Expert System Implementation of the Certainty Factor Method for Smartphone Damage Diagnosis

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Android smartphone is currently one of the most extensively utilized operating systems. Nevertheless, Android devices are susceptible to issues such as Ic Emmc, Ic Power, software malfunctions, Blank Screen, Hang, complete device malfunction, and boot loop. Prompt intervention is crucial when a smartphone experiences a problem to prevent more harm and safeguard the user. The Certainty Factor (CF) accounts for the inherent uncertainty in an expert's analysis. Expressions such as "uncertain," "highly probable," "likely," "very likely," "almost certain," and "certain" are frequently employed in this context. This study employed a manual questionnaire to assess the efficacy of the expert system in identifying malfunctions in Android devices. All five technicians and all five user respondents expressed significant agreement about the reliability of the expert system in the questionnaire, and the black box test yielded a perfect 100% success rate. Through accuracy testing, using 10 samples of expert analysis data and 10 samples of system data, it was determined that the expert system achieved an 80% accuracy rate in generating diagnostic conclusions based on the tested data.

Keywords: Android, Malfunction, Expert system, Reliability, Accuracy

1. INTRODUCTION

In light of the swift advancements in smartphone technology, there has been a growing imperative for effective diagnostic systems that can detect and resolve hardware and software malfunctions. As a subfield of artificial intelligence, expert systems provide a potentially effective resolution by harnessing the expertise of human specialists in order to mechanize the diagnostic procedure. As a probabilistic approach to reasoning, the Certainty Factor Method (CFM) offers a structured framework for addressing uncertainty in Android smartphone diagnosis, where a multitude of factors may interact to give rise to a solitary problem. Android OS 11, introduced on September 8, 2020, represents the most recent iteration of the Android operating system. Additionally, damage to Android smartphones is inseparable from the operating system, including power, software, LCD blank, hang, complete death, and boot loop. Prompt intervention is imperative in the event of smartphone damage to prevent the escalation of critical injuries that could endanger the user [1][2]. Users typically bring their phones to the service center to have the damage repaired. The duration of service center maintenance may cause users to experience a loss of time. Additionally, the risk of fraud and the cost of repair are factors to consider when bringing a phone to a service station. A computer program containing the knowledge of one or more human experts in a specific field is an expert system. Researchers in artificial intelligence initially created these applications during the 1960s and 1970s; commercial implementation commenced in the 1980s.

In its most general form, an expert system is a user-supplied program that analyses information about a particular issue by predetermined rules. Furthermore, a mathematical analysis of the problem is also executed by the expert system [3][4]. The authors of this investigation employed the Certainty Factor application. 1975 saw the proposal of this method by Shortliffe and Buchanan as a means of dealing with the uncertainty of expert thought or imprecise reasoning. When conveying information analysis, experts frequently use phrases like "probably," "most likely," and "almost certainly." The Certainty Factor is a metric utilized to quantify the degree of assurance an expert possesses regarding hardware and software malfunctions affecting Android smartphones. One benefit of employing this application is its compatibility with expert systems that incorporate elements of uncertainty. This procedure processes only data in a single calculation operation, thereby preserving the data's precision[5]. Drawing from the aforementioned synopsis, the objective of this study is to create an application that employs the Certainty Factor technique to diagnose harm to smartphones. The primary objective of this application is to furnish users with a confidence value about the nature of damage sustained by an Android smartphone. It intends to facilitate users in identifying the origin of potential complications that may arise on their device. Utilization of an Expert System and the Certainty Factor Method to diagnose hardware damage on devices. The interface of the system is straightforward, facilitating user operation of the expert system utilized for laptop hardware troubleshooting. The overall Certainty Factor (CF) value is calculated by summing the CF values of each rule in the diagnostic procedure and the degree of correspondence between symptom identification and

damage identification. Furthermore, in order to derive diagnostic outcomes from the symptoms provided, the minimum CF value, which signifies the potential for injury, is pursued [6][7][8].

Yash Madhwal examines the utilization of Expert Systems in the context of the forward chaining method mobile damage diagnosis[9]. Following the conclusion of the discussion and investigation that was conducted, the following can be stated: By utilizing the forward chaining method, an expert system application was developed to diagnose smartphone damage. This application's purpose was to identify the most significant risk of smartphone damage and offer appropriate management solutions by the Indicators of damage reported by smartphone owners. By utilizing forward chaining, this system enables smartphone proprietors to readily identify potential damage, ranging from minor to severe. This system makes it simple for non-technical users to determine the type of damage that a damaged smartphone may sustain. This smartphone damage expert system, utilizing the forward chaining method, can readily incorporate or modify data about smartphone damage in light of newly acquired information. By utilizing the Certainty Factor (CF) value provided by both users and experts, the developed system is capable of identifying damage to smartphones. This value is utilized to calculate the weighted average of smartphone damage [10][11][12].

The objective of this study is to furnish data about hardware and software degradation that may occur on a range of Android smartphone models. This investigation makes use of the Certainty Factor and Forward Chaining techniques. The findings of this study not only furnish users with knowledge regarding the potential forms of damage that may transpire but also instruct them on how to repair their damaged smartphones. It is anticipated that the information presented will enable users to identify damage to the smartphone before bringing it to the service location.

2. METHOD

In order to generate solutions, this expert system necessitates the classification of the damage. The varieties of damage that can occur to Android smartphones are detailed in Table 1, accompanied by explanations and potential solutions for each type of damage.

Table 1. Varieties of Crashes on Android Smartphones

No.	Code	Damage	Description	Solution
1	K1	*Hardware* IC Emmc	a. A state in which the smartphone ceases all functionality and does not receive any input.	Replace Emmc IC
2	K2	Hardware *IC Power*	a. A state in which the smartphone's engine is extremely hot and it is entirely dead. b. The circumstance in which the smartphone's motor rapidly overheats after it is powered on. c. One such condition is a sluggish smartphone.	Replace IC Power
3	K3	*Software*	A scenario in which the smartphone experiences sluggish performance, bootsloops, logo entrapment, and malfunctioning of the operating system.	Flashing / Re-software
4	K4	LCD	A circumstance in which the smartphone displays sound but no image.	Replace LCD
5	K5	Battery	A state in which the smartphone fails to power on, rapidly becomes unusable, and fails to charge when charged.	Replace Battery
6	K6	Charger Connector	The smartphone is incapable of charging or is unable to charge when the USB cable is connected.	Replace the Charger Socket
7	K7	IMEI	Smartphone Imei damage includes the absence of service and network visibility, despite the card being legible.	Enter or modify a new Imei
8	K8	SPEAKER	A mobile device in which the sound is muffled or the volume is reduced when the speaker sustains damage while the device is calling, listening to MP3, or viewing videos.	Replace Speaker
9	K9	CAMERA	A camera malfunction transpires when the camera application becomes inaccessible on an Android smartphone; consequently, the camera becomes non-operational and ultimately malfunctions.	Replace Camera
10	K10	SORT	A shorting incident, also known as SORT, transpires when the circuitry of a smartphone is compromised, leading to an	Assess the SORT Line by means of a multimeter.

	abrupt and complete shutdown followed by a restart.

