Research Article

Implementation of a Forward Chaining Expert System in Diagnosing Laptop Damage

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Abstract: Laptops have become a primary need for almost everyone, but the damage rate is also high. Manual diagnosis of laptop damage requires special expertise and is prone to errors that can exacerbate damage. The purpose of this study was to develop an expert system based on the forward chaining method to diagnose laptop damage. Data obtained through expert interviews, literature study, and the internet comprised 13 symptoms and five main types of laptop damage. Relate data in tables to form IF-THEN rules of the forward chaining method. The test results on six symptoms indicate that the system can diagnose IC Power damage with 100% accuracy, which is the highest diagnosis. In conclusion, the forward chaining method can diagnose laptop damage based on emerging symptoms.

Keywords: diagnose laptop damage; forward chainning; accuracy; expert system; indicate

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1. Introduction

Laptops have become very important electronic devices in today's modern life. Almost all groups, from students to professionals and business people, use laptops as a daily productivity tool. Along with the high intensity of use, damage to laptops becomes a very common problem. Laptops have now become a primary necessity for almost everyone to support activities and productivity. However, the rate of laptop damage is also very high. According to a survey, as many as 63% of laptop users have experienced damage in the last year. The most common damage is to the keyboard (20%), motherboard (15%), hard disk (14%), screen (13%), and others (38%).

Laptop damage can be caused by various factors, such as viruses, hardware and software bugs, and even human error. In general, repairing a damaged laptop is quite expensive at the service center and takes a long time. Apart from that, users are also often confused when they have to diagnose the type of damage their laptop is experiencing themselves. The correct diagnosis will speed up the repair process so that the laptop can be used again quickly. Manually diagnosing laptop damage requires special experience and expertise. Users are faced with many possible types of damage from existing symptoms and must determine which diagnosis is most appropriate. Misdiagnosis risks worsening the damage and increasing repair costs. Therefore, careful initial diagnosis of laptop damage is very important. With accurate diagnosis, damage can be quickly identified so repairs can be carried out efficiently. The Forward Chaining method [11-20] is a method used in technical research that begins with information being combined to become knowledge and will end as a conclusion (Imannuddin et al., 2021; Ramadhani et al., 2020) [1][2]. Forward tracing or forward tracing method, where the data-driven approach is used. This tracking method starts by entering information and then tries to explain the results.

Damage to a laptop requires a long time to find the cause, so an expert system is needed that can find the damage and resolve it. The forward chaining method was used in this research. An example of previous research using forward chaining is Aprilia Santika et al. with the title "Expert System for Diagnosing Mobile Phone Damage Using the Forward Chaining Method". The results of testing this research system show that it has good functionality, so it obtains an accuracy value of 88%. This means that the system created can be used to detect damage to cell phones. In another study conducted by Anto et al., "Diagnosis of Damage to Heavy Equipment Using the Forward Chaining Method," the accuracy of applying the forward chaining method was 88.89%. Of the 45 rules tested, five did not match the expert's opinion.

Furthermore, to overcome this problem, the forward chaining expert system is present as an intelligent and computerized solution for diagnosing laptop damage. With a knowledge base taken from laptop technician experts, this expert system can analyze damage symptoms and provide accurate diagnoses along with repair solutions. An Expert System (Expert System) is a technology that can carry out in-depth analysis of a problem to find solutions and solutions to produce information and solve a problem (Zhang et al., 2021) [3]. An expert system is a smart system that can imitate human reasoning used by experts in solving specific problems with the help of a computer to transfer this expertise into a computer program. (Nugroho et al., 2021)[4]).

The application of expert system science is a practical implementation of artificial intelligence aimed at a computer program designed to solve problems carried out by an expert [Baresi., 2024) [5] in decision-making, problem-solving, providing advice, and training in certain domains by imitate the cognitive processes carried out by human experts. The process of designing a good expert system is that the application being designed must be able to solve various problems by imitating the work and thinking of experts or experts. With the existence of an expert system, the community can solve real problems without having to get help from experts directly (Kurniawan., et al., 2019) [6].

Therefore, in general, an expert system is a system that tries to adopt human knowledge to a computer so that the computer can solve problems as experts (experts) usually do. An expert system is designed to be able to solve a particular problem by imitating the work of experts. Research in this Expert System Application uses the Forward Chaining method, which is a search technique that starts with known facts and then matches the facts so that when the rules are found, the decision-making machine can form conclusions or consequences (Hermawanto & Dyah Anggita., 2022)[7], The inference model used in creating this expert system is forward reasoning (Forward Chaining) while the search technique uses depth-first search. Determination in diagnosing an expert system is carried out through a consultation process between the system and the user (Ilyas, et al., 2022)[8]; the ability of a computer to store data or information well and can be utilized without having to depend on the shortcomings of humans. Such as hunger, thirst, and emotions that can be felt similarly by humans. Expert systems are one of the original branches of artificial intelligence that combines experience and inference engines for knowledge (Anto., et al., 2022) [9].

