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Accuracy Testing of Laptop Damage Diagnosis Using Forward Chaining and Certainty Factor Algorithms

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Abstract: Laptops are widely used for educational and professional activities, but non-technical users often have difficulty identifying hardware problems, which can delay repairs and increase costs. This study developed and evaluated a web-based expert system for diagnosing laptop hardware damage using the Forward Chaining (FC) algorithm and the Certainty Factor (CF) method. The knowledge base consisted of 30 symptoms and 11 hardware damage categories derived from observations and interviews with professional laptop technicians. Accuracy testing was conducted using 20 test cases, consisting of 16 general user questionnaire cases and 4 technician-verified real-world cases. The diagnostic results generated by the system were compared with technician diagnoses as the reference. The hybrid FC-CF approach correctly diagnosed 15 of 20 cases, resulting in an accuracy of 75%, while standalone Forward Chaining correctly diagnosed 5 cases, resulting in an accuracy of 25%. The results indicate that the use of Certainty Factor allows the system to produce diagnoses when user-provided symptoms are incomplete or uncertain. The remaining incorrect diagnoses were associated with user subjectivity in assigning confidence levels and overlapping symptoms among hardware damage categories. Based on the test results, the developed system can be used as a preliminary diagnostic aid for laptop hardware problems and should not be considered a replacement for professional technician assessment.

Keywords: Expert System; Certainty Factor; Forward Chaining; Laptop Damage Diagnosis.

1. Introduction

Laptops have become widely used computing devices in educational institutions and professional environments because they support various academic, administrative, and work-related activities. The increasing dependence on laptops also makes hardware problems an important issue because damage to components can interfere with users' activities and require appropriate troubleshooting. Identifying the source of a laptop malfunction, however, is not always straightforward because similar symptoms may be associated with different hardware components. For users with limited technical knowledge, determining the possible cause of a problem without assistance from a technician can therefore be difficult (Alhilal & Astuti, 2025; Burhanuddin & Akhsa, 2021; Kurnia & Haidir, 2024).

One approach that can assist users in identifying hardware problems is an expert system. An expert system represents knowledge from a specific domain in a computer-based system and uses that knowledge to generate conclusions based on facts provided by users. Several studies have developed expert systems for diagnosing laptop and computer hardware damage. Alhilal and Astuti (2025) developed an expert system for laptop fault diagnosis using Forward Chaining, while Burhanuddin and Akhsa (2021) developed an Android-based system for identifying laptop damage using the Certainty Factor method. Other studies have applied Certainty Factor to computer and laptop diagnosis (Jaelani & Akbar, 2025; Kalyzta & Syafrullah, 2023; Kurnia & Haidir, 2024; Widianto *et al.*, 2025). Forward Chaining has also been applied to diagnose laptop and computer damage (Marsandi *et al.*, 2024; Pratama *et al.*, 2022; Permadi *et al.*, 2025). These studies indicate that expert systems can be used to represent diagnostic knowledge and generate possible hardware damage based on symptoms reported by users.

Forward Chaining is a rule-based inference method that starts from known facts and applies predefined rules to derive new facts until a conclusion is reached. In laptop hardware diagnosis, the initial facts may consist of symptoms reported by users, which are processed through rules describing the relationship between symptoms and hardware damage. Alhilal and Astuti (2025) applied Forward Chaining to laptop fault diagnosis, while Marsandi *et al*. (2024) compared Forward Chaining and Backward Chaining for laptop damage detection. Pratama *et al*. (2022) used Forward Chaining to detect laptop or computer damage, and Permadi *et al*. (2025) implemented the method in a web-based laptop diagnostic system. Khatimah and Andini (2026) also developed a rule-based laptop damage diagnostic system using Forward Chaining. These studies show that Forward Chaining can be used to construct a diagnostic process by tracing relationships between observed symptoms and possible hardware damage.

However, a diagnosis based only on rule matching may be less suitable when users provide symptoms with different levels of confidence. In hardware diagnosis, users generally report symptoms based on their observations, while some symptoms may be more strongly associated with particular components than others. Certainty Factor can be used to represent the degree of certainty associated with the relationship between symptoms and diagnostic hypotheses. The method allows expert knowledge and user confidence to be incorporated into the calculation of a diagnostic result. Certainty Factor has been applied to laptop and computer hardware diagnosis in several studies, including Burhanuddin and Akhsa (2021), Kurnia and Haidir (2024), Romadhoni and Zayn (2023), Tarigan and Martiano (2026), and Widianto *et al*. (2025). These studies provide a basis for using Certainty Factor when the diagnostic process involves uncertainty in the evidence provided by users.

The combination of Forward Chaining and Certainty Factor has also been investigated in computer and laptop hardware diagnosis. Guftamal *et al*. (2022) developed a desktop-based expert system for diagnosing computer hardware damage using Forward Chaining and Certainty Factor. Saputra *et al*. (2022) implemented the same combination in a web-based computer hardware diagnostic system, while Marpaung and Handoko (2023) investigated computer damage diagnosis using both methods. Anggara *et al*. (2025) further applied the combination to a laptop damage diagnostic system. The use of these two methods provides a distinction between the rule-tracing process and the calculation of diagnostic certainty: Forward Chaining can be used to determine the applicable diagnostic rules, whereas Certainty Factor can be used to calculate the degree of certainty of the resulting diagnosis.

