

Implementing a Mobile Vehicle Failure and Malfunction Diagnosis Assistance System

Ajayi, Olusola Olajide
Department of Computer Science,
Adekunle Ajasin University
Akungba-Akoko, Ondo State, Nigeria
olusola.ajayi@aaua.edu.ng/
ajayilastborn@yahoo.co.uk

Ojeyinka, Taiwo O.
Department of Computer
Science, Adekunle Ajasin
University
Akungba-Akoko, Ondo State,
Nigeria
taiwooje@gmail.com

Bada, Oluwaseun Tajudeen
Department of Computer
Science, Adekunle Ajasin
University
Akungba-Akoko, Ondo State,
Nigeria
seunbadat@yahoo.com

Abstract

Applications in fault diagnosis are continuously being implemented to serve different sectors. Vehicle failure detection is a sequence of diagnostic processes that necessitates the deployment of expertise. This paper presents the imperatives for an expert system in developing vehicle failure solution detection model and the requirements of constructing successful knowledge-based system for such model. In addition, it exhibits the adaptation of the expert system in the development of vehicle failure and malfunction diagnosis assistance system (VFMDAS). Thus, the purpose of this paper is to assess the feasibility of augmenting the mechanic/vehicle user with a mobile application in the maintenance of vehicle. Based on the current diagnostic expert systems such as MYCIN, the expert diagnostic system discussed here will contain a knowledge base obtained from technical manuals and expert mechanics. It should be possible for less-qualified mechanic or a new vehicle user to quickly and accurately assess vehicle malfunctioning through interaction with our VFMDAS.

Keywords: *Implementing, Mobile Vehicle Failure, Malfunction Diagnosis Assistance*

System Introduction

Applications in fault diagnosis are continuously being implemented to serve different sectors. Vehicle failure detection is a sequence of diagnostic processes that necessitates the deployment of expertise. The Expert System (ES) is one of the leading Artificial Intelligence (AI) techniques that have been adopted to handle such task. The study presents the imperatives for an ES in developing vehicle failure detection model and the requirements of constructing successful Knowledge-Based Systems (KBS) for such model. In addition, it exhibits the adaptation of the ES in the development of Vehicle Failure and Malfunction Diagnosis Assistance System (VFMDAS).

Diagnostic systems are among the most successful applications of knowledge-based systems (KBS) technology. This is true both in terms of the number of applications built, and in terms of the benefits which such systems bring.

Ten years ago, this would not have been much of an issue – there was really only one solution for building diagnostic systems: such systems were built using an expert system shell or a programming language. However, there are now several good ways of building diagnostic systems, and the appropriate solution will depend on the characteristics of the specific diagnostic problem.

Vehicle diagnosis is an important area, but has some significant differences from diagnosis of devices designed by humans: e.g. in medical diagnosis, part replacement to prove malfunction is not often an appropriate diagnostic test, whereas it is a standard strategy in many areas of device diagnosis. Because of this, fuzzy reasoning has a much higher profile in medical diagnosis, whereas device diagnosis is more likely to use tests to provide exact answers.

The use of expert system can be beneficial in offering of diagnostic assistance for faulty and or malfunctioning vehicles by guides to vehicle's owner. Inexperienced mechanic/technician may at times wrongly diagnose a vehicle's problem, thereby causing a somehow complex damages to the vehicle. Moreover, in the busy time, the skilled mechanical engineer/technician may have no time to repair the vehicle and train new mechanical engineer in every step at the same time. Many vehicles' owners never know how to check their vehicles in order to keep them in a good condition; in this case they would have to pay more for maintenance cost. Thus, this research work intends to make Vehicle Failure and Malfunction Diagnosis Assistance System (VFMDAS) available to the vehicle's owners, the auto mechanics/technicians, automobile enthusiast, students and also, manufacturing companies. A large segment of the vehicle driving population is constituted by drivers who have little or very less information regarding troubleshooting a vehicle, thus this work is intended to assist such people in case of a breakdown where time, place, and availability of human expert is a problem.

