An Integrated Expert System for Mobile Phone Failure Diagnosis

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ABSTRACT: *In this paper, an integrated knowledge base system for mobile phone failure diagnosis will be designed. 'The Knowledge Extraction' and 'The System Development' are the main two challengesfaced during the knowledge based system development.The mobile phone hardware faults detection and maintenance is a critical process which needs a high level of expertise.In this paper the mobile phone issues are clearly described and analyzed. As well as the proposed knowledge base system structure, components and functions are presented and described.The CLIPS is used as an expert system tool for designing the proposed system. The proposedsystem consists of 125 rules for the differentmobile phone hardware types of failures and reasons. It can detect all the different types of hardware failures. The developed system has been evaluated and tested by many users and mobile phone experts, positive feedback was received.*

Keywords: Expert Systems, Knowledge Based System, Mobile Phone Diagnosis, CLIPS

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1. Introduction

The Expert systems (ES) or the Knowledge Base Systems (KBS) are main branches of Artificial Intelligence (AI). An ES can be defined as "*an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions*". (Giarratano and Riley 2004). The knowledge acquisition, knowledge base, inference engine, explanation facility and the user interface are the main ES components. In the expert system, the knowledge is usually transferred from ahuman expert to a computer and is usually represented by fact and rules in the systems. The system can provide an advice and proof for any problem in a specific domain for the users upon their request (Al-Taani 2005).

ES provides a powerful and effective method to solve a variety of serious problems that usually require a human expert. The ES have innumerable applications including but not restricted to the following: medical treatment, engineering failure analysis, decision support, knowledge representation, climate forecasting, decision making and learning, chemical process controlling and many others (Liao 2005).

Different theoretical and practical diagnoses have been conducted by researchers especially in medical and engineering fields (Milanoviæ et al. 2010). Al-Taani (2005) proposed a car failure detection KBS that contains 150 rules for different car failure causes by using CLIPS ES tools. Nabende and Wanyama (2008) proposed a heavy duty diesel engines diagnosis expert system which is called HDDEs. Jindal et al. (2010) presented many issues that need to be considered in designing car expert system such as the required time, the place and human expertise level. Mostafa1 et al (2012) proposed KBS for car failure and malfunction diagnosis (CFMDAS). Herga et al (2013) developed an ES for car failure diagnosis. The proposed system consists of four main components and was implemented using Cyc AI Environment.

Karagiannis et al (2007) designed of expert system for search allergy and selection of the skin tests using CLIPS. Ola et al (2008) designed an expert system for diagnosing eye diseases using CLIPS, The proposed system can help doctors and patients in providing a decision support system. Patra et al (2010) designed an expert system for diagnosis of human diseases. The proposed system used inference rules and played an important role by providing certain methods of diagnosis for treatment.Rolim and Moreto (2011) proposed a scheme that combines signal processing routines with expert systems for diagnosing occurrences of power generation units.

Nowadays, the mobile phone maintenance shops have become established in different countries and require a high level expert to detect faults and give solutions. Therefore in this paper an integrated expert system for mobile phone hardware failure detection is presented, implemented and tested. Two major motivations are behind developing an expert system for mobile phone failure detection, the first is the high cost of maintenance and the second is lack of confidence in the mobile phone maintenance shops. The mobile phone faults can be classified into three types: hardware, software and settings faults. The mobile phone hardware faults are the main focus in this paper.

This paper is organized as follows: section 2 identifies and assesses the mobile phone hardware problems. Section 3 presents the proposed mobile failure knowledge base system, design and implementation. It also presents the system components with examples. Section 4 provides the experimental results. Finally, the conclusions are presented.

2. Problem Identification and Assessment

The mobile phone faults can be classified into three types: hardware, software and settings faults. The hardware damage or faults are concerned with a set of errors in the mobile power system or mobile components which have a direct effect on the mobile performance. Therefore, the user must have proper knowledge about the mobile hardware components and Integrated Circuits (IC) to avoid probability errors [10].

The proposed system divides mobile phone faults into two major types:

2.1 The First Problem

The mobile phone does not turn on (mobile phone power issues). In this case the user cannot access any phone application. The power switch (touch or press) is usually used in a mobile phone to turn on and off mobile phones.

