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Decision Support System for Diagnosing Mobile Phone Failure using Rule-Based Technique

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Siti Aisyah Zainal Abidin[1], Nur Suhailayani Suhaimi[1,*]

[1] Faculty of Computer Science and Mathematics, Universiti Teknologi MARA Melaka, Malaysia

ABSTRACT

Nullfix Mobile Seri Kembangan is a mobile phone repairing service branch in Selangor that provides services to people who have problems with their mobile phones. In diagnosing the failure that is encountered by a customer, there are two types of failure; hardware faults and software faults. However, a phone technician found that there are a few problems in the current phone failure diagnosis process such as difficulty in determining the real problem, time consuming and lack of expertise. A computerized system that helps in diagnosing failure is developed to reduce these problems. The aim of this project is to develop a web-based system that implement the rule-based technique to assist technician to diagnose mobile phone failure. The rule-based technique is used due to the suitability of the technique for specific problems or situations. The objectives of this project are to gather and analyze data from Nullfix Mobile Seri Kembangan, to identify the rules for this system, to design the system by using rule-based technique and to develop the system to diagnose mobile phone failure. This project is successfully developed by performing rule-based technique. The system works by the technician selecting conditions that are related to the phone problem to know the solutions. The result of this system is that it displays the type of failure with the associated solution and the reasoning for why the solution is selected. This project has successfully achieved a satisfactory result. In the future, it is recommended that more types of failure can be added and other phone repairing service company can use the system for better enhancements of this system.

Keywords:
Decision support system; mobile phone failure; failure diagnosis; rule-based technique

1. Introduction

Nowadays, the demand for a reliable mobile phone is increasing as it simplifies the completion of everyday tasks. However, many people will face problems with their mobile phone eventually. Most users are lack of guidance on what to determine on the action needed to be done to diagnose their mobile phone failures. According to Al-Shatnawi *et al.*, [4], many different countries have established mobile phone repairing shops which requires an expert to detect faults and provide solutions. Mobile phone fault detection and identification is difficult for inexperienced technician because it requires a lot of knowledge for finding the fault. Therefore, they extremely depend on expert technician.

When a customer walks into the shop with the intention of repairing the phone, the technician will ask the problem that the customer is having and start repairing the phone after deciding what should the technician do in accordance to the problem. Usually, the process takes approximately 30 minutes to 1 hour for common faults and up to 5 days for rare cases of mobile phone faults. To

* *Corresponding author.*
E-mail address: Nur Suhailayani Suhaimi (khairul_nur@melaka.uitm.edu.my)

diagnose a phone failure, the technician will check whether the phone can be turned on or not. If the phone can be turned on, the technician will check the type of failure depending on the symptoms given by the customer. If the phone cannot be turned on, the technician will use a power supply to give direct current to the battery port and continue diagnosing the failure depending on the voltage reading from the power supply.

The problem with the current business process is it is difficult to determine the real problem of the phone failure because there is various possibilities of a phone failure. Besides that, it is time-consuming in detecting a phone failure as the technician is needed to check the type of failure whether it is hardware or software faults. Another problem is lack of expertise in repairing the phone. The technician may need a long time to repair a phone which causes customers to wait or leave their phone for some time when there are many phones needed to be repaired. It also would take a long period of time to train a new technician to acquire the right skills and understands all mobile phone faults and possible diagnosis. This failure diagnosis system is aimed to assist the technician to diagnose mobile phone failure and make decisions for everyday operation in a short time.

2. Literature Review

Decision support system (DSS) is a system specifically for supporting the solution to a specific nonstructured problem [5]. It is an approach for supporting or assisting business manager in making decisions that are unique, swiftly changing and not easily specified in advance. Meanwhile, failure diagnosis as defined by Chen *et al*., [6], is the activity of identifying location of the fault that led to the failure of a system or part of its component once it is detected. Manual failure diagnosis is time consuming, prone to errors, and requires much expertise. This is because it is impractical to examine each component manually for sources of errors if a system is in big size and complex. Therefore, automated approach for failure diagnosis is essential to be use by current system to improve system availability. One of the ways that automated failure diagnosis can be done is with the help of Artificial Intelligence (AI). Mobile phone failure diagnosis can be grouped into two categories of faults which are hardware and software faults [8]. The hardware faults are related to hardware malfunction while software faults are associated to faults originate from the operating system of the mobile phone. A mobile phone repair technician should know how to diagnose and troubleshoot faults in order to repair or fix mobile phones if failure happens.