In Table 1, the damage code is given with the symbol K, each damage has a description and solution for how to overcome the damage to the android smartphone.
Each damage to an Android smartphone has specific symptoms. Table 2 presents various types of Indicators of damage to Android smartphones that have been identified by experts.

Table 2. Indicators of Damage

No.	Code	Indicators of Damage
1	G1	An abrupt termination
2	G2	Fall
3	G3	Unable to launch the application
4	G4	Touch display failure to respond
5	G5	The network is not visible.
6	G6	Sim device not functioning
7	G7	Black Screen
8	G8	Cannot be chargeable
9	G9	Efficiently heat
10	G10	Impact
11	G11	Failure to charge while connected to a charger
12	G12	Absence of network service
13	G13	No speaker noise is audible.
14	G14	Miniature speaker noise
15	G15	Failed camera registration
16	G16	Camera application malfunctioning
17	G17	Self-restarts

The indicators of damage to Android smartphones are detailed in Table 2, where each sign is represented by the letter G.

As stated in [13], the utilization of Decision Trees employing the Certainty Factor application roach has gained significant traction in the realm of Android smartphone damage diagnosis. The certainty factor method is employed by the system to calculate the degree of assurance in diagnostic results, thereby furnishing reliable outcomes pertaining to smartphone injury[14]. An advantageous aspect of this application roach is the straightforward comprehension of the model's outcomes. The name "decision tree" derives from the resemblance of the resulting principles to a tree structure. The process of tree formation entails the application of binary recursive sorting to a cluster of data, resulting in increased homogeneity of the response variable values within each sorted data cluster. To illustrate, a tree may be constructed comprising nodes t1, t2,..., t4, where each node represents an internal node, three leaves, and one root. With each split, a nonterminal node is divided into two distinct nodes. The results of the response prediction are stored in the tree structure's terminal nodes (leaves).

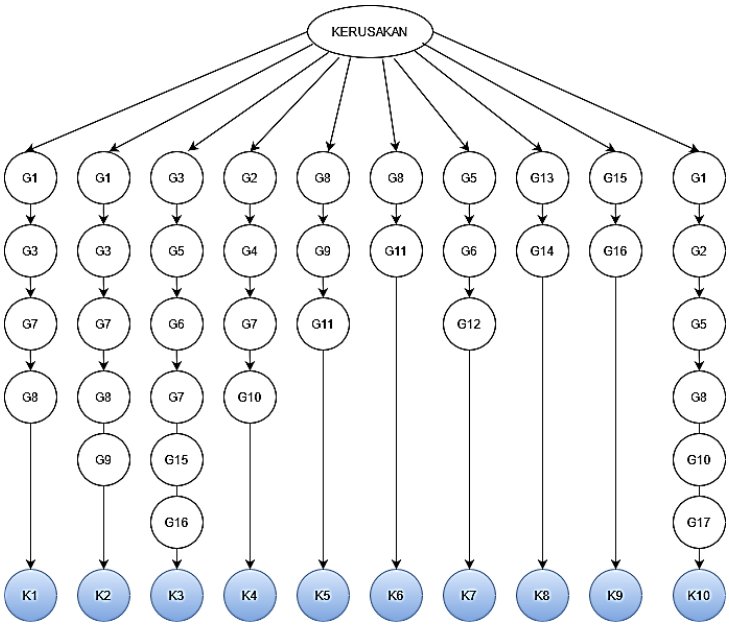

Figure 1. Decision Tree

Statement matching and reasoning in fact commence with the left component (IF). The logical progression commences with the examination of the information encapsulated in the premise of the IF [fact] THEN [conclusion] rule. As described in [15][16], information from the facts is utilized to establish the conclusion to the right of the IF [fact] THEN [conclusion] rule to verify the veracity of a hypothesis.

Production Regulations

Typically, production principles are structured using an if-then structure. The implication relationship between the premise (if) and the conclusion (then) is reflected in this rule. If the condition of the premise is met, then the validity of the conclusion is also established. Clauses, which constitute a rule, are comparable to subject, verb, and object sentences used to assert a fact. A rule comprises a presumption clause and a conclusion. Furthermore, it is worth noting that a rule may comprise multiple premises and more than one conclusion. Furthermore, logical operators such as "OR" or "AND" can establish a relationship between premises and conclusions [13][17]. When it comes to the identification of malfunctions in Android smartphones, Table 3 contains several production regulations.

Table 3. Production regulations

No.	IF/OR	THEN
1	IF sudden shutdown OR black screen OR cannot charge OR cannot open application location	IC EMMC
2	IF sudden shutdown OR black screen OR cannot charge OR cannot open application locations OR heats up quickly	IC POWER
3	IF network not available OR black screen OR sim is not read OR cannot open application OR no service OR camera application stops OR camera fails	SOFTWARE
4	IF fall OR black screen OR touch screen not responding OR impacted	LCD
5	IF cannot charge OR heats up quickly OR does not charge when on the charger	BATTERY
6	IF not charging while on charger OR cannot charge	Charger connector
7	IF no service OR sim is not read OR network is not available	IMEI
8	IF the speaker sound is small OR the speaker sound is not audible	SPEAKER
9	IF the camera application stopped OR the camera application failed	CAMERA
10	IF sudden shutdown OR Black screen OR cannot charge OR cannot open application OR Heats up quickly OR Crashes OR restarts on its own	SORT

A certain CF value is subsequently converted from the expert's interpretation of a "term" to determine the Certainty Factor (CF) value of a rule. The CF value is derived from the uncertain term value provided by the expert. As an illustration, it is presented in Table 3.