Therefore, the main objective of this research is to develop Vehicle Failure and Malfunction Diagnosis Assistance System (VFMDAS); a system that provides quick and precise expert guidance to vehicle fault diagnosis. Additionally, for training purposes, it helps in reducing the knowledge gap

between different individuals in vehicle fault diagnosis. The specific objectives of this research are as follows:

1. To investigate the related works on vehicle fault and malfunction diagnosis and Expert System (ES) domains.
2. To design appropriate representation architecture to the proposed Vehicle Failure and Malfunction Diagnosis Assistance System (VFMDAS).
3. To develop an expert system that supports the implementation of the proposed system's functionality.
4. To test and validate the system's performance.

To achieve these, data will be collected through book-search, site visitation and interviewing of some automobile practitioners/technicians.

Related Literature

The word artificial intelligence simply means the intelligence of machines and the branch of computer science that aim to create it. John McCarthy coined the word in 1956 and defined it as "The science and engineering of making intelligent machines". The phrase "AI" thus can comprehensively be defined as the simulation of human intelligence on a machine, so as to make the machine efficient to identify and use the right piece of "knowledge" at a given step of solving a problem.

Expert systems (ES), on the other hand, is a branch of artificial intelligence (AI), and were developed by AI community in the mid-1960s. An Expert System 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"- *Feigenbaum*. This means that expertise can be transferred from a human to a computer and stored in the computer in a suitable form that users can call upon the computer for specific advice as needed. Then the system can make inferences and arrive at a specific conclusion to give advices and explains, if necessary, the logic behind the advice.

Expert systems provide powerful and flexible means for obtaining solutions to a variety of problems that often cannot be dealt with by other, more traditional and orthodox methods. The terms expert system and knowledge-based system (KBS) are used synonymously. The three main components of Knowledge-based system are:

1. A Knowledge base
2. An Inference engine
3. And a specific user interface.

A knowledge base contains knowledge of a particular application domain. A knowledge base is consist of all the require solutions and advice to different and certain problem. In a rule base expert system, the knowledge is most often represented in the form IF.....THEN rules. The knowledge base contains both general knowledge base as well as case specific information.

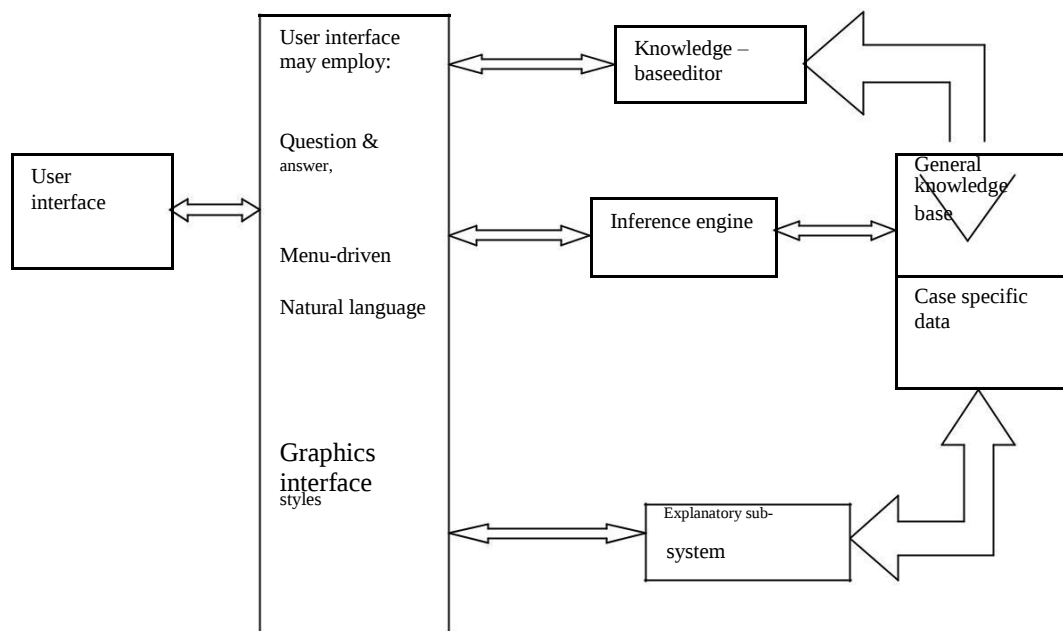


Figure 1. Basic structures of an expert system

Inference Engine applies the knowledge to the solution of actual problem. It is essentially an interpreter for the knowledge base. Inference rule is a statement that has two part, the 'IF' clauses and the 'THEN' clauses. The rule gives the expert system ability to find solution(s) to a diagnostic and prescriptive problem. Inference rule could either be in form of *forward-chaining rule* or *backward-chaining rule*.