2.1. Rule-Based Technique

The rule-based reasoning as stated by Hole *et al*., [9] is a rule consisting of several premises and a conclusion that is considered true if all premises are true. A rule-based expert system consists of domain knowledge encoded in the form of rules which is a conditional statement that links given conditions to actions gained from a human expert [11]. An expert's diagnosis experience and knowledge is transformed into a production rule to diagnose fault through a certain reasoning mechanism [3]. Among the advantages of rule-based approach includes readability, maintainability and the possibility of directly transferring domain knowledge into rules [10,12,13].

For this research, the suitable technique that can be used is the rule-based technique. This is because the knowledge is presented in the form of production rules and a rule is described through the action that should be taken if a symptom is observed. Besides that, the rule-based technique is suitable for a specific problems or situations. As compared to other technique, rule-based technique is more suitable to be used for technical problem such as automotive failure diagnosis, computer failure diagnosis and network failure diagnosis. Hence, it can be concluded that the suitable technique

that can be applied in diagnosing mobile phone failure is the rule-based technique.

The rule-based system architecture is consisting of working memory, knowledge base, inference engine, explanation facility, user interface and user. Input is the facts that are acquired from the user of the system to be compared with the rules embedded in the system. The rules are stored in a database. Next, inference engine is the component that would match the facts entered in accordance to the rules stored. The explanation facility explains about how and why the specific solution is selected for the problems input by the user. Lastly, the user interface is the display part where the user communicated with the system. Figure 1 shows the rule-based system architecture for this system.

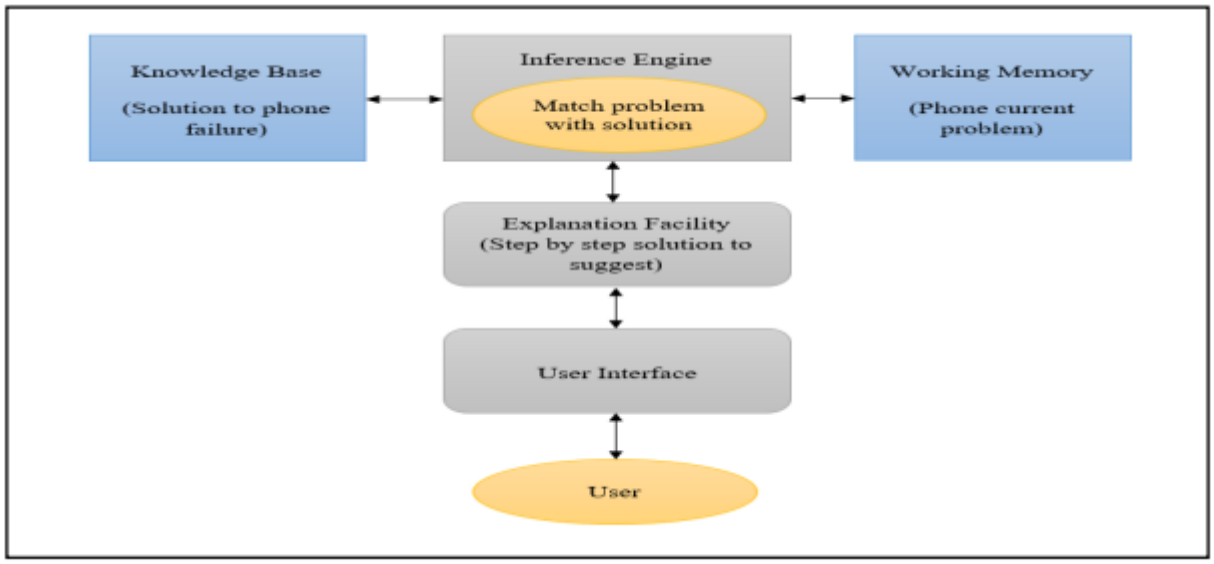

Fig. 1. Rule-based system architecture for this system

2.2. Other Failure Diagnosis Technique

The other techniques that can be used in developing failure diagnosis system are case-based reasoning, artificial neural network, and fuzzy logic. The case-based reasoning retrieve an existing case from memory, determine its relevance and decide what to do based on what happens in that case [1]. Meanwhile, the use of artificial neural network in diagnosing failure is by identifying the type of fault through different types of training samples [7]. As discussed by Akinyokun *et al*., [2], fuzzy logic is applied in fault diagnosis through determining the membership of an unknown data with respect to the known data of particular faults which ultimately find a precise solution to the given problem.