Table 4. Level of Confidence

No.	Answer	CF Weight (Expert)
1	Not Sure	0
2	Virtually Possible	0.2
3	Possible	0,4
4	Most Likely	0,6
5	Almost Certain	0,8
6	Definitely	1

The implementation of the Certainty Factor approach in expert systems necessitates adherence to a number of regulations comprising weight values assigned to variables (represented by symptoms denoted by the symbol G) by experts or technicians. Damage data for Android smartphones is extracted from documented damage records. As shown in the table, a numerical value is assigned to each symptom of injury present on an Android smartphone.

Table 5. Procedures for Determining the MB and MD Values

No.	Damage	Indicators of damage	MB	MD
1	IC EMMC	Suddenly off	0.8	0.2
2	IC EMMC	Black screen	0.8	0.6
3	IC EMMC	Cannot be charged	0.6	0.2
4	IC EMMC	Cannot open the application	0.4	0.4
5	IC POWER	Suddenly off	0.6	0.2
6	IC POWER	Black screen	0.6	0.2
7	IC POWER	Cannot be charged	0.6	0.2
8	IC POWER	Cannot open the application	0.8	0.2
9	IC POWER	Heat up quickly	0.8	0.2
10	SOFTWARE	The network does not applicationear	0.8	0.2

11	SOFTWARE	Black Screen	0.6	0.4
12	SOFTWARE	Sim card not read	0.8	0.2
13	SOFTWARE	Cannot open the application	0.8	0.4
14	LCD	Fall	0.8	0.2
15	LCD	Black screen	0.8	0.2
16	LCD	Touch screen not responding	0.8	0.2
17	LCD	Impact	0.6	0.4
18	BATTERY	Cannot be charged	0.8	0.4
19	BATTERY	Heat up quickly	0.8	0.4
20	charger connector	Does not charge when on charge	0.8	0.4
21	charger connector	Cannot be charged	1	0.4
22	IMEI	No network	0.8	0.4
23	IMEI	Sim card cannot be read	0.8	0.4
24	IMEI	No sevice	0.8	0.4
25	CAMERA	Camera application stop	0.6	0.2
26	CAMERA	Camera application fails	0.8	0.2
27	SPEAKER	Small speaker sound	0.8	0.2
28	SPEAKER	Voice is not heard	0.8	0.2

The aforementioned table presents the levels of confidence (MB) and disbelief (MD) regarding the indicators of injury. Consequently, the certainty value (CF) of the damage indicators MB minus MD equals CF (Expert).

The newly acquired value is subsequently utilized in the expert's calculation of MB (Measure of Belief) and MD (Measure of Disbelief). The value of the Certainty Factor (CF), which is the outcome of the comparison between MB and MD, is calculated utilizing the equation.

Table 6. Level of User Confidence

No.	Answer	CF Weight (Expert)
1	Do not know	0
2	Possible	0,4
3	Most likely	0,6
4	Almost	0,8
5	Definitely	1

The user's confidence in the response to the symptoms may increase when the user becomes acquainted with the indications of a smartphone malfunction.

3. RESULTS AND DISCUSSION

3.1. The implementation of the administration page

The program manual will be implemented to provide instructions on how to utilize each menu feature on the website utilized for this study.

Damage page and damage addition

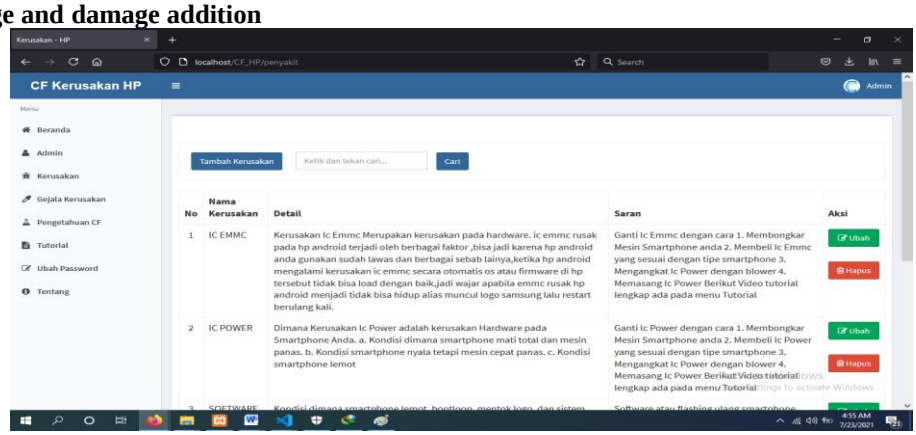

Figure 2. Damage page

The figure above depicts an administrator selecting the damage menu, which contains a menu to add damage, the number of damages to be added, their name, a description, and suggestions, as well as action buttons to amend and delete them.

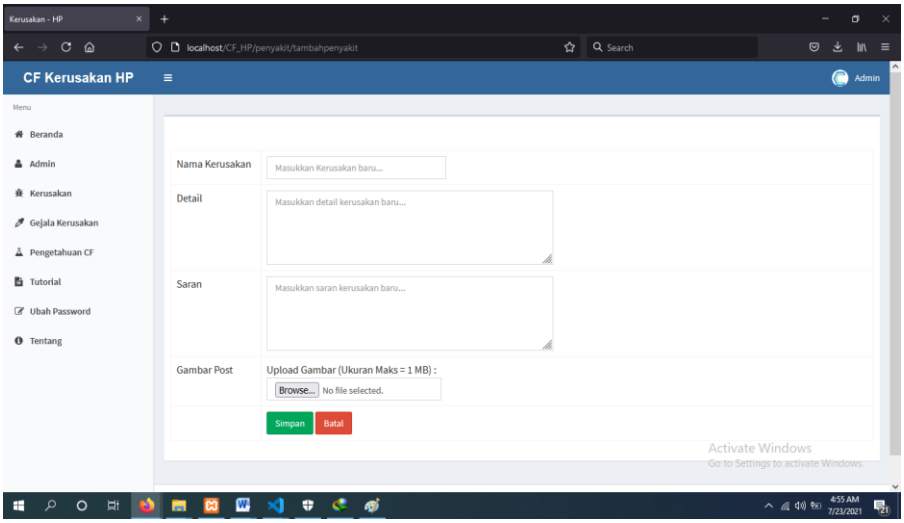

Figure 3. Add Damage Page

The figure above depicts an administrator selecting the "add damage" option from the damage menu. The "add damage" menu contains the following fields: the name of the damage to be entered, the description of the damage, suggestions for overcoming smartphone damage, images to be uploaded that will be applied to the results of damage diagnosis, and action buttons to save and cancel the damage and return to the damage menu, respectively.