User interface is the means through which users interact with the system. The user interface may employ: question and answer, natural language or graphics interface styles in its implementation.

Figure 1 above is a diagram illustrating a well structured expert system. Here the expert system uses a knowledge base containing facts and heuristics, and some inference procedure for utilizing its knowledge.

This deals with rule-based systems, where knowledge is represented by *production rule*. Firstly, the knowledge of a human expert must be mapped into the knowledge base. This is known as *knowledge engineering*. Then the expert is ready for use. There then follows a dialogue between the user and the system.

The user responds to the system's questions and is given advice or a final answer. The inference engine analyses situations, establishes sub-goals and draw conclusions.

Individuals involved in interaction with an ES includes: End users; Problem domain expert, and knowledge engineer.

End user: end users are the individuals who consult with the system to get advice which would have been provided by an expert.

Problem domain experts: these are the individuals who currently are experts solving a problem.

Knowledge engineer: knowledge engineering is an act of designing and building expert system. The person who does this is called "knowledge engineer".

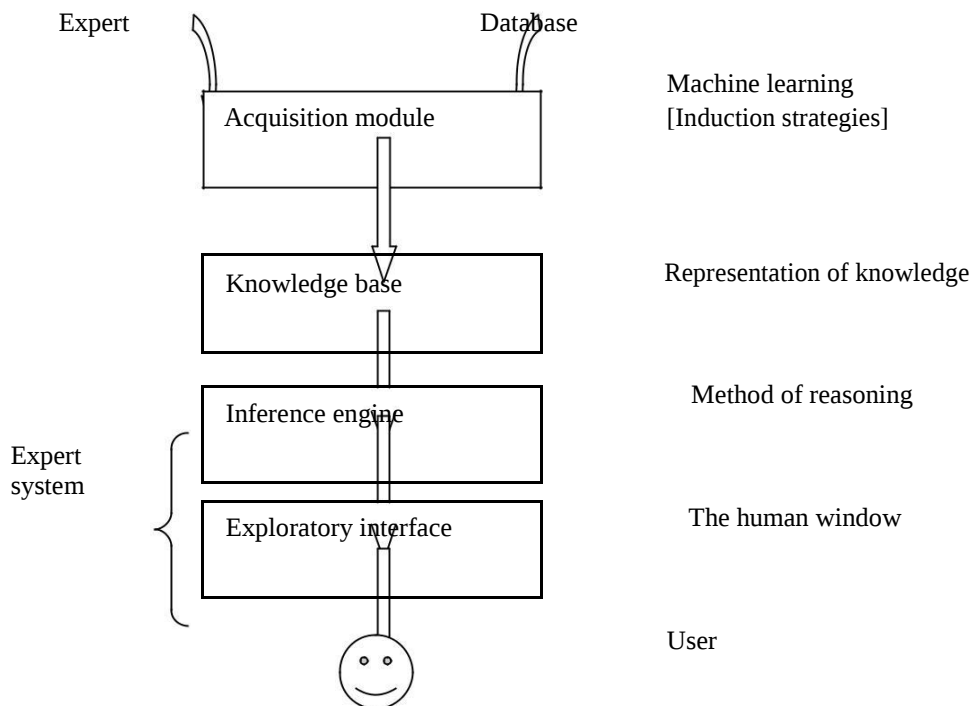


Figure 2. Expert system (user interaction)

MYCIN

MYCIN is a typical example for expert system illustrated above. The MYCIN system was designed for diagnosis and therapy recommendation for infectious diseases. The medical knowledge is represented as a set of production rules. For example:

IF:

1. The infection is primary-bacteremia
2. The site of the culture is one of the sterile sites
3. The suspected portal of the entry of the organism is the gastrointestinal tract.

THEN

There is suggestive evidence (0.7) that the identity of the organism is bacteriodes.