The evaluation of diagnostic accuracy is an important part of assessing the performance of an expert system. A system may successfully execute its rules and produce a diagnosis, but this does not necessarily mean that the diagnosis corresponds to the actual condition of the hardware. Laksana *et al*. (2024) compared the accuracy of CPU damage prediction using Certainty Factor and Forward Chaining, demonstrating the importance of evaluating diagnostic results when different inference methods are applied. Simatupang and Pusparini (2025) also evaluated a laptop damage diagnostic system using black-box testing and diagnostic cases. These studies show that system functionality and diagnostic performance need to be evaluated, particularly when the system is intended to support hardware diagnosis.

Although previous studies have applied Forward Chaining, Certainty Factor, and their combination to laptop and computer hardware diagnosis, the existing systems differ in their symptom sets, hardware damage categories, knowledge bases, implementation platforms, and evaluation procedures (Guftamal *et al.*, 2022; Laksana *et al.*, 2024; Anggara *et al.*, 2025; Tarigan & Martiano, 2026). Therefore, the diagnostic performance reported by one system cannot be directly generalized to another system with a different knowledge base and diagnostic scope. A specific system needs to be evaluated using its own set of symptoms and reference diagnoses to determine whether the resulting diagnoses are consistent with the established diagnostic cases.

Based on this research gap, this study aims to develop and evaluate a web-based expert system for diagnosing laptop hardware damage using Forward Chaining and Certainty Factor. The knowledge base consists of 30 symptoms and 11 categories of laptop hardware damage, which are obtained from technician knowledge and used to construct the diagnostic rules. The system processes symptoms provided by users using Forward Chaining and applies Certainty Factor to calculate the degree of certainty for each possible hardware damage category. The resulting diagnoses are then compared with reference diagnoses to measure the accuracy of the system. This evaluation is intended to determine the performance of the combined Forward Chaining and Certainty Factor approach in diagnosing laptop hardware damage and to assess the consistency of the system's diagnoses with the established reference cases.

2. Related Work

2.1 Rule-Based Inference and the Limitations of Forward Chaining

Rule-based inference is commonly used in expert systems for diagnosing laptop and computer hardware problems. One of the methods applied in this area is Forward Chaining (FC), which uses known facts and predefined rules to derive conclusions. In a diagnostic system, the facts can be symptoms reported by users, while the rules describe the relationships between symptoms and possible hardware damage (Alhilal & Astuti, 2025; Pratama *et al.*, 2022). Several studies have applied FC to laptop and computer diagnosis. Alhilal and Astuti (2025) used FC for laptop fault diagnosis, while Pratama *et al.* (2022) applied the method to detect laptop or computer damage. Permadi *et al.* (2025) also implemented FC in a web-based laptop diagnostic system. In addition, Marsandi *et al.* (2024) compared the use of Forward Chaining and Backward Chaining for laptop damage detection. These studies show that FC can be used to construct diagnostic rules based on relationships between observed symptoms and hardware damage. Although FC is suitable for rule-based diagnosis, the method does not directly represent the degree of uncertainty associated with the facts used in the inference process. The result of a rule-based inference depends on the facts and rules defined in the knowledge base. In practical laptop diagnosis, however, users may report symptoms based on their observations and may not always be able to determine the condition of a component with certainty. This situation creates a need for an additional method that can represent the level of confidence associated with the diagnostic evidence (Laksana *et al.*, 2024; Saputra *et al.*, 2022). Therefore, FC can provide the rule-based inference structure, while another approach is required when uncertainty in symptom information needs to be represented.

2.2 Managing Diagnostic Uncertainty with the Certainty Factor

Certainty Factor (CF) is a method used in expert systems to represent the degree of confidence associated with a hypothesis based on available evidence. In diagnostic applications, CF can incorporate knowledge from experts and the confidence level associated with symptoms reported by users. This approach allows a diagnostic system to distinguish between symptoms that provide different levels of support for a particular diagnosis (Burhanuddin & Akhsa, 2021; Widianto *et al.*, 2025). Several studies have applied CF to laptop and computer hardware diagnosis. Burhanuddin and Akhsa (2021) developed an Android-based system for identifying laptop damage using CF, while Kurnia and Haidir (2024) developed a web-based laptop diagnostic system using the same method. Romadhoni and Zayn (2023) applied CF to diagnose laptop hardware damage, and Tarigan and Martiano (2026) developed a web-based expert system for diagnosing laptop hardware failures using CF. Widianto *et al.* (2025) also implemented CF for laptop damage diagnosis. These studies indicate that CF is applicable when the diagnostic process requires the system to represent different levels of confidence in the relationship between symptoms and possible hardware damage.

2.3 Hybrid Architectures Using Forward Chaining and Certainty Factor

The complementary characteristics of Forward Chaining and Certainty Factor provide a basis for combining the two methods in an expert system. FC can be used to determine the rules and inference sequence from the symptoms entered by the user, while CF can be applied to calculate the degree of certainty associated with the diagnostic hypothesis. Several studies have used this combination for computer and hardware diagnosis. Guftamal *et al.* (2022) developed a desktop-based expert system for computer hardware diagnosis using Forward Chaining and Certainty Factor. Saputra *et al.* (2022) applied the same combination in a web-based computer hardware diagnostic system, while Marpaung and Handoko (2023) investigated computer damage diagnosis using Forward Chaining and Certainty Factor. Anggara *et al.* (2025) also developed a laptop damage diagnostic system using the combination of Forward Chaining and Certainty Factor. The application of these two methods provides a diagnostic structure in which the inference process is based on predefined rules and the resulting diagnosis can be associated with a certainty value. Laksana *et al.* (2024) examined the accuracy of CPU damage prediction using Certainty Factor and Forward Chaining, providing a reference for evaluating different inference approaches in hardware diagnosis. However, the performance of a diagnostic system depends not only on the selected inference method but also on the knowledge base, symptom definitions, damage categories, rules, and evaluation cases used in the system. Therefore, the results obtained from one diagnostic system cannot be directly generalized to another system with different diagnostic knowledge and test cases.