2. Method

The research methodology is shown in a Research Framework as shown in Figure 1. To simplify the process of understanding research, the stages of research are explained from the initial steps of research to the processing results and research conclusion data [10]. The Research Framework makes it easier to research because it will become the basis for research, which can be seen from the following structure in Figure 1.

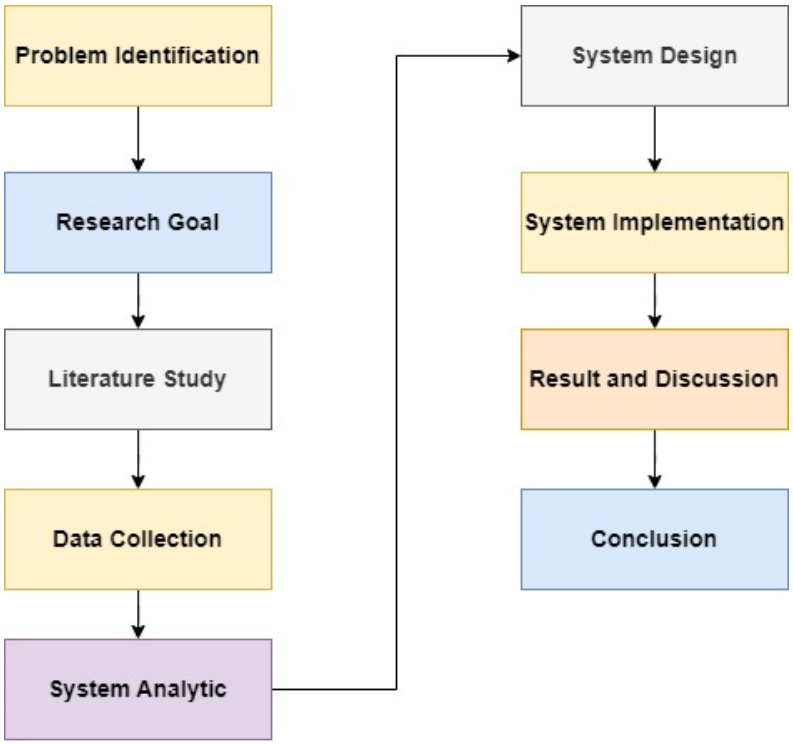

Figure 1. Research Framework

2.1 Problem Identification and Analysis

In the context of this research, the problems identified may include users' high curiosity about repairing laptops/PCs independently and their lack of knowledge about damage problems, which slows down the repair process.

from this analysis, several problems are usually found when diagnosing computer damage. Based on research, the following analysis of problems can be identified. The diagnosis of laptop damage has not been optimal. The diagnosis of laptop damage that has been carried out so far may still be inaccurate or take a long time. This causes the laptop repair process to become less efficient. Lack of ability to diagnose laptop damage. The ability and knowledge regarding types of laptop damage and how to diagnose them are still limited by laypeople and laptop technicians. Inefficiency of the laptop repair process. The process of identifying and repairing damage to laptops is currently considered to be inefficient in terms of time and cost. An intelligent system is needed to diagnose laptop damage. There is a need for an expert system or artificial intelligence that can diagnose laptop damage and provide repair solutions accurately and efficiently.

2.2 Research Goals

Based on problem identification and analysis, researchers set research objectives. Research objectives may include developing a forward chaining-based expert system to increase efficiency in diagnosing and repairing laptop defects. Research objectives need to be formulated clearly to provide a specific direction to the research.

2.3 Literature Review

Researchers conducted a literature review to understand the conceptual framework, theory, and current findings related to forward chaining methods, expert systems, and laptop damage diagnostics. Literature reviews help researchers build a knowledge base and ensure that their research is innovative and relevant.

Moreover, the questions and answers directly to the laptop technician regarding matters related to research with experts who have shops for servicing laptops and cellphones. Do this by first reading books and research journals or other references related to laptop damage and taking data on laptop damage from the internet.

2.4 Diagnosing using the Forward Chaining method

In this step, researchers apply the forward chaining method to diagnose laptop damage. Forward chaining is an approach in expert systems where the system takes existing information and uses rules to conclude or diagnose a condition. This helps identify defects and provide solutions efficiently.

Forward chaining is a forward search technique that begins by collecting facts or symptoms and then matching them with premises in a knowledge base in the form of IF-THEN production rules. If a suitable rule is found, then a conclusion can be drawn from the laptop damage diagnosis. Forward Chaining Formula;

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IF {symptom} THEN {damage}
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Weight Accuration equals a Weight calculation using knowledge of probability opportunities. Probability is used to determine the probability calculated from the presentation of the number of experiences of an event. InformationP(A) events n(A)value A, n total value n.

$$P(A) = \frac{Number\ of\ Selected\ Symptoms}{Total\ Number\ of\ Symptoms}\ x\ 100\% \quad (1)$$

After studying the method used, system design is carried out to create an expert system application. In this case, the system will be designed based on user usage needs. After the application is complete, system implementation is carried out at the location specified by the Author. It is also ensured that the application implemented must run following the system design. The calculation results will be used to create a laptop damage diagnosis model. These results will be used to detect laptop damage and offer solutions to solve it. The conclusions are the results of research conducted and obtained following the research objectives and suggestions for improving the research.

