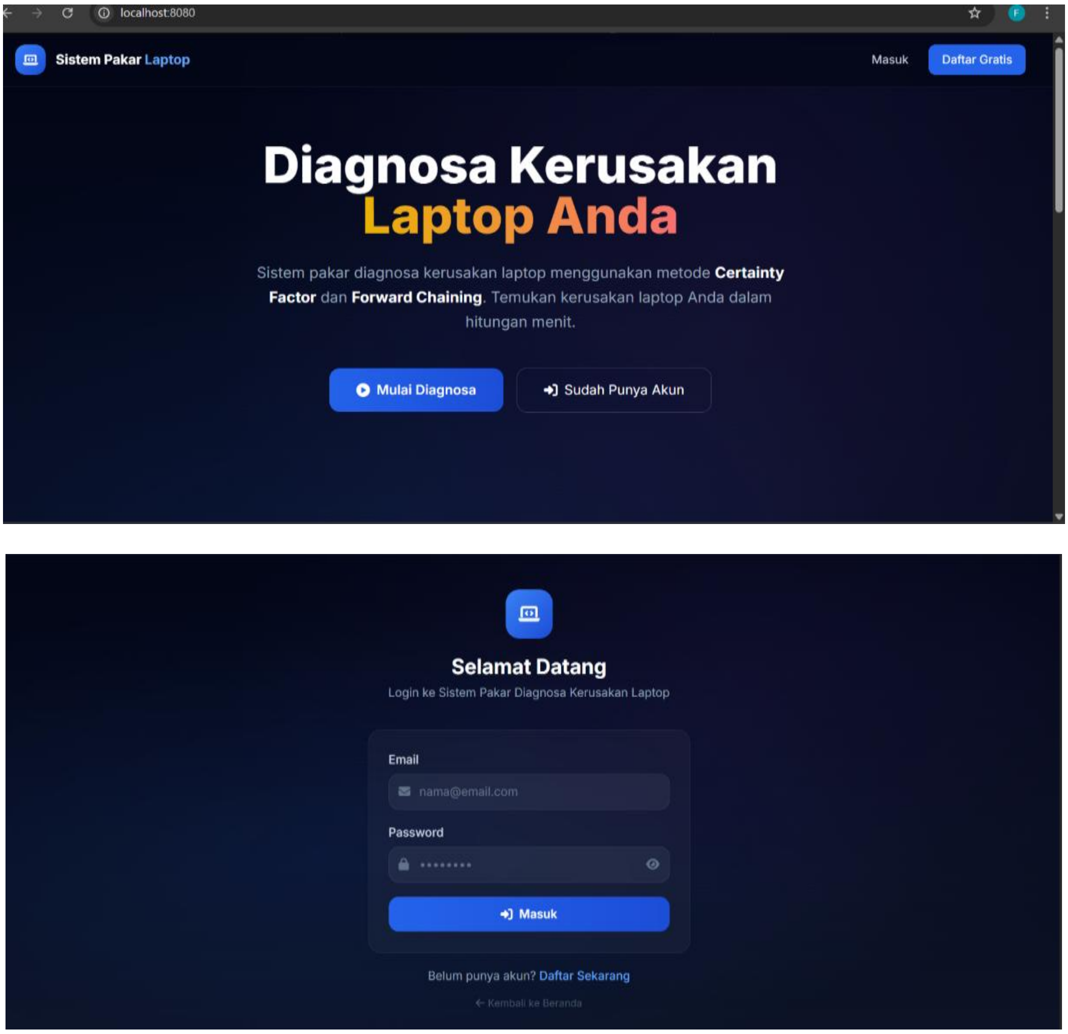

Figure 2: Expert System Login Page and Home Page

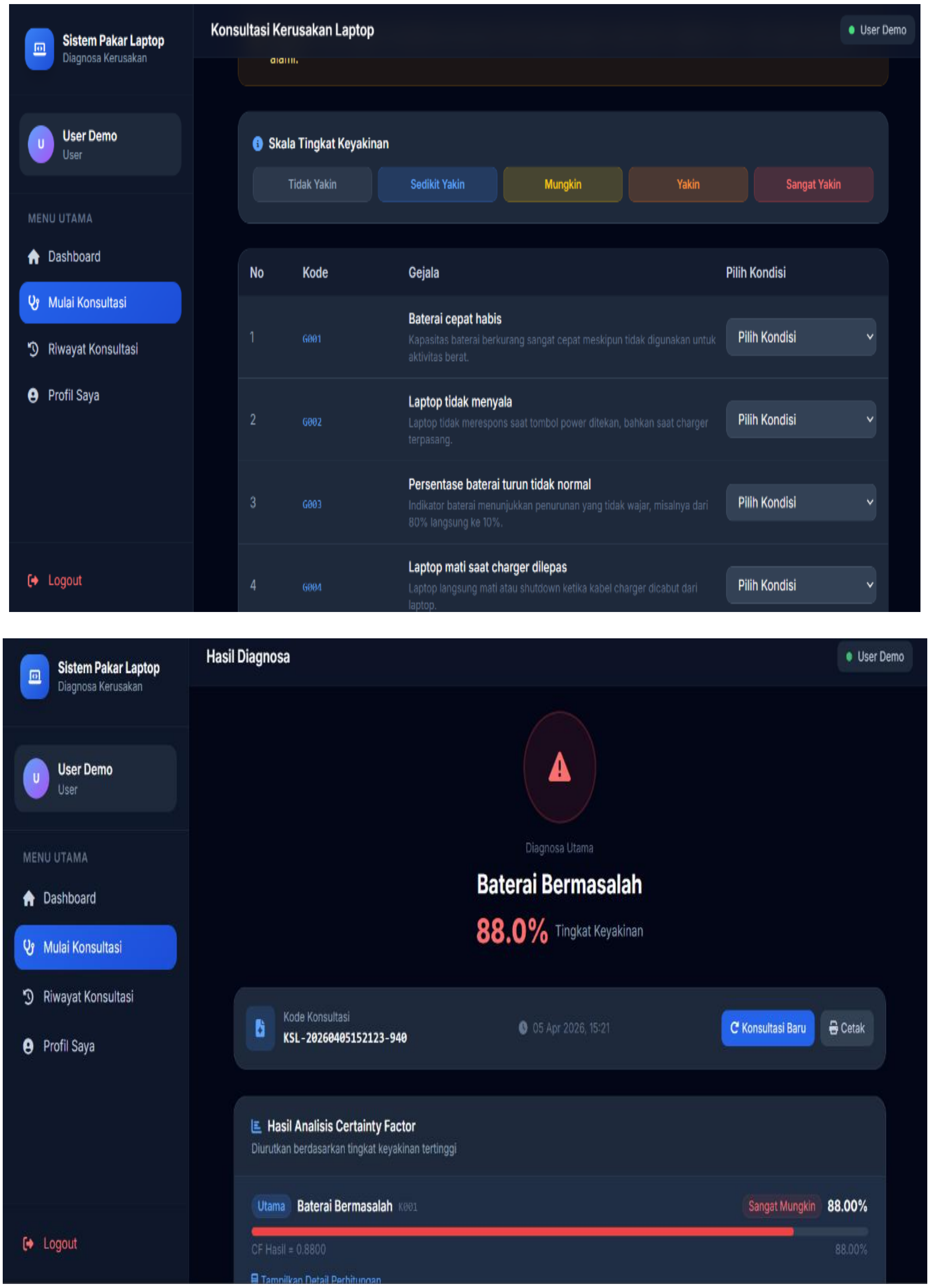

Figure 3: Diagnosis and Diagnostic Results

Figure 4: Admin Dashboard

3.2. Black-Box Testing

Black-Box Testing was performed on the system's main functions. The test results showed that all tested functions operated correctly. This indicates that the system has met the basic functional requirements for use as an initial diagnostic application.

No.	Testing	Expected Output	Result
1	Click the home page	The system displays the home page	Valid
2	Click "Log In"	The system displays the login page	Valid
3	Click "Consultation"	The system displays the diagnostics page	Valid
4	Click "Consultation History"	The system displays the history and results of previous diagnostics	Valid

3.2. Expert Agreement Testing

Agreement testing was conducted by comparing the system's diagnostic results with those of experts across five test cases. The purpose of this testing was to assess the extent to which the rule base and Certainty Factor values used were able to represent expert knowledge.

No.	Test Symptoms	System Results	Expert Results	Compliance
1	G01, G02, G03, G04	Battery issue	Laptop battery	Compliant
2	G11, G12, G13	SSD issue	SSD	Compliant
3	G23, G24, G25, G26	RAM issue	RAM	Compliant
4	G19, G20, G21	RAM issue	DC jack or charging port	Non-compliant
5	G16, G17, G18	DC jack or charging port issue	DC jack or charging port	Compliant

Based on the five test cases, four cases showed agreement between the system and the expert, while one case showed a discrepancy in results. This discrepancy occurred because some symptoms are similar and can point to more than one component. This indicates that the system still requires refinement of the CF weights and the addition of rule variations to more accurately distinguish overlapping symptoms.