In this problem the Power Supply Tester (PST) is usually used to detect the mobile phone power failures, see Figure 1. It provides a digital value and this value is obtained by connecting the tester wires with the mobile phone connecters. Based on the PST read value the mobile phone power failures are divided into three types:

1. If the user gets any value before the power switch is pressed, then the problem is short circuit. This problem usually happens because of carbon, rust or even water. The user should clean all ICs and the motherboard of the mobile phone. Then, the user needs to check all ICs one by one to find the short circuit.

2. If the user gets any value before the power switch is pressed and the mobile phone is working, then the problem is the battery and it needs to be changed.

3. If the user gets any value before the power switch is pressed, and the mobile phone is not working, then the problem is usually a result of the software or the power switch or ICs or otherwise the CPU.

2.2 The Second

The mobile phone turns on but it does not work properly (mobile phone performance issues). The mobile starts but the main

Figure 1. Power Supply Tester (PST)

reasons for the failure can be equipment or procedures that are not working well. In this case the performances of many mobile phone applications are affected. It divides mobile phone failures into six major types:

2.2.1 Insert SIM card problems

This problem usually appears as an insert SIM card message after the mobile phone starts. It can occur because of one or more of the following reasons:

A- The SIM card is not inserted, the mobile phone is working properly as usual but in most devices the user receives this message, while in the modern devices the user is reminded to insert it.

B- The inserted SIM card is not valid, this occurs because of the bad usage of the SIM card. In this case the user needs to replace it with another SIM card.

C- Faulty SIM Card Connector, SIM IC or bad connection to the mobile phone motherboard. Bad connections can happen for many reasons, such as if the SIM card is dropped or gets wet. A bad connection may also happen because of carbon, rust or even dirt.

In this case, initially the user should clean the SIM IC, SIM Card Connector and motherboard of the mobile phone. For cleaning purposes, liquids like CTC or similar are recommended. If you are certain that the bad connection is not because of your mobile phone, then you can replace the SIM Card Connector, SIM IC with a new one. It can be checked using the Avometer [11].

2.2.2 Mobile phone charging problems

Before implementing any hardware solution the user should clean the charger connecting points and the area around it to make sure that moisture or carbon is not causing the problem.

Within the charging domain, problems are divided into four major types

A- White screen and mobile phone heating occurs because of the charger itself, it needs to be changed.

B- "*Virtual charging problem*" usually occurs because of the dirt in the charger connecting point or error in the operating system or due to the problems in charging jumper or the charging IC.

C- "*Not charging*" usually occurs because of the charger or the battery or the charging resistors or the charging jumpers or the charging IC

D- "*Battery or charger not supported* " usually occurs because of problems in the charger or battery or the mobile phone software or the capacitors or the charger IC.

2.2.3 Hardware KeyProblems (Keypad problems)

This problem usually happens because of excess keypad usage or may also happen because of carbon, rust or even dirt in the keypad. The keypad problems are divided into two types: all the keys are not working and some of the keys are not working.

In the first instance, if all keys are not working, then the user should check whether the camera, sound or lock button keys got hangout, if yes then the user needs to replace them with new ones. If the problem remains the user needs to clean the keys, keypad ICs and motherboard of the mobile phone. The last choice is to replace the keypad ICs.

In the second instance, if some keys are working, then the user should clean the keys which are not working and the keypad connector. Then the last choice is to replace the keypad ICs.

2.2.4 White screen problems

This problem usually happens because of the mobile phone or may also happen because of carbon, rust or even dirt in the screen. This can be divided into two types, the mobile phone works but the screen shows only white (this means that you can hear the system is running but you cannot see anything because of whiteness) or it does not work at all

The first problem is because of the dirt on the screen connector or because the screen needs to be change or because the screen flat is exhausted or because of the screen IC. In the second case, when it does not work at all, the problem usually occurs because of an incorrect operating system version or dirt in the screen connector.

2.2.5 Network problems

Within the area of network problems, mobile phone failures are divided into three types including: "*No network service*" or "*Weak Signals*" or "*Virtual signals*". In these different failures the problems usually occurs because of an incorrect operating system, or the antenna and its jumpers or the BF or the network IC.

2.2.6 Others

Thisincludes camera, sound, wifi or bluetooth problems. If the camera is not working then the user needs to change it. The sound problem could be in the microphone or speaker.If the problem has occurred in the microphone then the user must replace it. On the other hand, if the problem is with the speaker, before doing any hardware solutions, the user should make sure that their earpiece is not busted, if yes then it should be replaced with a new one. Also the speaker connection points and the general area around them should be cleaned to make sure that moisture or carbon is not causing this problem.