2.4 Evaluation and Research Gap

Evaluation is an important part of expert system development because functional operation and diagnostic accuracy represent different aspects of system performance. Black-box testing can be used to determine whether system functions produce the expected outputs based on specified inputs, while diagnostic accuracy evaluation requires comparison between system diagnoses and an established reference diagnosis.

Simatupang and Pusparini (2025), for example, used black-box testing in the evaluation of a web-based laptop diagnostic expert system. Laksana *et al.* (2024) focused on the accuracy of CPU damage prediction when comparing Certainty Factor and Forward Chaining. These studies show that evaluation procedures may differ according to the objectives and characteristics of the diagnostic system. Based on the studies reviewed, previous research on laptop and computer hardware diagnosis has used different combinations of inference methods, symptom sets, damage categories, knowledge bases, and evaluation procedures (Guftamal *et al.*, 2022; Anggara *et al.*, 2025; Kurnia & Haidir, 2024; Tarigan & Martiano, 2026). Therefore, the diagnostic performance of a particular hybrid Forward Chaining–Certainty Factor system needs to be evaluated using its own knowledge base and reference cases. This study addresses this issue by developing a web-based expert system with 30 symptoms and 11 categories of laptop hardware damage and evaluating its diagnostic results against reference diagnoses. The evaluation is intended to determine the accuracy of the proposed system and assess the application of the combined Forward Chaining and Certainty Factor methods in laptop hardware diagnosis.

3. Methodology

This study uses an applied research approach to develop and evaluate a web-based expert system for diagnosing laptop hardware damage. The research consists of four main stages: knowledge acquisition, knowledge representation, system development, and diagnostic evaluation. The knowledge acquisition stage was conducted through direct observation and interviews with professional laptop technicians and was supplemented by relevant technical literature. The information obtained from these activities was used to identify 30 symptoms and 11 categories of laptop hardware damage, along with the troubleshooting solutions associated with each damage category. The relationships between symptoms and hardware damage were subsequently organized into a knowledge base. Each relationship was represented using IF-THEN rules and assigned Measures of Belief (MB) and Measures of Disbelief (MD) based on the knowledge obtained from the technicians. The knowledge base was implemented in a web-based expert system using PHP for application development and MySQL for data management. The database contains the symptom data, hardware damage categories, diagnostic rules, MB and MD values, and troubleshooting information. Users select the symptoms observed on their laptops, and the selected symptoms are processed by the inference mechanism based on the rules stored in the knowledge base.

The diagnostic mechanism combines Forward Chaining (FC) and Certainty Factor (CF). Forward Chaining processes the symptoms entered by users as initial facts and matches them with the predefined IF-THEN rules to determine the possible categories of hardware damage. Certainty Factor is then used to determine the degree of certainty associated with each diagnostic hypothesis. The calculation considers the MB and MD values assigned to the symptom-damage relationships and the user's confidence in the symptoms selected. When several symptoms support the same diagnostic hypothesis, their certainty values are combined to obtain the final certainty value for that hypothesis. System evaluation was conducted using 20 test cases, consisting of 16 general user questionnaire cases and 4 verified real-world cases. Each test case was processed through the developed expert system, and the resulting diagnosis was compared with the corresponding diagnosis established by a professional laptop technician. The comparison was used to determine whether the system produced a diagnosis that corresponded to the reference diagnosis. The diagnostic accuracy was calculated by comparing the number of correctly diagnosed cases with the total number of test cases using the following formula:

$$\text{Accuracy} = \frac{N_{\text{correct}}}{N_{total}}\ x\ 100\ \% \qquad (1)$$

Where N_{correct} represents the number of cases in which the system diagnosis corresponds to the reference diagnosis, while N_{total} represents the total number of evaluated cases. In this study, the total number of test cases was 20.

4. Result and Discussion

4.1 Results

4.1.1 System Implementation and Web-Based Interface Design

The developed expert system for laptop hardware damage diagnosis was implemented as a web-based application using PHP and MySQL. The system integrates a knowledge base containing 30 symptoms and 11 categories of laptop hardware damage. The knowledge base stores the relationships between symptoms and hardware damage in the form of diagnostic rules and certainty values obtained from the knowledge acquisition process. The system was designed to provide a diagnostic facility for users by allowing them to select symptoms observed on their laptops and provide their level of confidence regarding each selected symptom. The diagnostic interface consists of several stages, beginning with the system homepage, followed by symptom selection and confidence-level input, and ending with the presentation of diagnostic results. The homepage provides general information about the system and the diagnostic process. This page also serves as the initial navigation interface before users begin the consultation process.

Figure 1. Initial System Homepage Display

The homepage provides access to the diagnostic consultation process and presents general information about the purpose of the system. The interface is designed to provide a simple entry point for users who may not have extensive technical knowledge of laptop hardware. The symptom selection interface is the main input component of the system. Users select symptoms that correspond to the conditions observed on their laptops and provide a confidence value for each selected symptom. The confidence input is subsequently used in the Certainty Factor calculation to determine the strength of the evidence supporting each possible hardware damage category.