2.5 Determination and Weight of Symptoms

The following are the results of collecting symptom data obtained from interviews with experts and also obtained on the internet to identify the extent of damage experienced by laptops/computers from the symptoms used as indicators. Determination of symptoms can be seen in Table 1.

Table 1. Symptoms Code

Symptoms Code	Symptoms
G001	Laptop Screen is off
G002	Machine off
G003	The light inductor connected to the laptop charger: Off
G004	The laptop turns off when plugged into the charger
G005	Machine on
G006	The light on the laptop is dimly lit, but it still displays an image
G007	The screen sometimes turns on and off while displaying the image
G008	There are lines on the laptop's LCD
G009	There are dot pixels on the laptop
G010	There are scratches/unable to display some images from the LCD
G011	Some/all keyboard buttons don't work

Symptoms Code	Symptoms
G012	There is a long and continuous beep sound on the laptop when it is turned on.
G013	The light on the laptop is dimly lit, but it still displays an image

The following are several categories of damage to laptops/computers, namely damage to the power IC, VGA IC, flexible cable inverter, LC, and damaged keyboard, as shown in Table 2.

Table 2. Damage Data

Damage Code	Problems
K001	IC Power
K002	IC VGA
K003	Interference with Flexible Cables
K004	LCD
K005	keyboard

The relationship table is a way to match/connect the symptom table with the damage table, which is a condition matrix that has been considered in predicting laptop damage using the symptom data results. Table 3 illustrates the relationship obtained by matching the symptom table with the damage table.

Table 3. Relation Tables

No	Code	Problems				
		K001	K002	K003	K004	K005
1.	G001	1	0.5	1	0.33	0
2.	G002	0.5	0	0	0	0
3.	G003	1	0.5	0	0	0
…	…..	…..	…..	…..	…..	…..
63.	G011	0	0	0	0.33	0
64.	G012	0	0	0	0	0.5
65.	G013	0	0.5	0	0	1

2.6 Forward Chaining Rules

After the data has been processed, rules will be created that refer to the symptoms in each damaged data. Production rules are written in IF-THEN form. The following rules for the forward chaining method are related in Table 3.

Table 4. Rules Forward Chaining

Kode	IF	THEN
R1	IF G001 AND G002 AND G003 AND G004	K001
R2	IF G001 AND G003 AND G005 AND G006 AND G007 AND G013	K002
R3	IF G001 AND G005 AND G007 AND G008	K003
R4	IF G001 AND G005 AND G008 AND G009 AND G010 AND G011	K003
R5	IF G005 AND G012 AND G013	K003