The inference engine uses the backward-chaining technique to achieve a certain goal; it establishes one or more sub-goals. MYCIN (Buchanan & Shortliffe, 1984) was a pioneering ES which demonstrated the value of this technique of reasoning under uncertainty. MYCIN deals with the identification and treatment of blood infections. It handled diagnosis and suggested appropriate medication and dosage. It used a variety of information, including patient's complaints and pathological laboratory reports. Even healthy people harbour bacteria, and therefore pathological tests could be occasionally misleading. MYCIN took such possibly misleading evidence and managed to use it intelligently. It also had information reflecting the fact that a bacterium normally susceptible to a given antibiotic may turn out, in some individuals, to be resistant to that antibiotic.

GRADE

The GRADE™ diagnostic authoring toolset from GenRad is a good example of a diagnostic system building toolset designed for a specific area of application. GRADE has been designed for the purpose of building diagnostic applications for the electrical systems for automobiles, and GenRad claim that using GRADE is at least five times as efficient as writing code. In order to understand some of the features of GRADE, it is beneficial to understand the context in which the diagnostic systems built with GRADE are used. Vehicle electrical systems have gradually become more complex. As that has happened, misdiagnosis of problems has increased and many automobile manufacturers have begun to respond to that increase. One response is to build more monitoring systems into vehicles, so that the monitoring systems detect and record problems in the form of diagnostic trouble codes (DTCs). This is termed *on-board* detection of faults. On-board detection can usually only detect problems and decide on a course of action. Problems can either be severe enough to mean that the vehicle should be halted immediately, or can allow “limp home” functionality, where the driver is warned of the problem, and is informed that the vehicle should be serviced as soon as possible, but that the problem is not severe enough to prevent the operation of the vehicle in the short term.

A second response is to provide automated diagnostic assistance in automobile service centres. The assistance usually takes the form of a computer running a diagnostic program, often with access to other useful information such as online manuals. The service centre diagnostic computer will be linked to the vehicle in order to read DTCs from the on-board diagnostic system, and will have other sensors which the technicians can link to the vehicle so that instrument test readings can be read directly by the diagnostic system rather than entered on the keyboard by the technician.

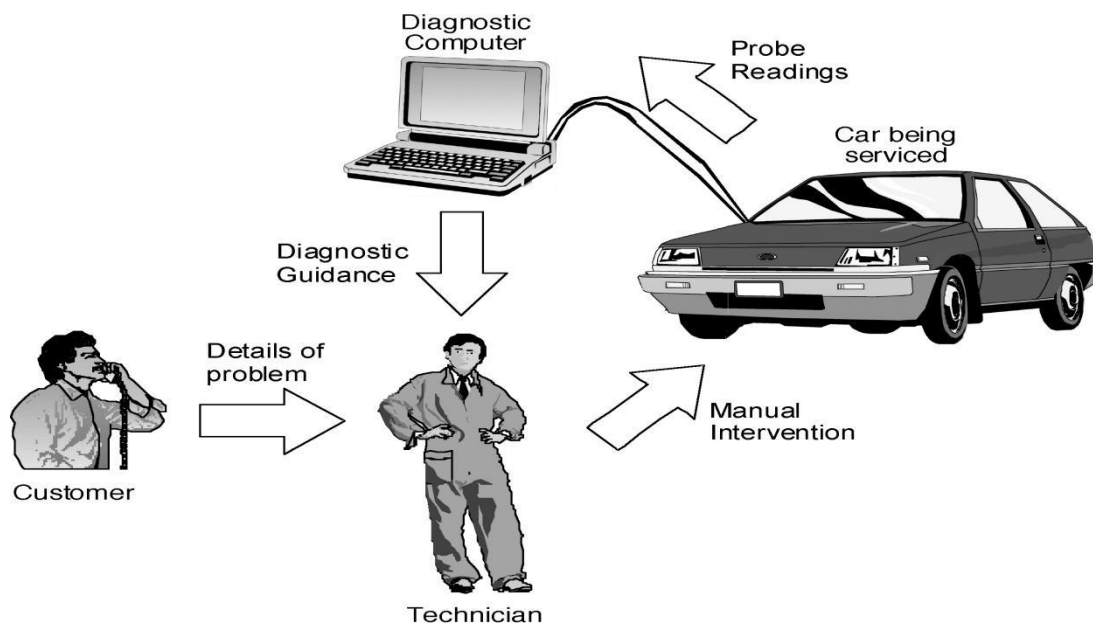


Figure 3. Use of garage-based diagnostic system

Source: *Computer-Based Diagnostic Systems* by Chris Price, University of Wales Aberystwyth

GRADE provides facilities for constructing diagnostic programs for use by technicians in automobile service centres. Figure 3 shows the context in which such diagnostic programs operate. The technician can talk to the driver to obtain the symptoms that caused the driver to bring in the vehicle in

the first place. The technician can use these symptoms to guide the investigation carried out by the diagnostic program.