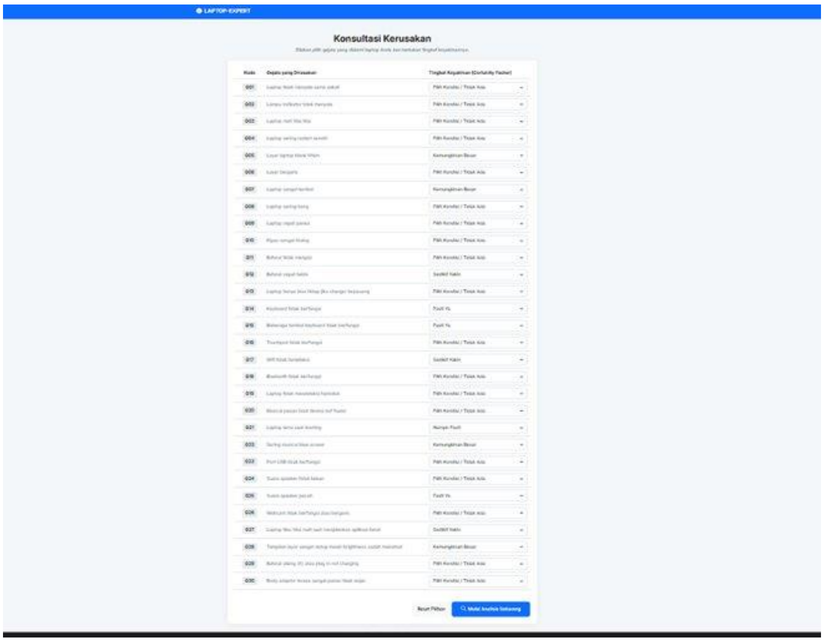

Figure 2. Symptom Selection Interface with Certainty Factor Scale

The symptom selection page allows users to provide information based on their observations. The use of a confidence scale enables the system to distinguish between symptoms that users recognize with high confidence and symptoms about which they are less certain. These user-provided values are subsequently combined with expert-assigned MB and MD values during the CF calculation. After the symptoms have been processed, the system displays the diagnostic results together with the corresponding certainty value and recommended troubleshooting solution.

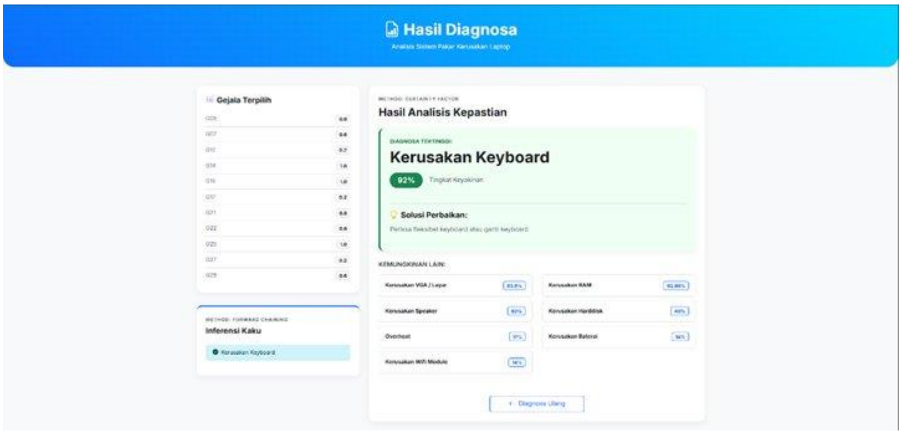

Figure 3. Diagnosis Results Page

The diagnosis results page presents the hardware damage identified by the system and its corresponding certainty value. The system also provides troubleshooting information associated with the identified damage category. This output is intended to provide users with preliminary information regarding the possible source of the laptop problem and the recommended next step.

4.1.2 Diagnostic Accuracy Testing

The diagnostic performance of the developed system was evaluated using 20 test cases. The test cases consisted of 16 cases obtained from general user questionnaire responses and 4 verified real-world cases. Each test case was processed using the developed expert system, and the resulting diagnosis was compared with the reference diagnosis established by professional laptop technicians. The comparison was conducted to determine whether the diagnosis generated by the system corresponded to the reference diagnosis. A diagnosis was categorized as correct when the system's primary diagnostic result corresponded to the reference diagnosis. Otherwise, the result was categorized as incorrect. This classification was used to calculate the diagnostic accuracy of the system.

Table 1. Sample Diagnostic Results

No.	Reference Diagnosis	Selected Symptoms	FC Result	CF Result	Evaluation
1	Keyboard Damage	G05, G07, G12, G14, G15, G17, G21, G22, G25, G27, G28	Keyboard Damage	92.00%	Correct
2	Battery Damage	G01, G02, G03, G07, G08, G09, G10, G11, G12, G13, G19, G20, G21, G23, G24, G25, G29	Power IC, Harddisk, Battery, Speaker	80.70%	Requires interpretation based on primary CF diagnosis
3	Speaker Damage	G10, G12, G20, G21, G24, G25	Speaker Damage	72.96%	Correct
4	Overheat	G01, G03, G04, G09, G10, G11, G12, G13, G22	Battery Damage	80.80%	Incorrect
5	RAM Damage	G03, G04, G07, G08, G09, G10, G20, G21, G22, G27	RAM, Overheat	95.01%	Requires interpretation based on primary CF diagnosis