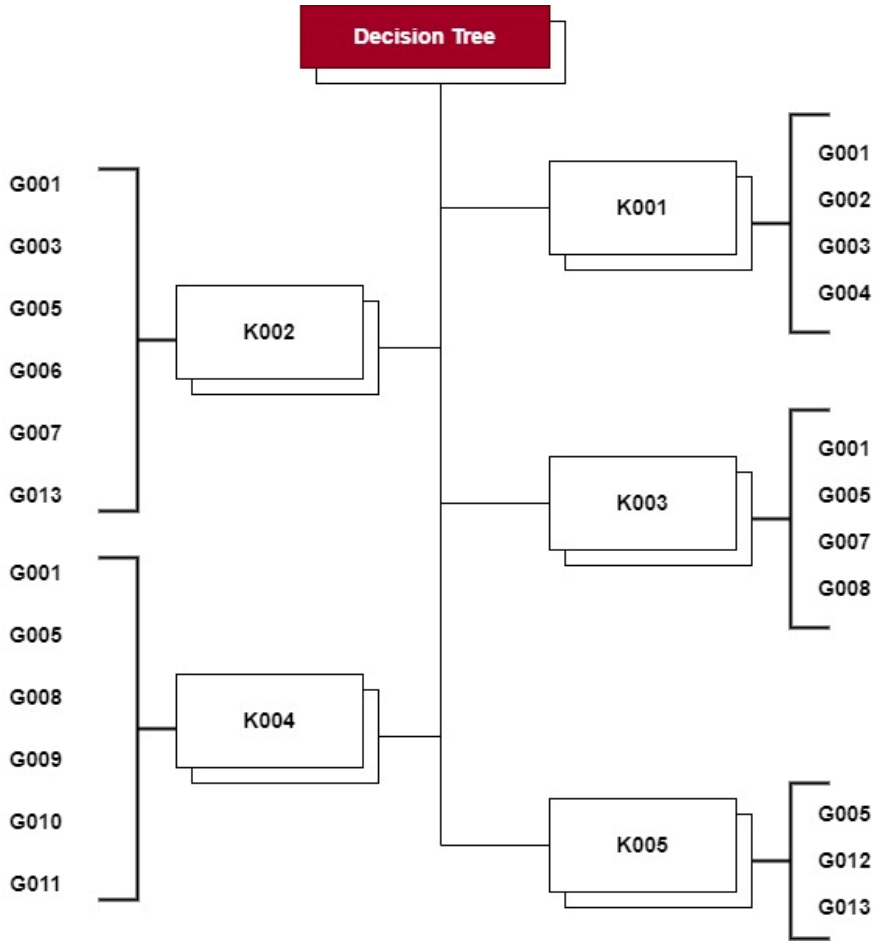

Figure 2. Decision Tree

2.7 System Design

System Design shows the relationship between external elements, inputs, and outputs of a system, context diagrams use circles that represent the system as a whole. There is always one process in the context of the diagram, assigned process number 0, that serves as the process for the system as a whole. Each actor has a data flow diagram, which only contains the process and shows the system as a whole, as explained in diagram 1. This diagram describes the scope of the system to be developed. There are two flows for each actor: the flow from the user to the system shows activity on the system, and the flow from the user to the system shows feedback from the actor's activity.

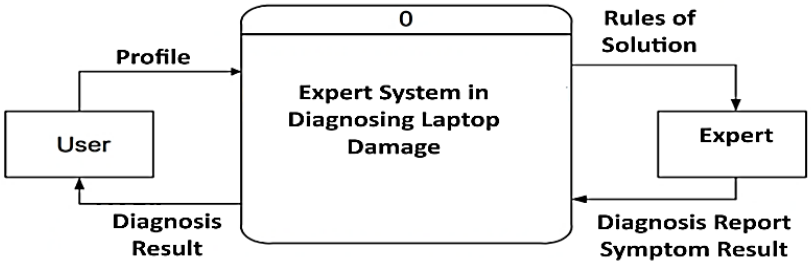

Figure 3. Context Diagram

The following is an explanation of the Context Diagram:

1. The expert system application can be accessed offline by users.
2. After logging in, users can note symptoms of laptop or PC damage.
3. Users can identify the type of damage to their laptop or PC based on the symptom data they enter.
4. Through the use of an expert system, experts identify symptoms, types of damage, and solutions.
5. For every visitor to the expert system application, the damage experienced by the user can be tracked by experts.

3. Result and Analyzes

3.1 the test and symptom data

The results of the test and symptom data that will be processed weigh the accuracy of diagnosing laptop damage.

Rule:
R1 = IF G001 AND G002 AND G003 AND G004 THEN K001
R2 = IF G001 AND G003 AND G005 AND G006 AND G007 AND G013 THEN K002
R3 = IF G001 AND G005 AND G007 AND G008 THEN KOO3
R4 = IF G001 AND G005 AND G008 AND G009 AND G010 AND G011 THEN K004
R5 = IF G005 AND G012 AND G013 THEN K005
Detected symptoms: G001,G002,G003, G004 = 4

Moreover, the formula accuracy weight, is shown as in equation 1, the rule that has detected symptoms

R1=IF ***G001*** *AND* ***G002*** *AND* ***G003*** *AND* ***G004*** *THEN K001*

$$P(A) = \frac{4}{4} \text{ x } 100 = 100\%$$

R2= IF ***G001*** *AND* ***G003*** *AND G005 AND G006 AND G007 AND G013 THEN K002*

$$P(A) = \frac{2}{4} \text{ x } 100\% = 50\%$$

R3= IF ***G001*** *AND G005 AND G007 AND G008 THEN KOO3*

$$P(A) = \frac{1}{4} \text{ x } 100\% = 25\%$$

R4= IF ***G001*** *AND G005 AND G008 AND G009 AND G010 AND G011 THEN K004*

$$P(A) = \frac{1}{4} \text{ x } 100\% = 25\%$$

R5= IF G005 AND G012 AND G013 THEN K005

$$P(A) = \frac{0}{4} \text{ x } 100\% = 0\%$$

From the calculations, it is possible to diagnose laptop damage as follows:
Damage to Damaged IC Power (K001) of 100.%
Damage to VGA IC (K002) by 50%
Damage to the Interver/Interference in Flexible Cable (K003) by 25%

Damage to LCD (K004) by 25%

Damage to the keyboard (K005) is 0%

Therefore, the biggest possibility of diagnosing laptop damage is hardware damage (K001), which has an accuracy weight of 100.00%. The diagnostic conclusion obtained is based on the results of the highest weight value for each diagnosis of possible damage that has occurred.

3.2 System Implementation

a. Login Admin

Figure 3 shows the administrator login form, which administrators use to enter the main application page.