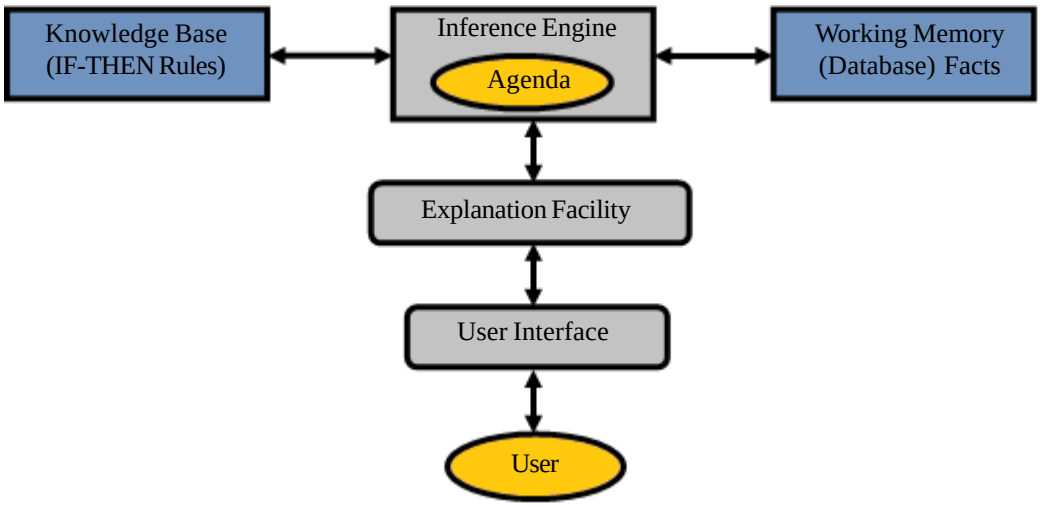

Figure 2. The proposed mobile phone failures expert system components and structure

3. The Proposed Knowledge Base System Design and Implementation

The knowledge extraction and the system development are the main two challenges are usually faced during the development and implementation of the knowledge based system. The proposed knowledge based system developed in this research is divided into four main components including: user interface, explanation facility, knowledge base and inference engine stages. The proposed mobile phone failures expert system components and structure is shown in Figure 2. The four components are presented and discussed in the following sections.