The sample results demonstrate that the system can produce diagnoses from different combinations of symptoms. In Case 1, the system identified keyboard damage with a certainty value of 92.00%, which corresponds to the reference diagnosis. Case 3 also produced a diagnosis corresponding to the reference diagnosis, with a certainty value of 72.96%. However, Cases 2, 4, and 5 demonstrate that the diagnostic process may produce multiple possible hardware damage categories when symptoms overlap. In Case 2, the Forward Chaining process generated four possible damage categories, including battery damage. Therefore, the evaluation criterion must be clearly defined to determine whether the appearance of the reference diagnosis among several FC results is considered a correct diagnosis or whether only the primary diagnosis is counted as correct. Case 4 represents an incorrect diagnostic result because the reference diagnosis was overheat, whereas the system identified battery damage. This result indicates that several symptoms associated with the case were also linked to the battery-damage rules in the knowledge base. Consequently, a high certainty value does not necessarily indicate that the diagnosis is correct.

4.1.3 Comparison of Forward Chaining and Certainty Factor

The evaluation results show different behaviors between Forward Chaining and Certainty Factor. Forward Chaining correctly identified 5 of the 20 test cases, while 4 cases produced results that did not correspond to the reference diagnosis and 11 cases did not produce a diagnosis under the implemented rule-matching mechanism. In contrast, the Certainty Factor process produced a diagnostic result for all 20 test cases. Of these cases, 15 corresponded to the reference diagnoses, while 5 did not. Based on the classification of correct and incorrect diagnoses, the diagnostic accuracy was calculated as follows:

$$\text{Accuracy} = \frac{N_{\text{correct}}}{N_{total}}\ x\ 100\ \% \tag{2}$$

Where N_{correct} represents the number of test cases in which the system diagnosis corresponds to the reference diagnosis and N_{total} represents the total number of test cases. For the Certainty Factor evaluation:

$$\text{Accuracy} = \frac{15}{20}\ x\ 100\ \% = 75\ \%$$

Therefore, the CF-based diagnostic results achieved an accuracy of 75%. For Forward Chaining:

$$\text{Accuracy} = \frac{5}{20}\ x\ 100\ \% = 25\ \%$$

Thus, based on the same evaluation criterion, Forward Chaining achieved an accuracy of 25%.

Table 2. Recapitulation of Diagnostic Evaluation

Evaluation Category	Forward Chaining	Certainty Factor
Correct diagnosis	5	15
Incorrect diagnosis	4	5
No diagnosis	11	0
Total test cases	20	20
Accuracy	25%	75%

The results indicate that the Certainty Factor approach produced a higher proportion of correct diagnoses than Forward Chaining in the evaluated test cases. The difference is particularly evident in cases where the available symptoms did not satisfy the rule conditions required by the Forward Chaining implementation. In such cases, Forward Chaining produced no diagnostic result, whereas the Certainty Factor calculation was still able to generate a certainty value for the available diagnostic hypotheses. However, the results should not be interpreted as evidence that Certainty Factor is universally superior to Forward Chaining. The comparison is specific to the knowledge base, symptoms, rules, test cases, and implementation used in this study. The 75% accuracy indicates that the CF-based approach performed better under the conditions of the present evaluation, but five cases still produced diagnoses that did not correspond to the reference diagnoses.

4.1.4 Certainty Factor Calculation

The Certainty Factor calculation process transforms user confidence and expert-assigned certainty values into a final diagnostic certainty value. For each selected symptom, the system calculates an individual CF value using the MB, MD, and user confidence values. When several symptoms support the same diagnostic hypothesis, the individual CF values are combined iteratively to obtain the final certainty value.