The diagnostic symptom is linked to the vehicle, and can also use diagnostic trouble codes as starting points for diagnosis. During the investigation, the diagnostic system will keep the technician informed of the likely failures and will request tests to be performed. These might entail the technician setting the vehicle into a particular state, e.g. running the engine until normal operating temperature is reached, or might entail performing tests. Some tests will be carried out by the technician; others will involve the technician in connecting probes from the diagnostic system to the vehicle so that the diagnostic system can read test values directly from the vehicle's on-board electronics.

When a diagnosis has been made, the diagnostic system will provide the technician with repair information. Further tests might need to be performed in order to verify that the repair was successful, and the diagnostic system will be able to guide the technician through those tests as well.

Diagnosis Using Diagnostic Fault Tree

One of the main ways in which engineers have represented a diagnostic strategy is by using diagnostic fault trees. Diagnostic fault trees are also a convenient way of thinking about building diagnostic systems.

Here the diagnostic fault tree is used as a common representation for discussing different ways of approaching diagnosis, and shows how the qualities of the diagnostic tree affect the choice of technology for building the diagnostic system effectively. Some of the approaches are closer to diagnostic fault trees than others, but it is hoped that in all cases the comparison with diagnostic fault trees will shed light on the characteristics of the diagnostic system being built.

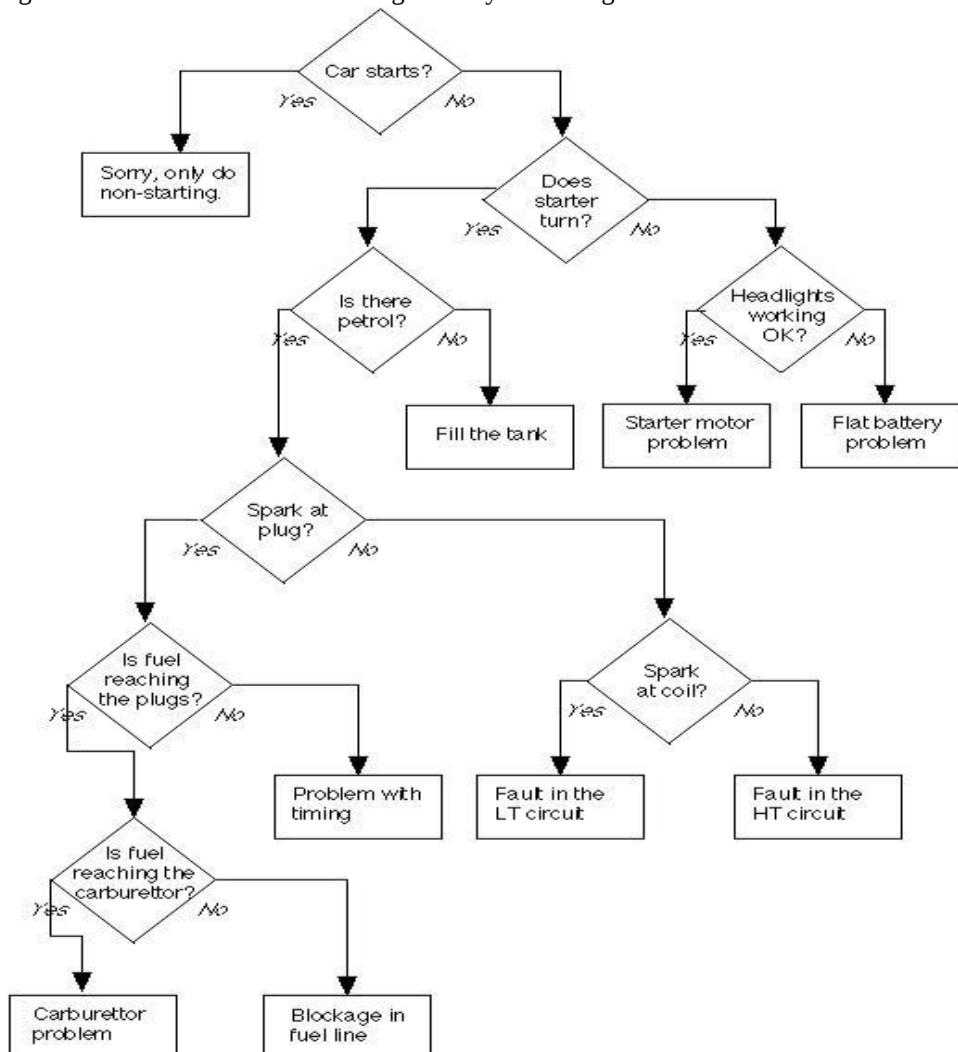


Figure 4. A simple diagnostic fault tree

Source: *Computer-Based Diagnostic Systems* by Chris Price, University of Wales Aberystwyth

In order to draw a diagnostic fault tree such as the one in Figure 4, one must decide what the first diagnostic test to be done will be, and draw it at the top of the tree. The possible next actions or questions are drawn beneath it, linked by the answers which lead to those actions or questions. In the example shown, only yes/no questions are used, but the same technique can be used for more complex sets of answers.

Materials and Methods

In implementing an Expert Diagnostic Assistance System for Vehicle failure and malfunction there is a need to examine the methodology involve in its implementation as well as analysis of the existing system. Methodology of implementing this type of expert system could be referred to as knowledge engineering methodology. Knowledge Engineering Methodology involves several technical procedures/steps in actualizing a perfect expert system – as depicted below:

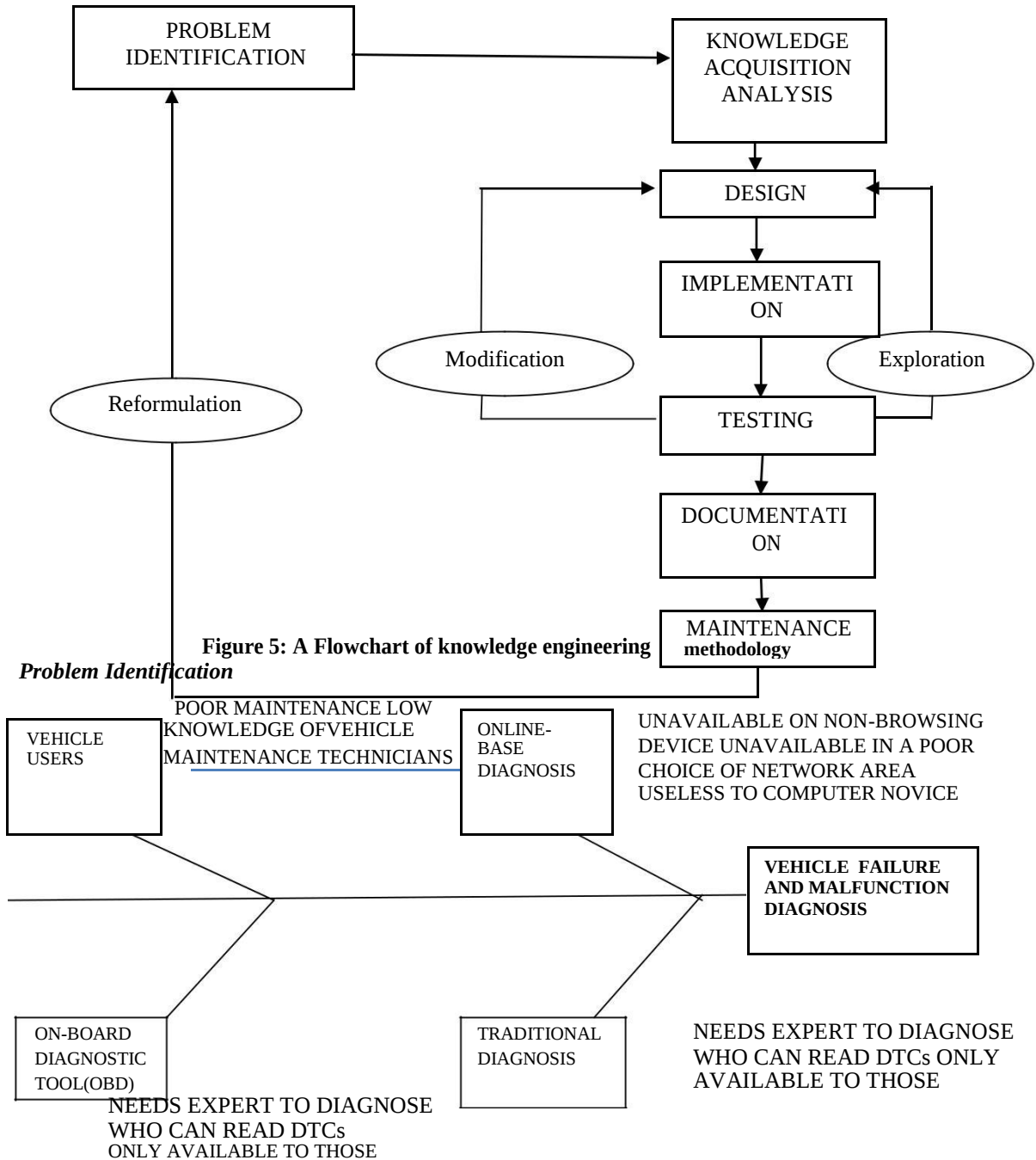