Damage symptoms page and damage symptoms addition

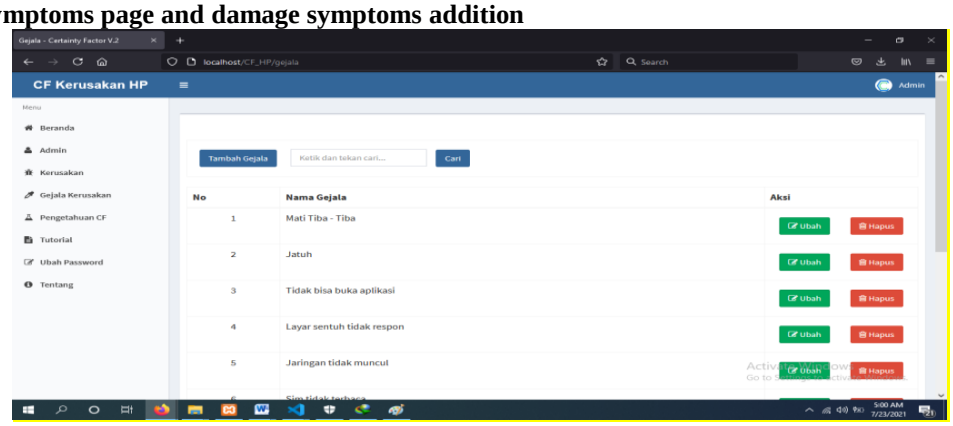

Figure 4. Damage Symptoms Page

The figure above depicts an administrator selecting the damage symptoms menu, which also includes an option to add damage symptoms. The damage symptoms menu presents the quantity and name of the damage, along with action options that enable the modification and removal of damage.

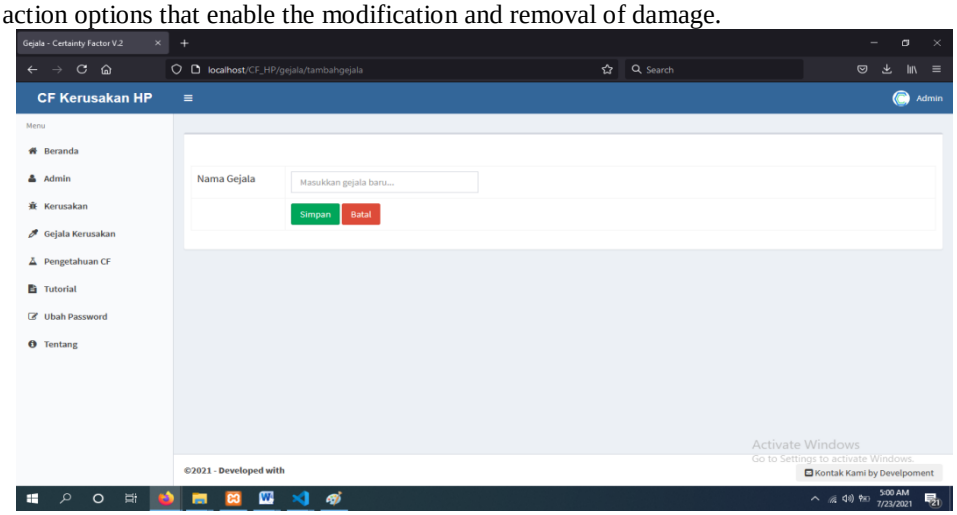

Figure 5. Add Damage Page

As illustrated in the figure above, the Admin navigates to the damage symptom menu and selects the "Add Damage Symptom" option. The menu's contents include the name of the damage symptom, which the user enters, as well as action buttons for saving and cancelling the selection to return to the damage symptom menu.

CF knowledge page and CF knowledge addition

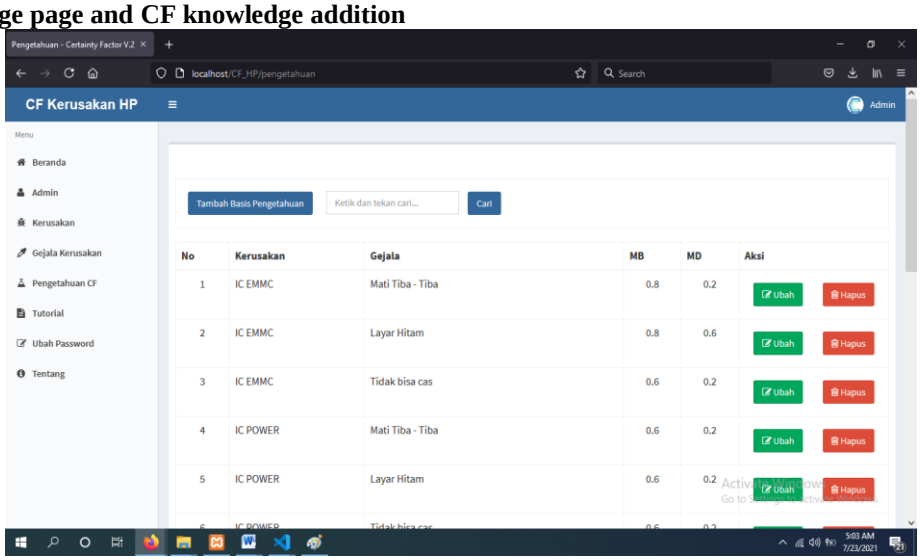

Figure 6. CF Knowledge Page

The figure above depicts Admin selecting the CF knowledge menu, which includes an additional knowledge menu. The knowledge menu contains the following information: no, damage name, symptom name, MB, MD, as well as action icons for editing and deleting knowledge.