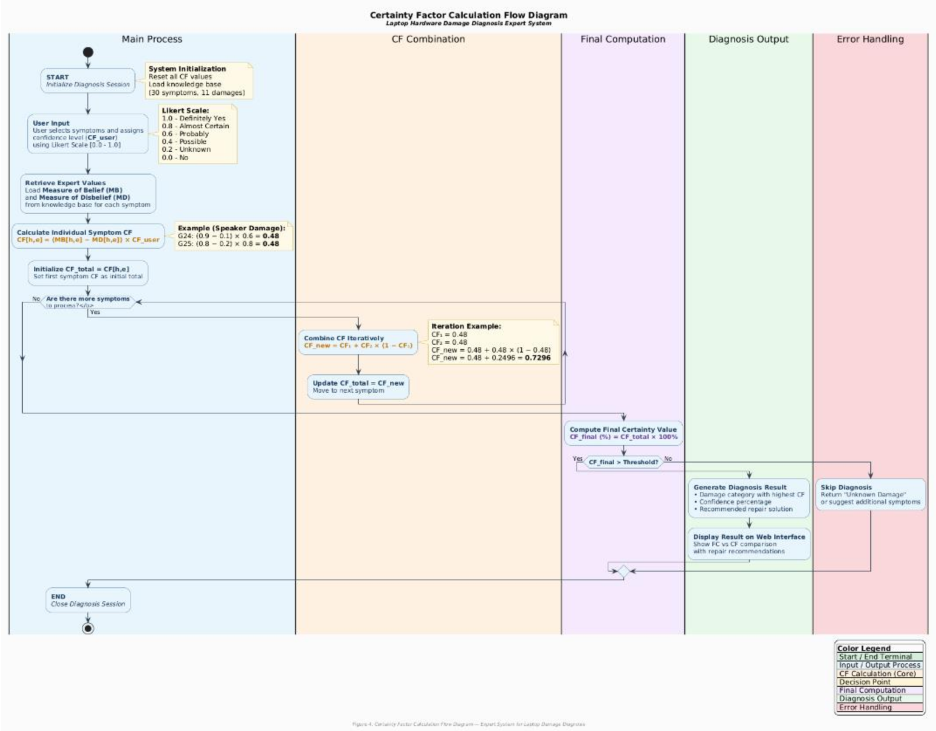

Figure 4. Certainty Factor Calculation Flow Diagram

Figure 4 illustrates the calculation process implemented in the system, beginning with symptom selection and user confidence input, followed by the calculation of individual CF values based on the expert-assigned MB and MD values. The resulting CF values are then combined for symptoms associated with the same diagnostic hypothesis until a final certainty value is obtained. The final value is used to determine the diagnostic result presented by the system. For example, in Case 3 (Speaker Damage), symptom G24 has an MB value of 0.9, an MD value of 0.1, and a user confidence value of 0.6. Therefore: $CF\ (G24) = (0.9 - 0.1)x\ 0.6 = 0.48$ For symptom G25, with MB = 0.8, MD = 0.2, and user confidence = 0.8: $CF\ (G25) = (0.8 - 0.2)x\ 0.8 = 0.48$ The two CF values are then combined: $CFcombine = 0.48 + 0.48(1 - 0.48)$ $CFcombine =\ 0.7296$ Thus, the final certainty value is 72.96%, which corresponds to the CF result reported for Case 3.

4.1.5 Error Analysis and System Limitations

The evaluation identified five incorrect diagnoses among the 20 test cases. These errors indicate that although Certainty Factor allows the system to generate diagnostic results when the available information is uncertain, the resulting diagnosis is not always consistent with the reference diagnosis. The errors can primarily be discussed in relation to symptom overlap, user confidence, and knowledge-base limitations. However, the study should not assign a numerical proportion to each error source unless the test data explicitly records and supports such classification.

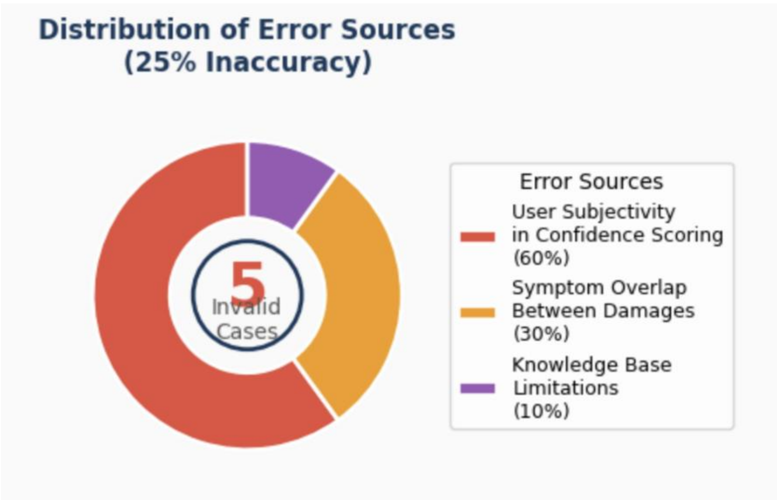

Figure 5. Error Distribution Analysis

Figure 5 presents the distribution of diagnostic outcomes obtained from the evaluation. The figure should be based directly on the actual test results and should distinguish between correct diagnoses and incorrect diagnoses. Based on the reported evaluation, 15 of the 20 test cases were correctly diagnosed using the Certainty Factor approach, while 5 cases produced diagnoses that differed from the reference diagnoses. If Figure 5 is specifically intended to show the FC versus CF performance, it is better presented as a comparison chart with the following values:

4.2 Discussion

The diagnostic evaluation demonstrated that the proposed expert system achieved an overall accuracy of 75% using the Certainty Factor approach, compared with 25% for the Forward Chaining approach. This result indicates that incorporating certainty values into the diagnostic process provides greater flexibility in processing user-reported symptoms than relying solely on rule matching. The finding is consistent with Laksana *et al.* (2024), who directly compared Certainty Factor and Forward Chaining for computer damage prediction and reported an average accuracy of 84.9% for Certainty Factor and 82.9% for Forward Chaining. Although the accuracy levels differ from those obtained in the present study, both studies demonstrate that certainty-based reasoning can be effectively applied to computer hardware diagnosis.

The result is also consistent with previous studies that have implemented Certainty Factor for laptop and computer hardware diagnosis. Widianto *et al.* (2025) implemented the Certainty Factor method in a laptop damage diagnosis expert system, while Simatupang and Pusparini (2025) developed a web-based notebook damage diagnosis system using Certainty Factor and evaluated its functionality through black-box testing. These studies support the applicability of Certainty Factor in hardware diagnostic systems, particularly when the diagnostic process involves symptom-based reasoning and different levels of confidence. The present study differs from these previous implementations in its evaluation design. Rather than relying only on functional or black-box testing, the proposed system was evaluated using 20 diagnostic cases and compared with reference diagnoses established by professional technicians. Therefore, the 75% value reported in this study represents the proportion of test cases in which the system diagnosis corresponded to the established reference diagnosis. This distinction is important because successful system functionality does not necessarily indicate diagnostic accuracy. The use of technician-based reference diagnoses provides a more direct assessment of whether the diagnostic conclusions generated by the system correspond to the actual diagnostic assessment.