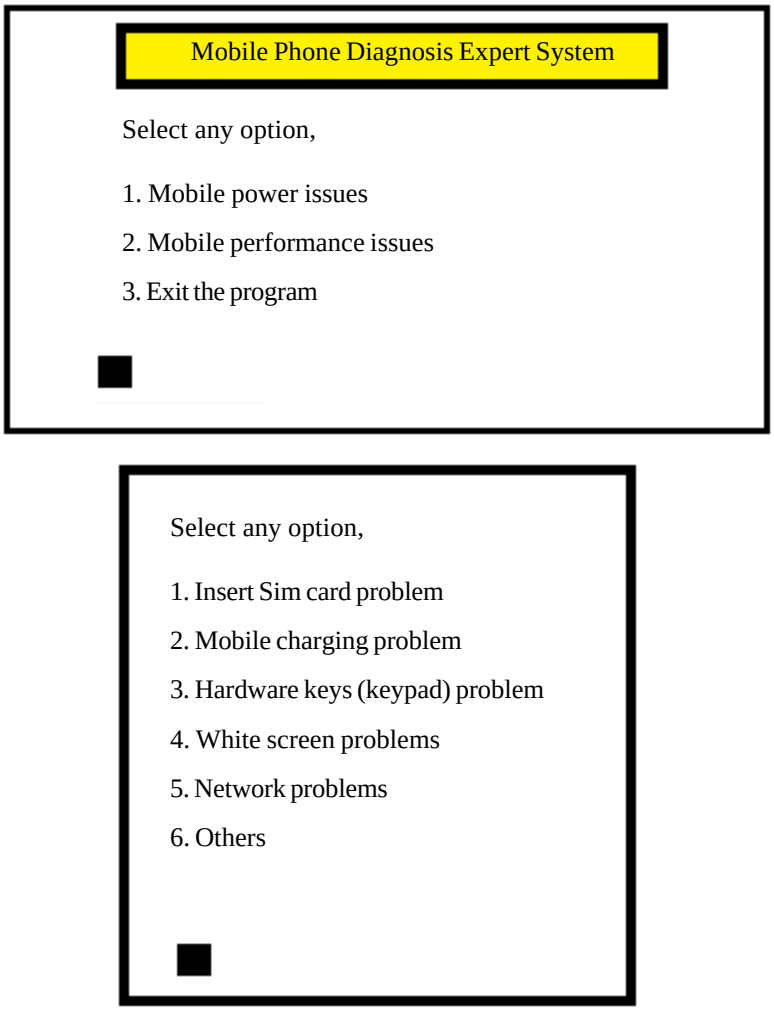

Figure 3. The proposed mobile phone failures expert system main menu

3.1 User Interface

The user interface is the display part which users parable to communicate with the system through menus of list and questions. It is written in English. Users have to select a specific option with a specific list. As well as this, for more explanation, a hint is provided for users in order to select the proper options. Generally the CLIPS run with two comments, the first is a "*reset*" command which is usually used to clear the working memory, while the second is a "*run*" command.

The system main menu consists of three options including: mobile power issues, mobile performance issues and exit option as in Figure 3. Figure 4 shows two different screens, the first screen displays many options and the user has to select the option that represents his mobile phone's state, while the second is "*yes or no*" questions, and the user has to answer it based on his mobile phone's state.

3.2 Explanation Facility

The explanation facility defines the entire scenario for the user. It informs the user about how and why the system gives a cause for some corresponding problem. For example, if the problem is that the mobile phone shows a white screen and the mobile phone heats while charging, then the system will provide the solution. The solution is to change the charger because it is damaged and the system explains the reason for choosing this solution. That increases the system dependability and reliability.

3.3 Knowledge Base Structure

The knowledge is collected from different resources such as specialized books and many mobile phone maintenance experts and

In this case, Power supply tester (PST) is used for testing the mobile power failiure
==> f-2 (power-tester shows value)

Does the Power supply tester shows a value (yes/no)? yes
Does the Mobile switched on (yes/no)? yes
Does the Mobile working properly (yes/no)? ■

Figure 4. Examples of the diagnosis menus

different mobile phone maintenance websites [9-11]. This knowledge is translated into facts and rules and the knowledge base of the proposed system contains about 135 production rules for different types of mobile phone failures and their causes. The following are two rules of the proposed expert system which are shown as examples.

Rule 1:
Check the mobile state, when the power supply tester shows a value
IF the selection is 1 *"mobile-power-state"*
AND the PST shows a valueAND the Mobile is switched on
AND the Mobile is working well
THEN
The battery is damaged.Replace it with a new one.

Rule 2:
IF the selection is 2 *"mobile-performance- state"*
THEN
The problem is Insert Sim card OR Mobile phone charging
OR Hardware Keys (*Keypad problems*) *OR White screen problems*
OR Network problems OR Others.

As a rule-based shell, CLIPS stores the knowledge in rules, the above Rule (Rule1) is written in logic based structures as shown in Figure 5.

Rule No 1 – Mobile-Power-State

(Defrule Rule1 "Check the mobile state, when the power supply tester shows a value"
(Selection 1)
(PST Shows Value)
(Mobile Switched On)
(Mobile Working-Well)
<=
(printout t "The Battery is damaged")
(printout t "Advise: Replace with new battery")

Figure 5. Clips Representation of the Mobile power state rule (above Rule1)

3.4 Inference Engine
When a mobile phone fault occurs, the inference engine of KBs will match the stored facts in the working memory with the rules stored in the system, then the rule that satisfies this matching will be the active rule and will be placed in the agenda part, then only one rule will be selected based on it is higher priority for execution "*firing*" step to find the suitable solutions. In order to explain the inference engine mechanism the following four rules are assumed to be in the agenda.

Rule 1: *IF the mobile phone turns off, AND the PST gives a value,*
THEN the problem is short circuit.

Rule 2: *IF the mobile phone turns on AND it works properly, AND the PST gives a value,*
THEN the problem is battery.

Rule 3: *IF the mobile phone turns on AND it doesnot work properly,*
AND the PST gives a value
THEN the problem is software OR power switch OR ICs OR CPU.

Rule 4: *IF the mobile phone turns on and it doesnot work properly,*
THEN the problems are Insert Sim card OR Mobile phone charging
OR Hardware Keys (Keypad) OR White screen OR Network OR Others.