3.3. System Accuracy

System accuracy is calculated based on the number of test data points that align with the expert's decision. Out of five test cases, four were consistent. Thus, the system's accuracy is:

Accuracy = (4 / 5) x 100% = 80%

An accuracy of 80% indicates that the system is capable of providing diagnoses consistent with the expert's in the majority of test cases. However, the limited number of test data points means the accuracy results cannot yet be widely generalized. Research on rule-based expert systems places greater emphasis on the alignment of rules with expert knowledge; however, additional validation is still required to ensure stronger system performance in real-world applications (Mustafa et al., 2023)

4. Conclusion

This study successfully designed and developed a web-based expert system for diagnosing laptop hardware failures using the Certainty Factor. Forward Chaining was used to trace rules based on symptoms selected by the user. The developed system covers six types of failures and thirty symptoms, and provides a consultation feature for users and knowledge base management for administrators. Black Box testing results indicate that the system's core functions operate correctly. Expert validation testing on five test cases yielded four valid cases and one invalid case, resulting in an accuracy rate of 80%. These results indicate that the system can be used as a tool for the initial diagnosis of laptop hardware failures. Further development is recommended to increase the number of failure types, expand the variety of symptoms, involve more than one expert in determining CF values, and conduct testing with a larger number of cases to make the evaluation results more representative.

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