The comparison between Forward Chaining and Certainty Factor further illustrates the effect of uncertainty handling in the proposed system. Forward Chaining correctly identified 5 of the 20 test cases, resulting in an accuracy of 25%, while 11 cases did not produce a diagnosis and 4 cases produced diagnoses that did not correspond to the reference diagnosis. In contrast, Certainty Factor correctly identified 15 cases, resulting in an accuracy of 75%, while 5 cases were incorrectly diagnosed and no cases were left without a diagnostic result. This difference indicates that the CF mechanism allowed the system to generate a diagnostic hypothesis even when the selected symptoms did not completely correspond to a predefined rule pattern.

This finding is particularly relevant to the characteristics of laptop hardware diagnosis. Several hardware problems can produce similar or overlapping symptoms. Consequently, a single symptom may not be sufficiently specific to identify a particular hardware component. The use of expert-assigned weights and user confidence values in Certainty Factor allows the system to distinguish between competing diagnostic hypotheses according to the accumulated strength of the available evidence. Simatupang and Pusparini (2025) similarly describe Certainty Factor as a method that combines expert weights with user values in the diagnosis of notebook damage. The findings also support the relevance of combining Forward Chaining and Certainty Factor rather than treating the two methods as completely independent diagnostic approaches. Forward Chaining provides the rule-based mechanism for processing the relationships between symptoms and possible hardware damage, whereas Certainty Factor provides a numerical representation of diagnostic confidence. A similar combination has been implemented by Anggara *et al.* (2025) in a web-based laptop damage diagnosis system using Forward Chaining and Certainty Factor. Their study confirms the feasibility of combining the two approaches to process laptop damage symptoms and generate a percentage representing the certainty of the diagnosis.

The 75% accuracy obtained in the present study also indicates that the hybrid approach does not completely eliminate diagnostic errors. Five of the 20 test cases produced diagnoses that differed from the reference diagnoses. These errors should not automatically be attributed solely to user subjectivity because the available evaluation data do not provide sufficient evidence to quantify the contribution of each individual error source. The discrepancies may instead be associated with several factors, including overlapping symptoms, incomplete representation of hardware conditions in the knowledge base, differences between user descriptions and technician observations, or limitations in the weighting of symptom-damage relationships. The results therefore suggest that the proposed system should be positioned as a preliminary diagnostic support tool rather than as a replacement for professional laptop technicians. The system can assist users in identifying possible hardware problems and provide an initial indication of diagnostic certainty, but the final determination of hardware damage should still be verified through physical inspection and professional testing. This interpretation is also consistent with the role of expert systems described in previous laptop and computer hardware diagnostic studies, where the system is intended to support the diagnostic process rather than completely replace expert assessment. Widianto *et al*. (2025), Simatupang and Pusparini (2025), and Anggara *et al*. (2025) all demonstrate the use of expert systems as tools for assisting hardware diagnosis. The findings demonstrate that the proposed FC-CF expert system provides a more effective diagnostic mechanism than standalone Forward Chaining within the tested dataset. Nevertheless, the difference between the 75% accuracy obtained in this study and the results reported by previous studies should be interpreted carefully because the datasets, hardware categories, symptom sets, testing procedures, and reference standards are not identical. Therefore, the present result should not be interpreted as universally superior to previous systems. Instead, it demonstrates that the proposed implementation was able to provide useful diagnostic results under the specific conditions and test cases employed in this study.

5. Conclusion and Recommendations

This study developed and evaluated a web-based expert system for diagnosing laptop hardware damage using a combination of the Forward Chaining (FC) and Certainty Factor (CF) methods. The system was developed using a knowledge base consisting of 30 symptoms and 11 categories of laptop hardware damage obtained from professional technician knowledge. Forward Chaining was used to process the symptom-based rules, while Certainty Factor was applied to represent the level of certainty associated with the diagnostic results. Based on the evaluation of 20 test cases, the Forward Chaining method correctly identified 5 cases, produced 4 incorrect diagnoses, and failed to produce a diagnosis in 11 cases, resulting in an accuracy of 25%. In comparison, the Certainty Factor method correctly identified 15 cases and produced 5 incorrect diagnoses, resulting in an accuracy of 75%. These results indicate that the Certainty Factor approach performed better than Forward Chaining in the tested cases, particularly when the symptoms provided did not completely satisfy the predefined rules. The results therefore demonstrate the usefulness of incorporating certainty values into the diagnostic process for laptop hardware damage.

The five incorrect diagnoses produced by the Certainty Factor method indicate that the system still has limitations in distinguishing between hardware damage categories with similar symptoms. In addition, the diagnostic results may be influenced by the accuracy of the symptoms selected and the confidence values provided by users. Therefore, the 75% accuracy obtained in this study should be interpreted as the performance of the system on the evaluated 20 test cases rather than as a definitive measure of performance for all possible laptop hardware failures. For future development, the knowledge base should be expanded by adding more symptoms, hardware damage categories, and diagnostic rules based on additional technician cases. The relationships between symptoms and hardware damage should also be reviewed to improve the differentiation of conditions with overlapping symptoms. Furthermore, the user interface can be improved by providing clearer descriptions or examples for each symptom and confidence level so that users can provide more accurate inputs. Additional testing with a larger and more diverse set of technician-verified cases is also recommended to obtain a more comprehensive evaluation of the system's diagnostic accuracy.