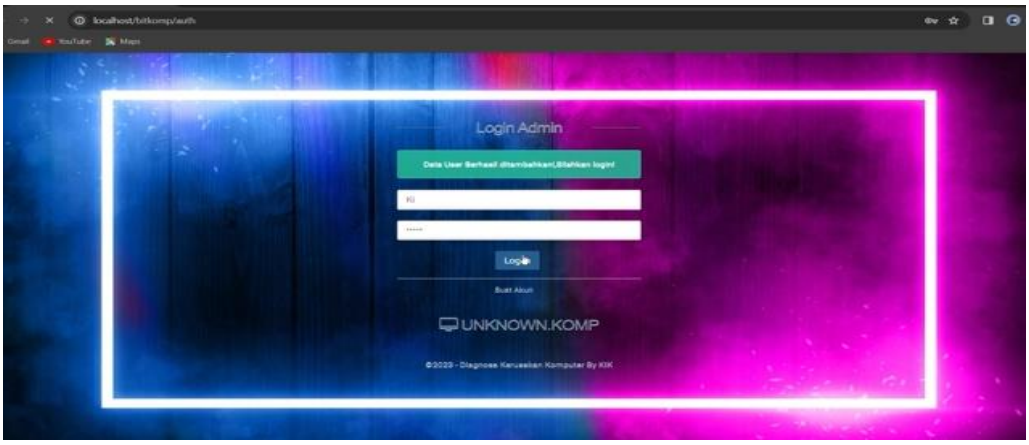

Figure 3. Page of Login Admin

b. Dashboard of Admin

The administration page is the page where all data can be seen by the admin, as shown in the following Figure 4.

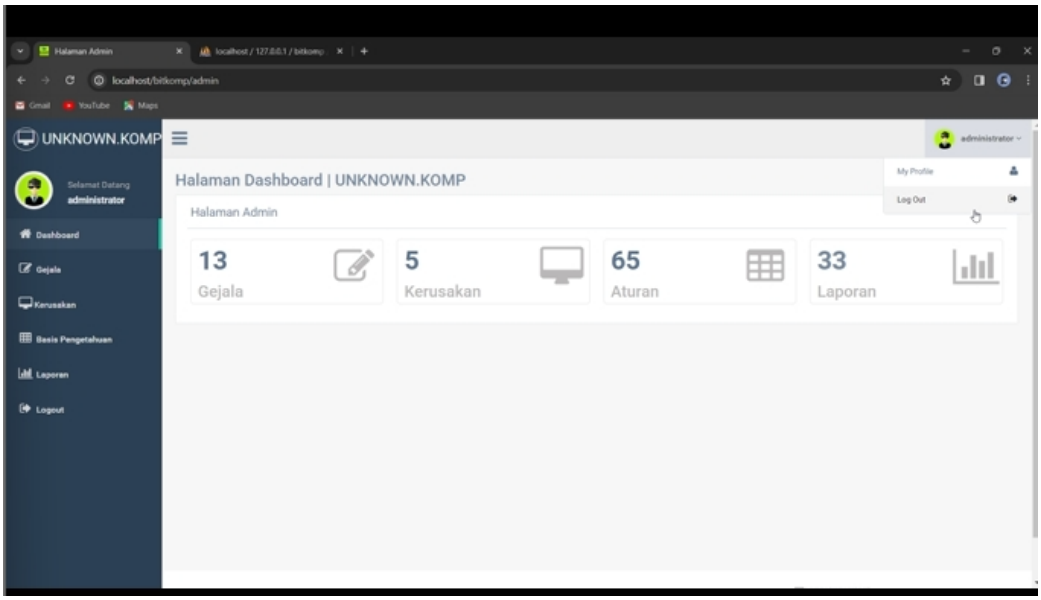

Figure 4. Page of Dashboard

c. Symptom Page

Moreover, to enter symptom data, this form is located in the symptoms menu and has a symptom entry submenu. How to use it is as follows in Figure 5.

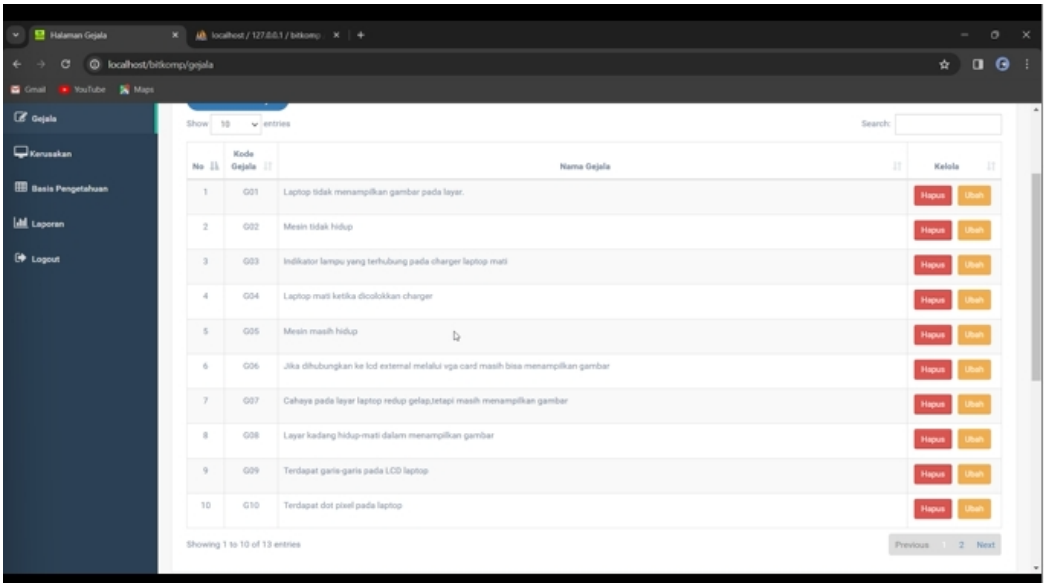

Figure 5. Symptom Page

d. Damage Page

This page functions to display damage data. Administrators can add new crash data, delete crash data, and change crash data on this page, as shown in Figure 6.