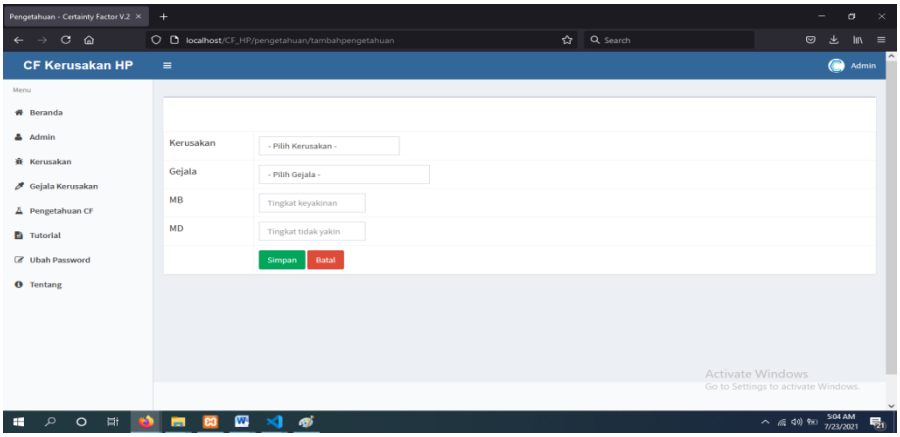

Figure 7. Add CF Knowledge Page

As shown in the figure above, when Admin chooses the CF knowledge add menu from the CF knowledge menu, a selection of damage names and symptoms entered in the damage menu and damage symptom menu, respectively, are displayed in the add knowledge menu. By entering the MB value, which represents the expert's confidence level, the Indicators of damage can be classified as follows: 0.4 (Possible), 0.6 (Most Likely), 0.8 (Almost Certain), 1 (Definite); 0.0 (Uncertain); 0.2 (Almost Possible); 0.4 (Possible); 0.6 (Most Likely); 0.8 (Almost Certain); and 1 (Definite). respectively. When the MD value is entered, it represents the expert's level of uncertainty in the same manner as the MB value.

Tutorial and add tutorial page

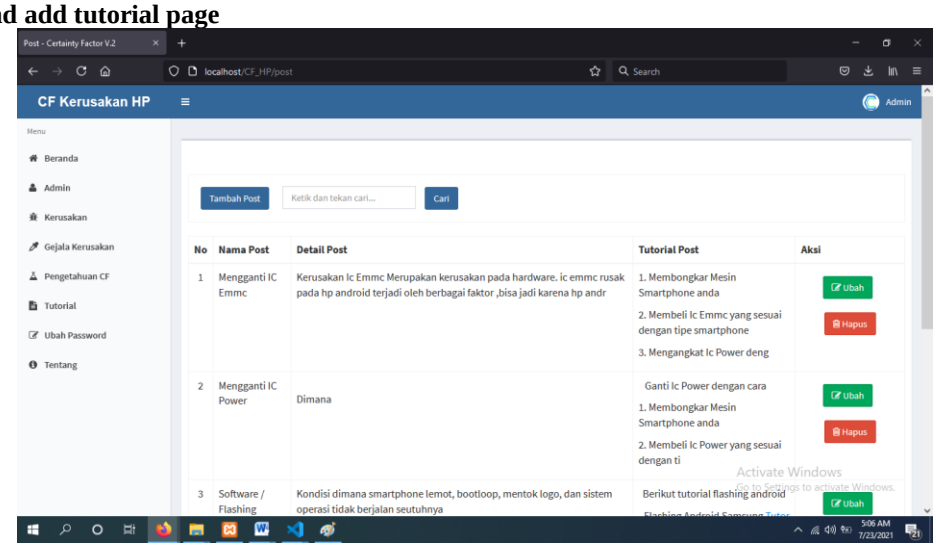

Figure 8. Tutorial page

As shown in the figure above, when Admin selects the tutorial menu, which contains a menu for adding tutorials, the following information: number, name, details, and tutorials; action icons for editing and deleting tutorials are also present.

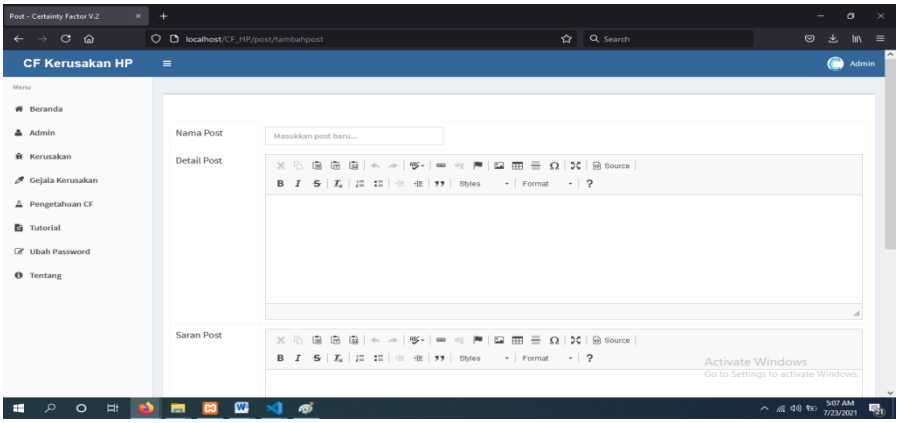

Figure 9. Add Tutorial Page

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3.2. User Page Implementation

User Diagnosis Menu Page

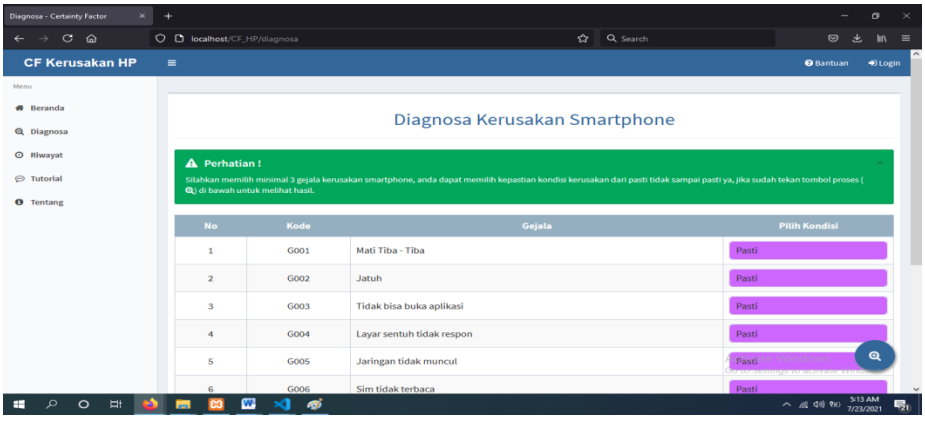

Figure 10. User Diagnosis Page

In the preceding figure, in order to diagnose damage to the Android smartphone, the user navigates to the diagnose menu. This menu exhibits the damage code entered by the administrator, as well as the damage

indicators and condition that were also entered by the administrator. The Android smartphone harm condition is assessed through the user's selection of symptoms, which include the options of certain, mixed sure, most likely, maybe, and don't know. The user proceeds by selecting multiple symptoms and subsequently categorizing them by condition before clicking (+) to access the damage diagnosis results. The format for presenting diagnostic results is as follows.