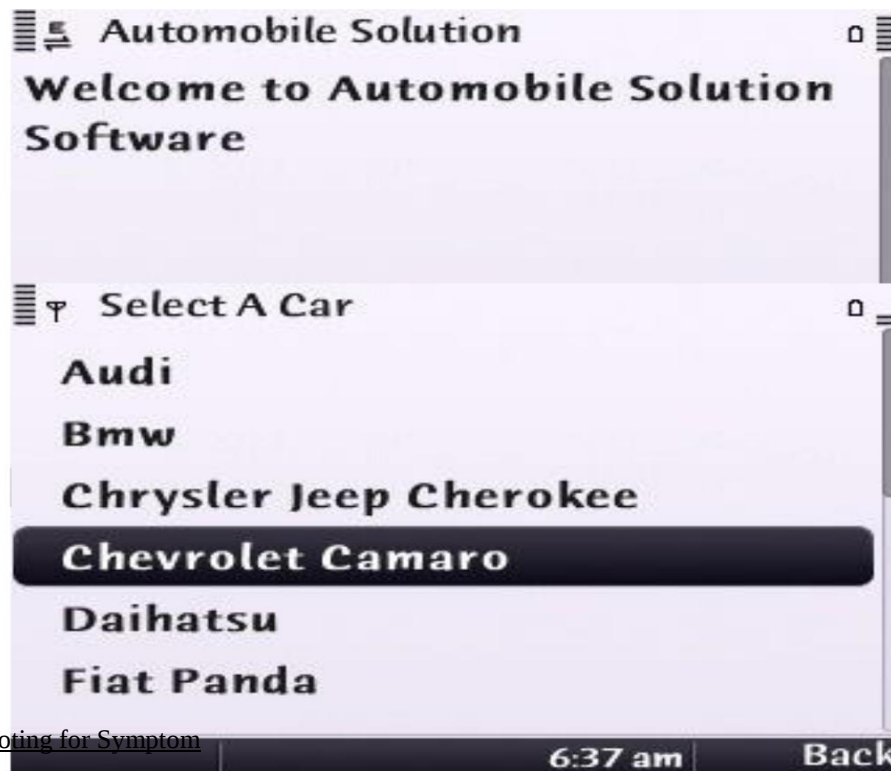