References

Alhilal, M., & Astuti, H. (2025). Expert system for laptop fault diagnosis using the Forward Chaining method. *Jurnal Inovasi Ilmu Komputer, 4*(1), 23–34.

Anggara, Y. A. R., Wibowo, S. A., & Pranoto, Y. A. R. (2025). Sistem pakar diagnosa kerusakan laptop berbasis Forward Chaining dan Certainty Factor. *IJAI (Indonesian Journal of Applied Informatics), 9*(2), 296–309. https://doi.org/10.20961/ijai.v9i2.95556

Burhanuddin, N. I., & Akhsa, A. T. P. D. (2021). Identifikasi kerusakan laptop dengan metode Certainty Factor berbasis Android. *Jurnal Teknologi Komputer, 1*, 53–60.

Guftamal, M. H., Astuti, I. F., & Islamiyah, I. (2022). Rancang bangun sistem pakar diagnosis kerusakan hardware komputer dengan metode Forward Chaining dan Certainty Factor berbasis desktop. *Jurnal Rekayasa Teknologi Informasi (JURTI), 6*(2), 188–195. https://doi.org/10.30872/jurti.v6i2.9455

Jaelani, A., & Akbar, R. (2025). Perancangan sistem pakar berbasis web untuk menentukan kerusakan komputer menggunakan metode Certainty Factor. *Journal of Computer Science and Information Technology, 1*(1), 26–31.

Kalyzta, J., & Syafrullah, M. (2023). Sistem pakar diagnosa kerusakan komputer dengan algoritma Certainty Factor pada Lab ICT Budi Luhur pada Universitas Budi Luhur. *Skanika, 6*(1), 12–21. https://doi.org/10.36080/skanika.v6i1.2996

Khatimah, K., & Andini, Y. (2026). Development of a Rule-Based Laptop Damage Diagnostic Expert System Using the Forward Chaining Method. *Digital Informatics*, *2*(1), 11-19.

Kurnia, M. A. R., & Haidir, A. (2024). Perancangan sistem pakar dalam mendiagnosa kerusakan pada laptop berbasis web menggunakan metode Certainty Factor. *Jurnal INSAN: Journal of Information System Management Innovation, 4*(2), 74–83. https://doi.org/10.31294/jinsan.v4i2.5233

Laksana, T. G., Iskandar, A. R., & Ahmad, W. N. W. (2024). Comparison of CPU damage prediction accuracy between Certainty Factor and Forward Chaining techniques. *Jurnal Pekommas, 9*(1), 109–120. https://doi.org/10.56873/jpkm.v9i1.5531

Marpaung, A. J., & Handoko, K. (2023). Sistem pakar untuk diagnosa kerusakan komputer menggunakan metode Forward Chaining dan Certainty Factor. *Jurnal Comasie, 6*.

Marsandi, A. F., Pratama, A. R., Kusumaningrum, D. S., & Rohana, T. (2024). Sistem pakar deteksi kerusakan laptop menggunakan algoritma Forward Chaining dan Backward Chaining. *KLIK: Kajian Ilmiah Informatika dan Komputer, 5*(1), 49–56. https://doi.org/10.30865/klik.v5i1.2041

Permadi, D., Handayani, D., Kustanto, P., Yasir, M., Noeman, A., & Hidayat, A. (2025). Implementasi Forward Chaining pada sistem pakar diagnosa kerusakan laptop berbasis web: Studi kasus layanan servis laptop. *Jurnal Information and Information Security, 6*(2), 115–128.

Pratama, H. S., Efendy, M. P., Roby, M., & Tusakdiyah, S. H. (2022). Sistem pakar deteksi kerusakan laptop atau komputer menggunakan metode Forward Chaining. *JEKIN: Jurnal Teknik Informatika, 2*(1). https://doi.org/10.58794/jekin.v2i1.100

Romadhoni, R. M., & Zayn, A. R. (2023). Sistem pakar untuk mendiagnosa kerusakan hardware laptop menggunakan metode Certainty Factor. *Multidisciplinary Applications of Quantum Information Science (Al-Mantiq), 3*(2). https://doi.org/10.32665/almantiq.v2i2.2004

Saputra, O., Fitri, I., & Handayani, E. T. E. (2022). Sistem pakar diagnosa kerusakan hardware komputer menggunakan metode Forward Chaining dan Certainty Factor berbasis website. *Jurnal JTIK (Jurnal Teknologi Informasi dan Komunikasi), 6*(2), 0–8.

Simatupang, R. B. J., & Pusparini, N. N. (2025). Sistem pakar diagnosa kerusakan notebook berbasis web menggunakan metode Certainty Factor dengan pengujian black-box. *Jurnal Riset Sistem Informasi dan Teknik Informatika, 3*, 247–266.

Tarigan, M. H. F., & Martiano, M. (2026). An expert system for diagnosing laptop hardware failures using a web-based Certainty Factor method. *Jurnal ICT: Information and Communication Technologies, 17*(1), 32–40. https://doi.org/10.35335/jict.v17i1.321

Widianto, S. C., Widada, B., Sandradewi, K., & Remawati, D. (2025). Implementasi metode Certainty Factor dalam sistem pakar untuk diagnosa kerusakan laptop. *Jurnal Teknologi Informasi dan Komunikasi (TIKomSiN), 13*(1), 40–49. https://doi.org/10.30646/tikomsin.v13i1.931