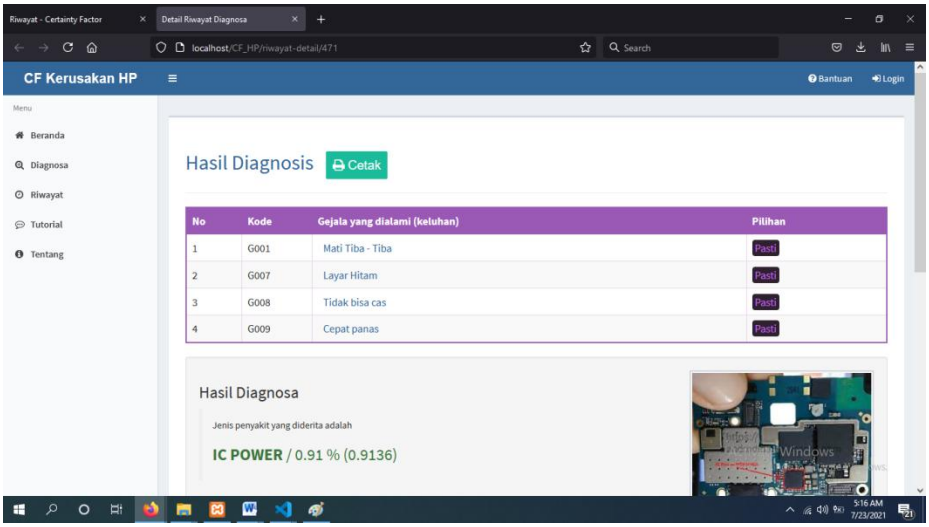

Figure 11. User Diagnosis Results Page

The diagnostic results, which correspond to the previously selected symptoms and conditions, are illustrated in the figure above. The results include the percentage (%) of the damage to the Android smartphone, the name of the damage, recommendations for repairing the damage, and additional potential causes of damage to the Android smartphone.

User History Menu Page

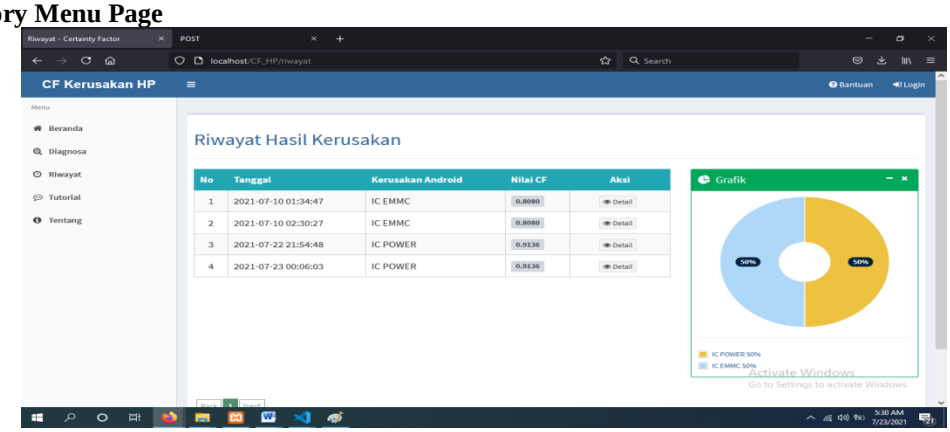

Figure 12. User Diagnosis Page

The figure above illustrates the user selecting the History menu to access the outcomes of multiple histories previously diagnosed by the user. The history menu contains the following information: the value of CF damage and Android damage, with no date of diagnosis specified; an action button provides access to the specifics of the previous diagnosis results; and a graphical representation illustrates the average damage diagnosed by this expert system.

User Tutorial Menu Page

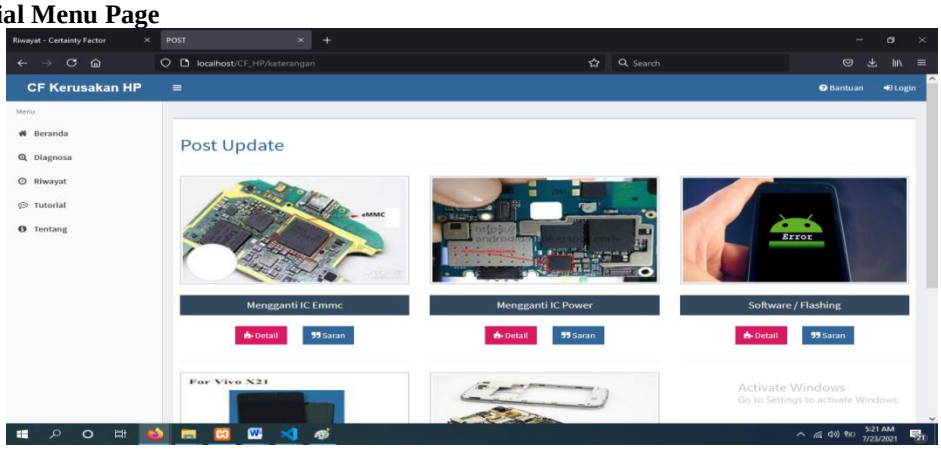

Figure 13. User Tutorial Page

As illustrated in the preceding figure, by selecting the Tutorial option, a number of repair tutorials for Android smartphones are displayed.

The execution of the database creation procedure follows the database design phase. This phase is essential for accessing, modifying, deleting, modifying, and entering data or information from the entirety of the Expert System website system. This procedure of creating a database employs Mysql.