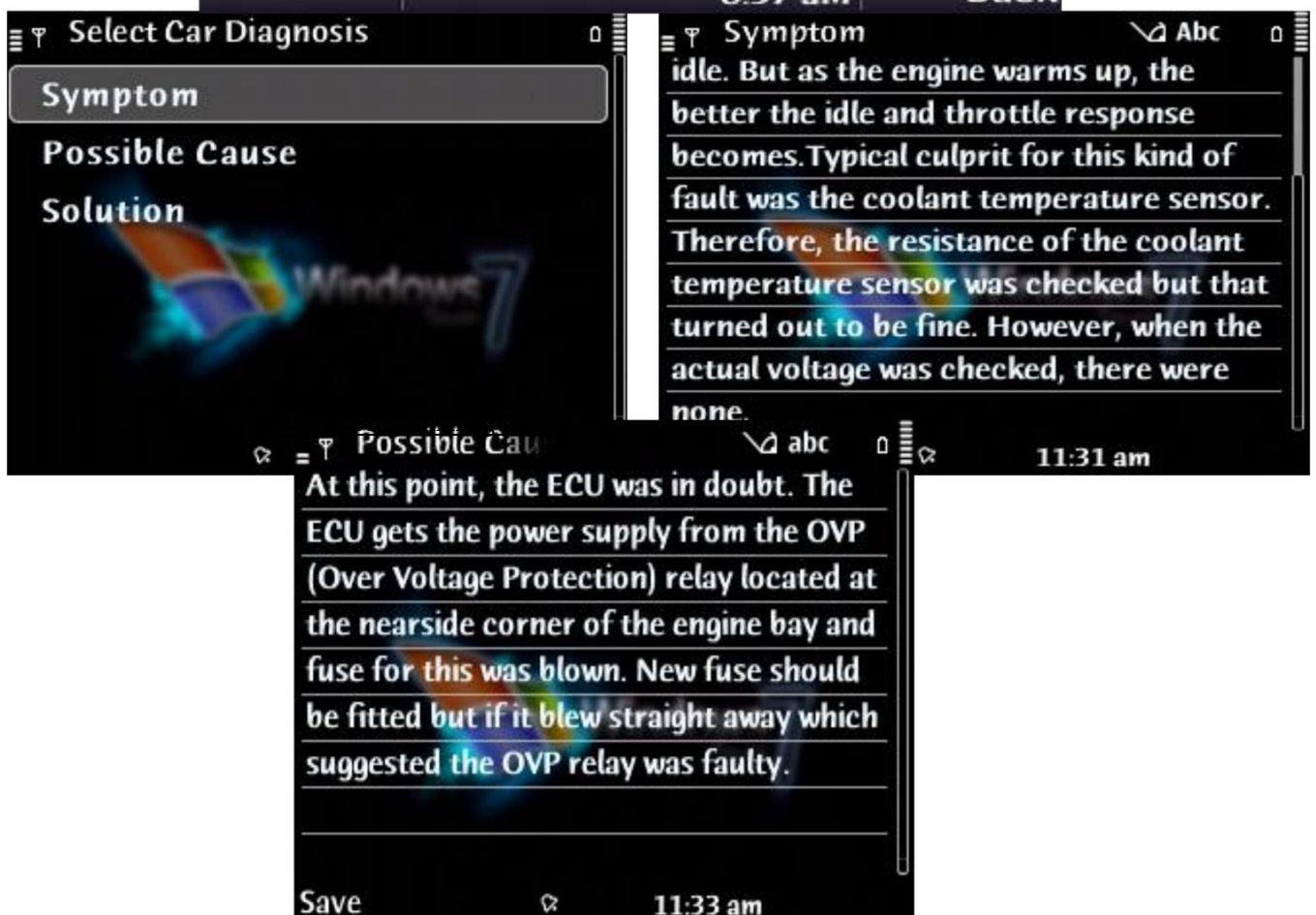
Figure 6. Ishikawa diagram showing problem of vehicle failure and malfunction diagnosis

Source: Authors

Design Analysis
Specifications



Troubleshooting for Symptom



JAVA was made the choice of programming language, been an object-oriented programming language that centres its concern on both data and process. Specific data and the process that create, read, update and delete that data are integrated into construct called an object. To operate the application, it would be deployed on a JAVA-enabled phone.

Conclusion

The research work covered the operations performed by automobile, vehicle, technical experts to rectify and solve certain malfunction and fault develop by vehicle. Systems such as VFMDAS can be highly useful in assisting mechanics for failure detection and training purposes. Moreover, capturing and retaining valuable knowledge on such domain yield more accurate and less time consuming models. Diagnostic systems are among the most successful applications of knowledge-based systems (KBS) technology. This is true both in terms of the number of applications built, and in terms of the benefits which such systems bring.

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