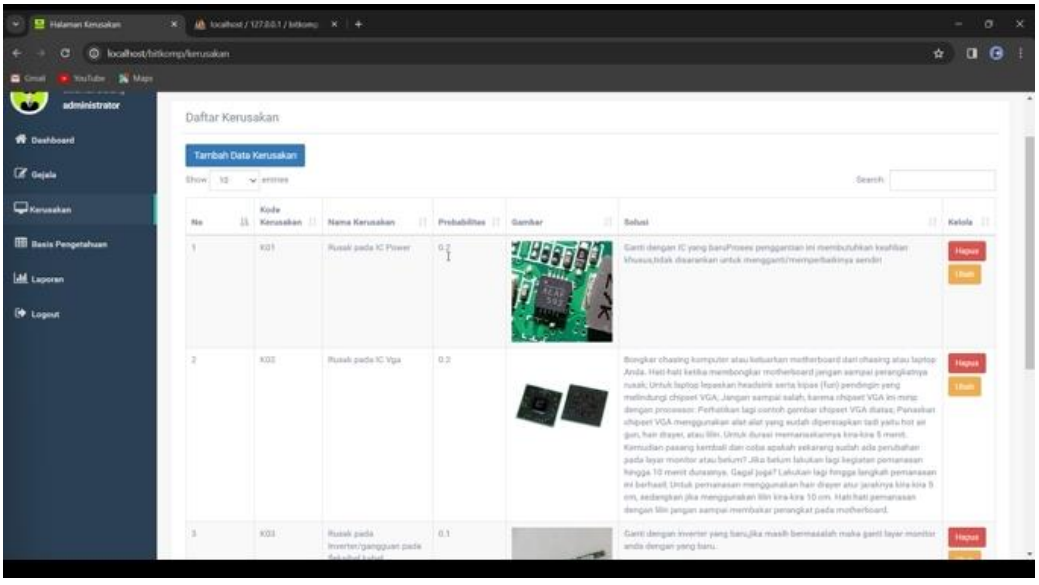

Figure 6. Damages Page

e. Knowledge Relation Page *(rule)*

This page functions to display rule data. Administrators can add, delete, and change rule data on the rule page, as shown in Figure 7.

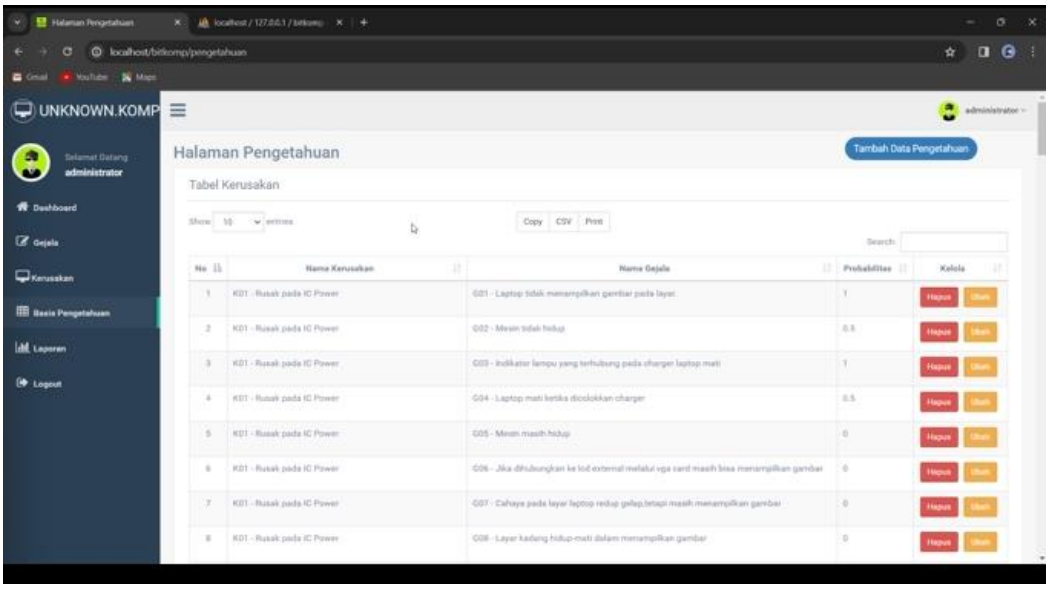

Figure 7. Page Knowledge Relation

f. Report Page

It contains a collection of diagnostic information from several users to identify damage to the laptop, which is stored in the database and displays the report page in Figure 8.