User Table

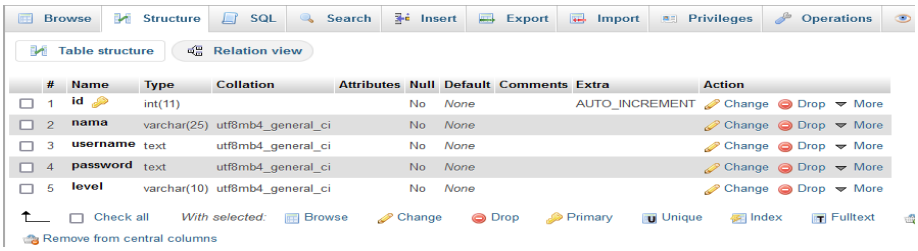

Figure 14. User database table

The figure above depicts the database user table, which includes the following information for users who are authorized to log in to the admin: id, name, username, password, and level.

Database Damage table

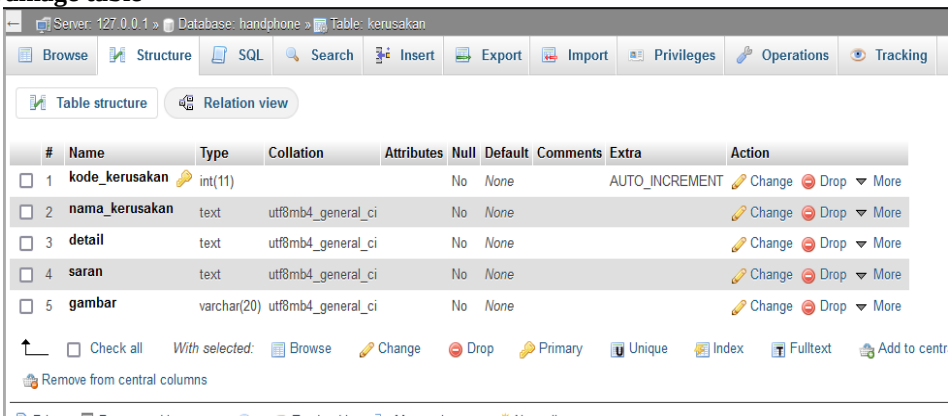

Figure 15. Damage database table

The damage table database, depicted in the figure above, comprises the following elements: damage code, damage name, details, suggestions, and photographs for storing damage data.

Database Symptom table

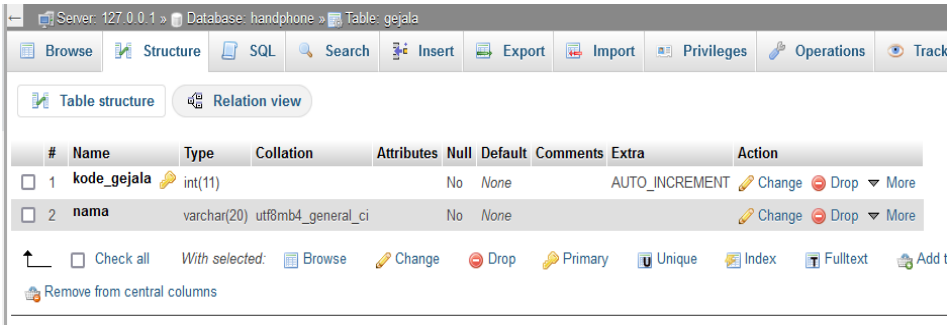

Figure 16. Symptom database table

The figure above depicts the symptom table database, which is utilised to store symptom data and includes the symptom code and name.

Database Knowledge table

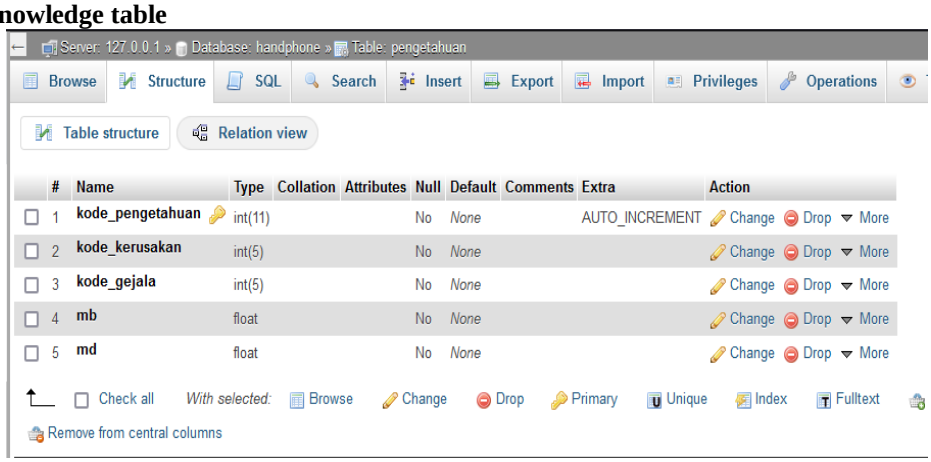

Figure 17. Knowledge database table

The knowledge table database, depicted in the figure above, stores knowledge data and includes the following columns: knowledge code, damage code, symptom code, and md.

Database Tabel tutorial

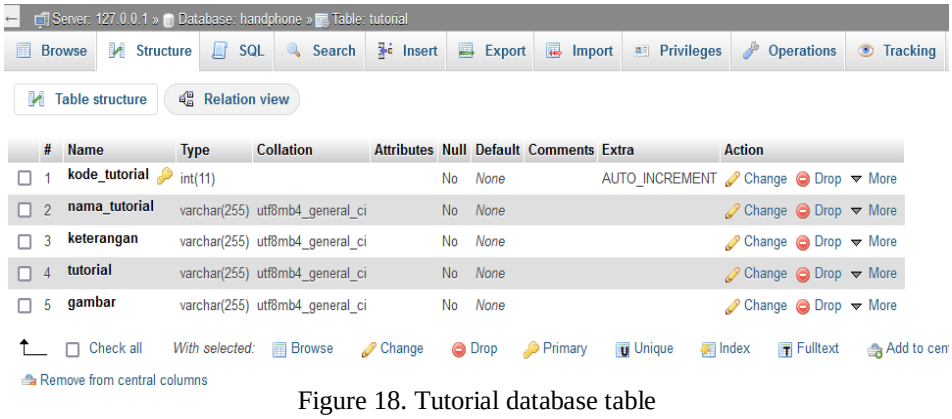

Figure 18. Tutorial database table

The figure above depicts the database table for the tutorial table, which stores tutorial data as code_tutorial, name_tutorial, description, tutorial, and image.