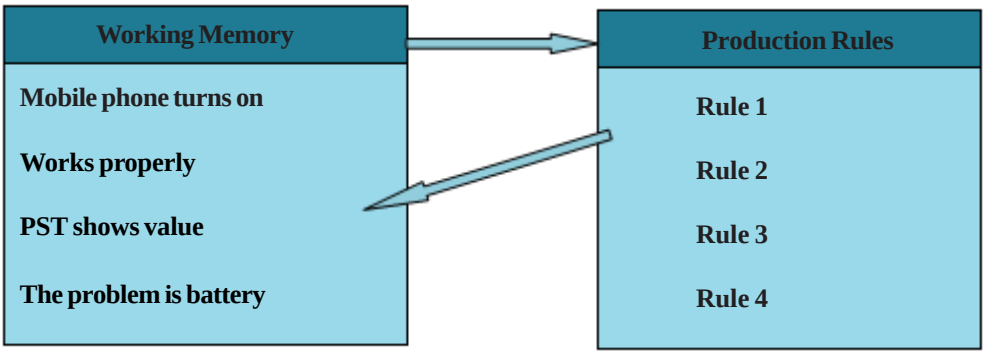

Figure 6. The production system after Rule 2 is fired

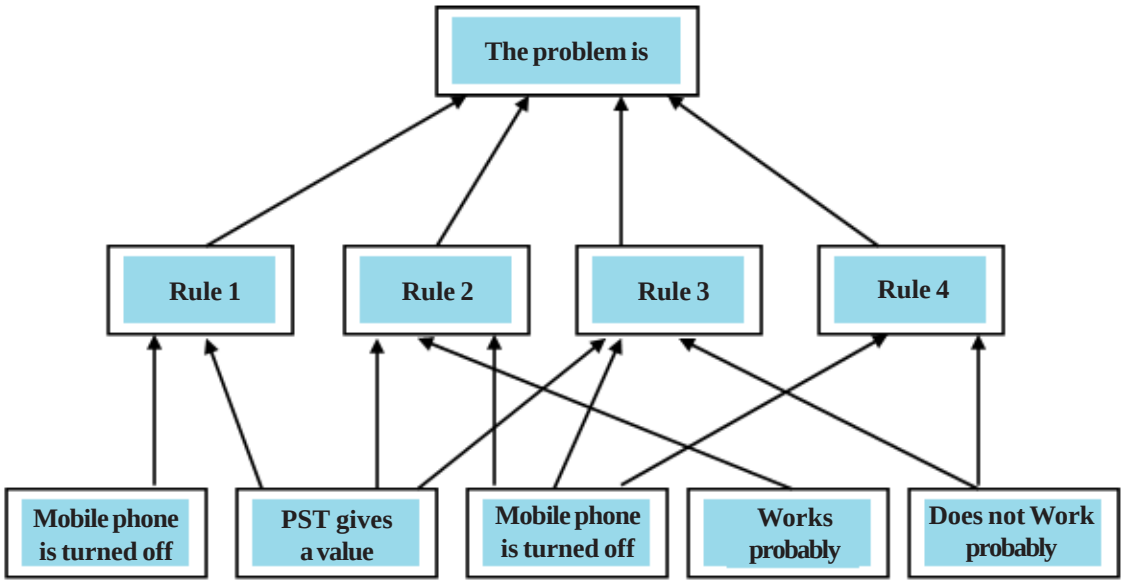

Figure 7. the relationships between the above four selected rules

The inference process of the KBs using the rules listed above is shown in Figure 6, while the relationships between the above four selected rules is shown in Figure 7.

4. Experiment Results

The proposed expert system has been implemented usingthe CLIPS (C Language Integrated Production System) expert system tool on core i3 2.13 GHZ in 2013. The CLIPS 6.3 beta for windows version is used due to itsavailability, flexibility, and expandability. CLIPS date back to 1984 at NASA's Johnson Space Center. It has many different features such as transferability between different operating systems and Interactive Development, more details can be found in Giarratano (1993). Figure 9 shows an example about invalid SIM card problem. Many experimental results examples are shown in the Figure 10.