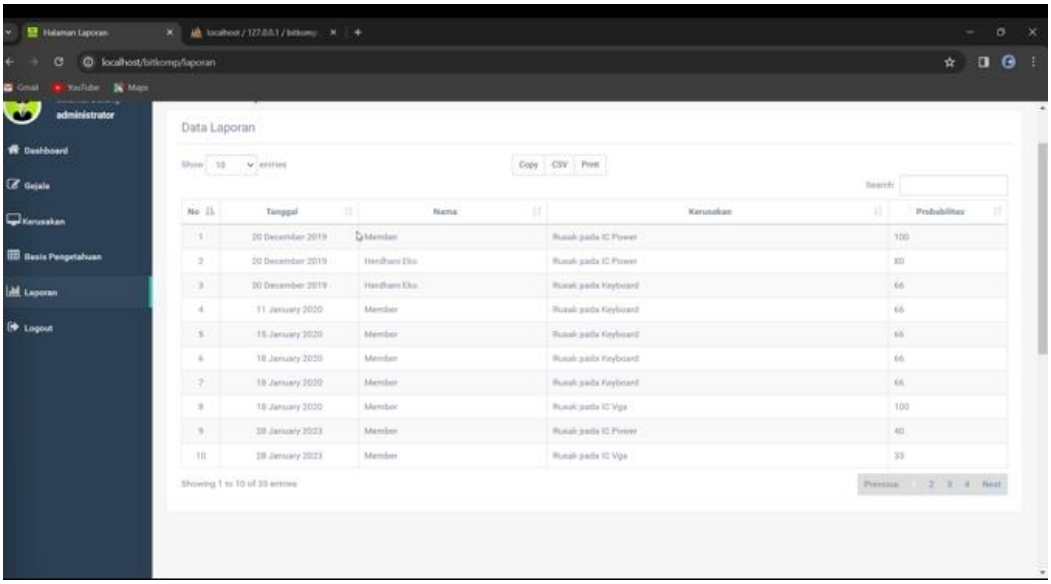

Figure 8. Report Page

g. Login User Page

This research expert system is web-based. Users must log in first to start the diagnostic process. Users can select the login menu if they do not have a username and password. Figure 8 shows the initial appearance of the web expert system for diagnosing laptop damage.

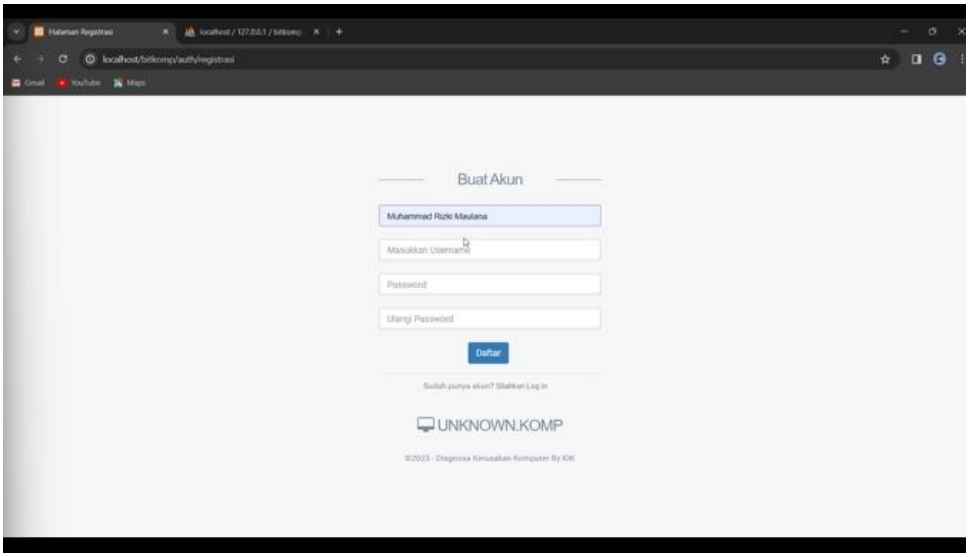

Figure 9. Page Login User

h. Main Dashboard Page

The main page, also known as the initial display, is the first page that novice technicians see when they access a web page, as shown in Figure 10.