Database Result table

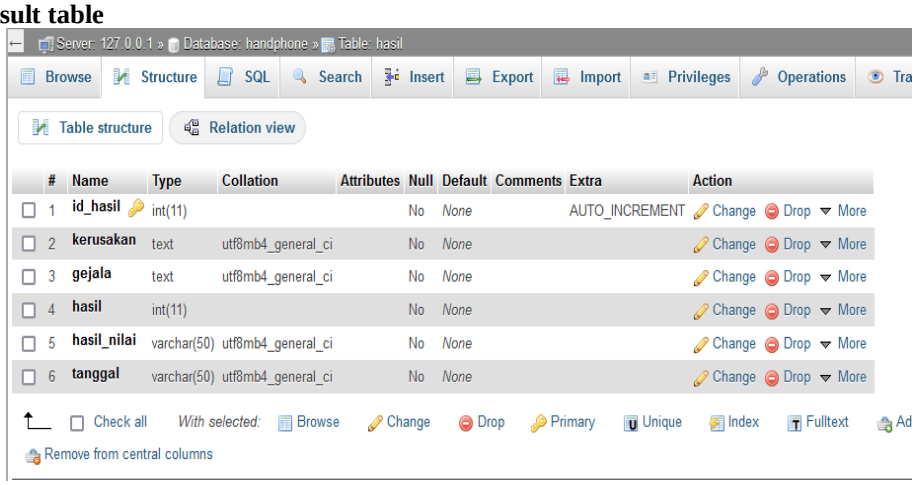

Figure 19. Result database table

The figure above depicts the result table database, which stores historical result data for each diagnosis and includes the following fields: id_result, damage, symptom, result, result_value, and date.

Database Condition table

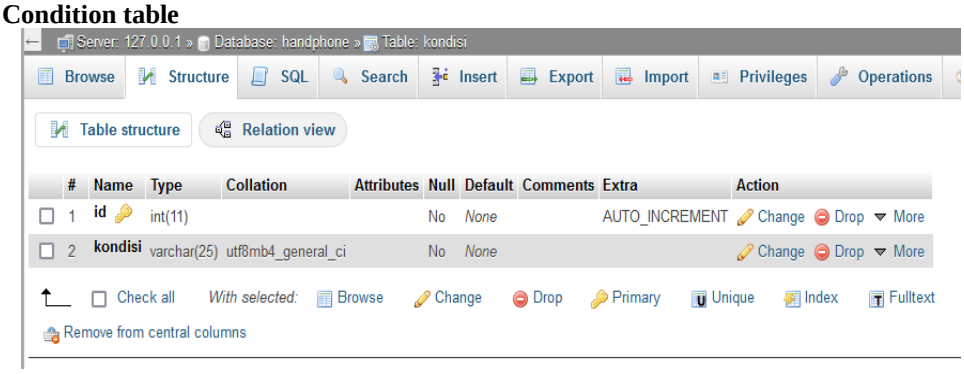

Figure 20. Database condition table

The condition table database, depicted in the figure above, is comprised of the fields id and condition and is utilized to store condition data.

The scholarly publication describes a system specifically designed to identify damage in Android handsets. The system encompasses an extensive array of functionalities: The administration page of the system provides explicit guidance on how to utilize its diverse functionalities. Admins can add, amend, or delete damages via the damage page, which also features fields for the damage's name, description, recommendations for overcoming the damage, and image uploads. The page dedicated to damage symptoms allows for the modification, addition, and removal of symptoms. It displays pertinent information regarding the damage, including its name and quantity, as well as appropriate actions. With the ability to amend and delete, the CF Knowledge page enables administrators to input knowledge about damages and symptoms, including levels of confidence and uncertainty. Furthermore, the tutorial page facilitates the generation of tutorials by providing action icons for editing and deleting tutorials and sections for the number, name, and details of each tutorial. The system offers users an intuitive interface through which they can diagnose damage to their Android smartphones. To access diagnosis results, users can categorize symptoms by condition. Historical diagnostic results are presented on the user history page, encompassing CF damage values, Android damage, and a graphical depiction of the average damage diagnosed. In conclusion, the user tutorial page guides how to repair Android smartphones.
Overall, the system exhibits a comprehensive and well-organized design, providing users and administrators with an extensive array of functionalities. Facilitating the diagnosis of damage to Android smartphones and providing simple access to repair tutorials are the primary objectives of its user-friendly interface.

The black box test yielded an impeccable success rate of one hundred percent, representing a substantial advancement in comparison to prior investigations [18]. This indicates that the expert system developed in this study for diagnosing hardware damage on Android smartphones is extremely dependable and precise.

On the basis of the evaluated data, the expert system generated diagnostic conclusions with an accuracy of 80%. This finding signifies a substantial advancement in contrast to prior investigations [19], as it substantiates the system's capability to precisely detect malfunctions in Android devices.

The intuitive user interface of the expert system facilitates the operation of the system by users in order to troubleshoot laptop hardware. In comparison to prior investigations, this constitutes a substantial advancement by rendering the system more comprehensible to individuals lacking technical expertise [20]. Additionally, the research integrates the Forward Chaining technique, which empowers smartphone proprietors to easily detect potential harm, spanning from minor to severe. These findings present a substantial advancement in comparison to prior investigations, as they furnish users with a more all-encompassing comprehension of the potential harm that could transpire on their devices.

4. CONCLUSION

The following findings can be derived from the research conducted during the development of expert system applications that utilize the website-based Certainty Factor method to diagnose damage to Android smartphones: The expert system designed to diagnose damage to Android smartphones is capable of discerning damage through the examination of inputted symptoms and employing the Certainty Factor method to compute the level of confidence in the diagnostic outcomes. The findings from the system functionality test indicate that the system functions at an optimal level, attaining a score of 100%. This is indicated by the questionnaire responses of ten participants, all of whom selected "yes" for each of the ten inquiries posed. Eighty percent accuracy was achieved in the expert system accuracy test utilizing ten test data points. The obtained result indicates that the expert system exhibits a commendable capacity to deliver accurate diagnoses based on the evaluated data. Thus, the development of this expert system was a triumph, and it is now capable of generating dependable diagnostic outcomes for harm to Android smartphones in accordance with the symptoms inputted.

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