Does the Mobile phone working properly (yes / no)? yes
Does the Mobile phone shows an insert sim card message to the user (yes / no)? no
Does the Sim card show invalid message (yes / no)? yes

User Input --->

The Mobile phone is working properly and the sim card shows invalid message

Result

Bad usage of Simcard

Advise: Replace it with a new simcard

CLIPS

Figure 9. Invalid SIM card problem

You should clean the charging connector points and the general area

Does the Mobile phone shows a white screen and mobile heats while charging (yes / no)? no
Does the Mobile phone shows a virtual charging (yes / no)? no
Does the Mobile phone shows no charging when charger is still plugged in (yes / no)? yes

User Input --->

The Mobile phone shows no working during plugged in

Result --->

the problems are charger or the battery or the charging resistors or the charging jumpers or the charging IC

CLIPS>

Does all the Mobile phone keys or some of the keys are not working (yes / no)? yes
Does some of the Mobile phone keys are working (yes / no)? yes
Is the camera sound or lock button keys is hangout (yes / no)? yes

User Input --->

Some of the keys are working and the camera sound or lock button keys is hangout

Result --->

Replace the keys with a new one

CLIPS>

Figure 10. Examples of experimental results

5. Conclusions

In this paper, an integrated knowledge base system for mobile phone failure diagnosis is presented, designed and implemented. In light of the high cost of mobile maintenance and lack of confidence in the maintenance shops, this research provides an integrated expert system that is able to assist the inexperienced public in the area of mobile hardware components by detecting the faults and repair it if by providing a decision support system. It is also considered to be an interactive training tool that can provide expert guidance in mobile phone failure detection. Furthermore it can act as an expert advisor. The proposed system is developed using the CLIPS expert system tool. Its components are well presented and clarified. The knowledge is collected from different resources such as books written by experts as well as many mobile phone maintenance experts and different mobile phone maintenance websites. This knowledge is translated into facts and rules and the knowledge base of the proposed system contains about 135 production rules for different types of mobile phone failures and causes. The developed system has been evaluated and tested by many users and mobile phone failure experts, positive feedback was received. The proposed system focuses on the mobile phone hardware faults, further work is need to enable the system to detect software and setting faults.

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References

[1] Al-Taani, A. T. (2005). An expert system for car failure diagnosis. *World Academy of Science, Engineering and Technology*, 1 (12) 457-560.

[2] Giarratano, J. C. (1993). CLIPS User's guide. *NASA Technical Report*, Lyndon B Johnson Center.

[3] Herga, Z., Bradeško, L. (2013). Call centre knowledge acquisition and decision support prototype. *Conference on Data Mining and Data Warehouses* (SiKDD 2013), Ljubljana, Slovenia. October 7th.

[4] Jindal, Y., Jain, S., Aggarwal, R., Verma, N. (2010). Approach towards Car Failure Diagnosis-An Expert System. *International Journal of Computer Applications* (0975-8887).

[5] Joseph, G., Gary, R. (2005). Expert systems: principles and programming. Boston: Thomson Course Technology. Fourth Edition.

[6] Karagiannis, S., Dounis, A. I., Chalastras, T., Tiropanis, P., Papachristos, D. (2007). Design of expert system for search allergy and selection of the skin tests using clips. *International Journal of Information Technology*, 3 (2).

[7] Liao, S. H. (2005). Expert system methodologies and applications—a decade review from 1995 to 2004. *Expert Systems with Applications*, 28 (1) 93-103.

[8] Milanoviæ, D. D., Misita, M., Tadiæ, D., Milanoviæ, D. L. (2010). The design of hybrid system for servicing process support in small businesses. *FME Transactions*, 38 (3) 143-149.

[9] Mobile Formy, http://www.formymobile.co.uk/

[10] Mobile phone hospital, http://mobilephonehospital.blogspot.com/

[11] Mobile phone repairing help, http://repair-mobiles.com/

[12] Mostafa, S. A., Ahmad, M. S., Mohammed, M. A., Obaid, O. I. (2012). Implementing an expert diagnostic assistance system for car failure and malfunction. *International Journal of Computer Science Issues* (*IJCSI*), 9 (2).

[13] Nabende, P., Wanyama, T. (2008). An expert system for diagnosing heavy-duty diesel engine faults. *In Advances in Computer and Information Sciences and Engineering* (p. 384-389). Springer Netherlands.

[14] Naser, S. S. A., Ola, A. Z. A. (2008). An expert system for diagnosing eye diseases using Clips. *Journal of Theoretical and Applied Information Technology*, 4 (10).

[15] Patra, P. S. K., Sahu, D. P., Mandal, I. (2010). An expert system for diagnosis of human diseases. *International Journal of Computer Applications*, 1 (13).