3. Methodology

The first step in developing the system is interviewing the owner and technician of Nullfix Mobile Seri Kembangan to understand the current process of diagnosing mobile phone failure. Based on the interview, the stakeholder's problems were extracted and gathered in the form of requirements to develop the system. After all the requirements have been gathered, the analysis of the data was conducted.

Next, the rules for this system is identified using the gathered data to be used as the constraints for failure diagnosis in the system. The rules is identified from the data collected that were converted

into an understandable format by using Microsoft Excel 365. All the data are converted to reduce errors in identifying the rules. There are approximately 100 rules of different types of mobile phone failures and its solutions for this project.

The third step is designing the interface of the system. Before creating the real user interface (UI), the storyboard of the UI was created beforehand to visualize and arrange the layouts and contents of the webpage. Next, the rule based architecture of the system consisting of working memory, knowledge base, inference engine, explanation facility, user interface and user is designed. The last step is writing the codes of the system. It began with applying the suitable template to create the interface of the system. Then, all the codes in bean, data access object and controller classes were instantiated, compiled and run to ensure that they were running as expected. The rule architecture is also embedded in the system during this step.

This system is implemented by using the Eclipse version Luna tool on Intel(R) Core(TM) i5-8250U CPU computer processor. Java language is used due to its availability, flexibility and transferability between different operating systems. This system is only focusing on the type of failures that are most encountered by customers to show how the rule-based reasoning works.

4. Findings and Analysis

This system works by allowing staff to select conditions related to the problem of the mobile phone and provides solution towards the specified problem. Inference engine of the rule-based architecture matched the problems selected by the staff with the rules stored in the database to get the solution. The highest percentage of conditions matched with the rules are selected as the solution. Table 1 shows the example of experimental results of the system.

Table 1
Example of experimental results of the system

	Inputs Selected	No. of constraints matched	Solution	Percentage matched	Suggested Solution
Problem A (Bloated battery problem)	phoneState = 1 phoneOperability = 2 problemType = 1 problemSymptom = 2	1	Change battery	100%	Change battery
Problem B (Charging port problem)	phoneState = 1 pstValue = 1 phoneOperability = 2	2	Change charging port	100%	Change charging port
			Change motherboard	75%	
Problem C (White screen problem)	phoneState = 1 phoneOperability = 2 problemType = 5 problemSymptom = 13	2	Change LCD screen	100%	Change LCD screen
			Change display IC	75%	
Problem D (Power issue problem)	phoneState = 1 pstValue = 2 phoneOperability = 2	2	Change motherboard	100%	Change motherboard
			Change charging port	75%	

By having this system, it can be seen that the process of failure diagnosis took a short time as compared to the manual process. This is because the type of failure is known immediately with the help of the rule-based technique implemented. The system also reduces the workload of the technician by 70% as the technician would not need to check one by one the component that is malfunction. Besides that, the system increases the work productivity of the technician as the time usage in repairing a phone is reduced. Last but not the least, customer satisfaction is increased by 80% with the aid of the system as the customer will get to have their phone repaired in a short time.

5. Conclusion

The ability to diagnose mobile phone failure is vital in continuing the success of a mobile phone repairing service shops. In diagnosing the accurate solution to the type of failure of a mobile phone, it requires training for the phone technician. Previously, a phone technician is trained by a trainer who has expertise in diagnosing failure. However, it takes a long period of time to train a new phone technician to acquire the right skills and understands all the mobile phone faults and possible diagnosis. This project provides an easier way to diagnose a mobile phone failure in getting the right solution to specific failure. It is aimed to develop a web-based system to assist technician to diagnose mobile phone failure. By having this system that is implemented using rule-based technique, it reduces the work load of staff and improves staff work productivity as failure diagnosis would be faster. This research can be enhanced by adding more types of failure and provide accessibility for other phone repairing service company.

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