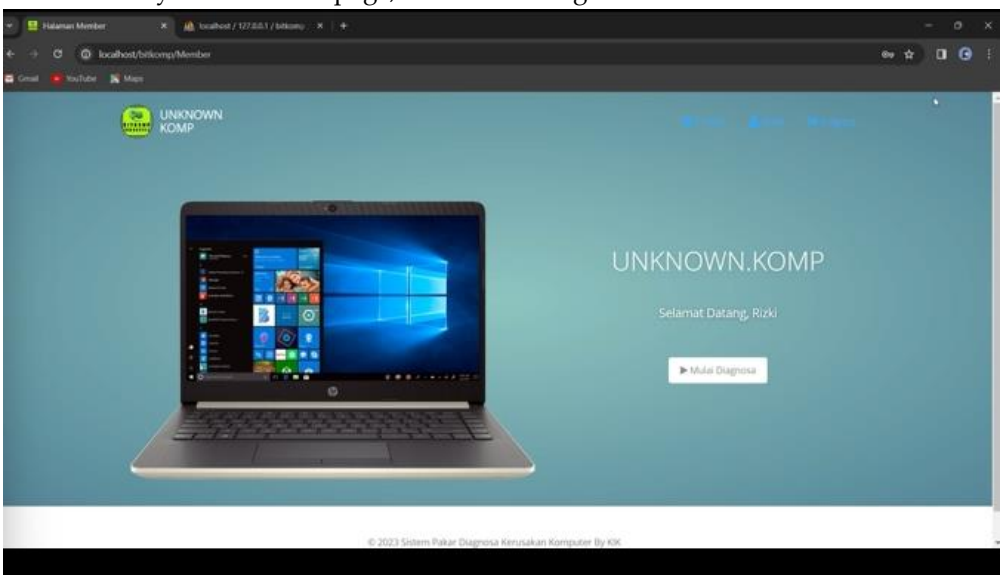

Figure 10. Page Dashboard User

i. User Symptom Data Input Display

This page displays cellphone symptom data. Where diagnosis begins by selecting a symptom, the test symptoms are selected from the first to the fourth. Figure 11 shows the page display for selecting laptop damage symptoms.

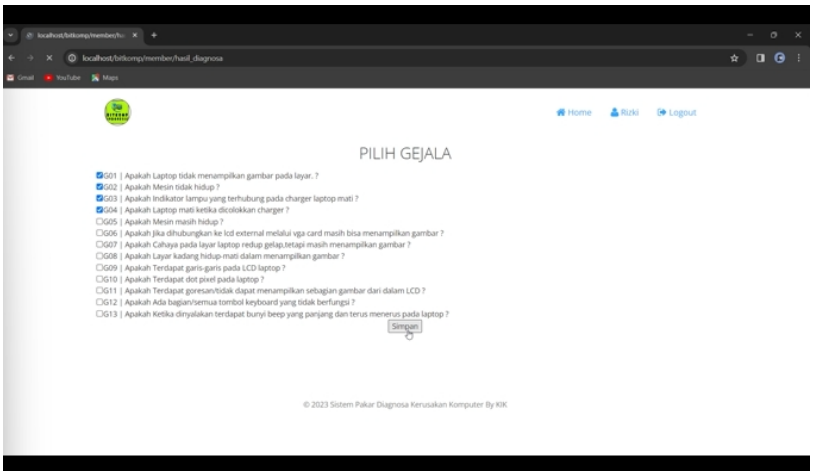

Figure 11. input condition of the device

j. User Diagnosis Results and Solutions

Figure 12 shows the display of the cellphone damage diagnosis results page. After the symptom selection process is complete, the system will display the diagnosis results and solutions. As seen in the picture, the result of the diagnosis of the selected symptom is damage to the Power IC with a damage code, namely K001. The results obtained are 100% worth. The expected results correspond to calculations carried out manually with 99% accuracy.

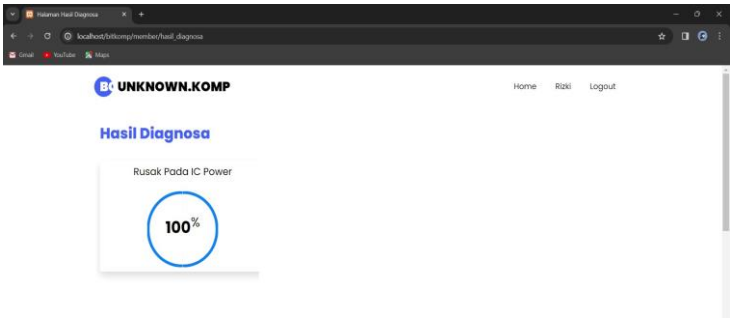

Figure 12. Page of User Diagnosis and Solution

5. Conclusion

Laptop damage is a very common problem, with a damage rate of 63% within one year. The damage that most often occurs is to the keyboard, IC Power, LCD, and others. Manually diagnosing laptop damage requires special skills. Misdiagnosis can worsen the damage and increase repair costs. Therefore, an intelligent system is needed to diagnose damage accurately and efficiently. This research develops an expert system for diagnosing laptop damage using the forward chaining method. The system is designed to imitate the work of experts in diagnosing damage based on the symptoms that appear. Data was obtained through expert interviews, literature studies, and the Internet. The data consists of 13 symptoms data and five main types of damage to laptops. The data is then related in tables to form diagnostic rules. Diagnosis rules are made in the form of IF-THEN with the forward chaining method. The system will match existing symptoms with rules to conclude the most likely damage diagnosis along with its accuracy percentage. The test results show that the forward chaining method can diagnose laptop damage, namely damage to the Power IC, namely 100% damage to the laptop

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Conflicts of Interest: The authors declare no conflict of interest.

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