**CHAPTER ONE**

**INTRODUCTION**

* 1. **BACKGROUND OF THE STUDY**

Identification and detection of vehicular faults is not easy for inexperienced mechanical engineer or driver because a lot of knowledge and expertise is required for such fault identifications and detections. Therefore, most drivers and vehicle owners depend extremely on expert mechanical engineer for vehicles fault diagnosis. Vehicles comprise of cars, buses, vans etc. and they are all fault-prone due to their machine and continuous usage nature. Of course the subject of thermodynamics has proven beyond all reasonable doubt that, there is currently no such machine that can work continuously without taking energy from outside. Vehicles are nowadays used in a variety of activities by different walks of life and as such are not considered a luxury but rather a necessity. Individuals use vehicles to go to work and firms use vehicles for their transport and logistics activities. Individuals who cannot afford a vehicle such as a car usually employ the services of public transport buses for travelling purposes. As a result of such examples and scenarios, it can be realized that all types of vehicles have their individual uses and are necessary for our daily lives depending on our particular activities.

When there is a problem or a fault with a vehicle, drivers or vehicle owners normally call in for the services of mechanical engineers/automobile engineers for help. In cases where the diagnosed fault of the vehicle is of a high level and severity, it would be sent to an automobile shop for repairs.

It would have been appropriate if most vehicle owners were exposed to knowledge about vehicle components, how each component works, and how small problems could be solved. This is however impossible because some vehicular problems require technical knowledge to analyze and understand the problems. The technical knowledge and problem solving of vehicles is usually studied by mechanical and automobile engineers. Therefore if a vehicle owner or driver is an auto-mechanic then it becomes easier for him or her to apply a preliminary action or repair it immediately themselves in uncertain situations. In a situation where the vehicle owner or driver is not an auto-mechanic, there should be systems in place to help diagnose and solve vehicle problems. In such cases, the vehicle owner or driver may diagnose a problem wrongly and it may cause more severe problems to their vehicle. Also, in uncertain situations, vehicle owners and drivers need to cope with the unexpected problems as fast as possible. Vehicle fault detection and identification is not easy for inexperienced mechanic or driver because it requires a lot of knowledge for finding the fault. Therefore, they extremely depend on expert mechanic. For example, detection of fault diagnostics and repairs of a Bus is likely to be different since their mechanical parts are different in size, portability; durability etc. Dependence of the expert can be minimized if its expertise can be documented into a computer system. With rapid advances and proliferations in mobile devices such as Personal Digital Assistants, Smartphones and Mobile phones, an expert system, which is a computer software program used to solve problems, coupled with mobility and mobile devices will help vehicle owners detect faults and pre-diagnosis of vehicle faults.

In this paper, we propose a mobile expert system to diagnose vehicle engine fault for vehicle owners and drivers. Our proposed mobile expert system will be designed to detect faults of vehicles and produce a pre-diagnosis for vehicle owners or drivers. In cases where the vehicle owners or drivers cannot repair the vehicles themselves as a result of an acute fault and there is no automobile mechanic around, the expert system will advise the vehicle owner or driver on the probable cause of the fault and also advice for the services of a mechanic through a report of the pre-diagnosed fault.

With the expert system, the user can interact with a computer to solve a certain problem. This can occur because the expert system can store heuristic knowledge. Then the system can make inferences and arrive at a specific conclusion to give advices and explains, if necessary, the logic behind the advice. ES 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 often used synonymously.

The first expert system were created in the 1970s and the proliferated in the 1980s. Expert systems were among the first truly successful forms of A1 software.

The basic role of an expert system is to replicate a human expert and replace him or her in a problem-solving activity. In order for this to happen, key information must be transferred from a human expert into the knowledge database and, when appropriate, the inference engine. Two different types of knowledge emerge from the human expert: facts and procedural or heuristic information (Mittal, Kartikeyn, Vishal Dahiya, 2015).

Because computers are general symbols manipulating devices, the non-numeric and heuristic aspects of problem solving can be encoded in computer programs as well as the mathematical and algorithmic aspects (Newell, A. & Simon, 1976).

Artificial Intelligence research has focused on just this point. Working on expert systems is, in one sense, the applied side of AI, in which current techniques are applied to problems to provide expert-level help on those problems. However, there is more to building an expert system than straightforward application of AI techniques. In this early stage of development, each new application challenges the current stock of ideas, and many applications force extensions and modifications.

We focus on rule-based approach in building our application because they clearly demonstrate the state of the-art in building expert systems and illustrate the main issues. In a rule-based system, much of the knowledge is represented as rules, that is, as conditional sentences relating statements of facts with one another.

The first expert system was developed in 1965 by Edward Feigenbaum and Joshua Lederberg of Stanford University in California, U.S. Dendral, as their expert system was later known, was designed to analyzeChemical compounds. Expert systems now have commercial applications in fields as diverse as medical diagnosis, petroleum engineering, and financial investing.

In the late 1960's to early 1970's, expert systems began to emerge as a branch of Artificial Intelligence. The intellectual roots of expert systems can be found in the ambitions of Artificial Intelligence to develop “thinking computers”. Domain specific knowledge was used as a basis for the development of the first intelligent systems in various domain. Feigenbaum (1981) published the best single reference for all the early systems. In the 1980's, expert systems emerged from the laboratories and developed commercial applications due to the powerful new software for expert systems development as well as the new possibilities of hardware. Feigenbaum (1982) defined an expert system 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 solution". Differences from conventional programs include facts such as: An expert system simulates human reasoning about a problem domain as the main focus is the expert's problem solving abilities and how to perform relevant tasks, as the expert does. An expert system performs reasoning over representations of human knowledge in addition to doing numerical calculations or data retrieval using the knowledge base and the inference engine separately. An expert system solves problems using heuristic knowledge rather than precisely formulated relationships in forms that reflect more accurately the nature of most human knowledge dealing with symbolic values and procedures. The first diagnostic expert systems for technical fault diagnosis were developed in the early 1970’s at MIT as is reported by Scherer and White (1989). Since then numerous systems have been built. Surveys of the first diagnostic expert systems of technological processes are provided by (Paul 1986), (Tzafestas 1989), (Scherer and White 1989).

* 1. **STATEMENT OF THE PROBLEM**

When a vehicle develops a fault, mechanical/automobile engineers are usually employed to repair/solve the vehicle fault in question. The gravity of the vehicle fault may at times be minor and not so serious to seek help from an automobile/mechanical engineer.

The automobile/mechanical engineer may be too far away from the vehicle fault site or the vehicle owner or driver may also be in a hurry to arrive at his/her destination. Therefore vehicle owners and drivers need systems that can help them to have instant solutions, especially when the gravity of the vehicle fault is minor and not so serious to require help from an engineer. We believe that the use of a mobile vehicle expert system can be beneficial in such situations through giving temporary and instance guides to vehicle owners and drivers anytime and anywhere. We also note that, not all mechanical automobile/mechanical engineers have the required expertise to solve vehicle faults. An inexperienced mechanic may wrongly diagnose the fault of a vehicle, which can easily cause the loss of customer and income, with the advice of a mobile expert system which has a knowledge base of experienced human automobile/mechanical engineers, inexperienced mechanic will have a repository of knowledge at their disposal. Many vehicle owners don’t know how to check minor faults of their vehicles in order to keep them in a good and everlasting condition. A mobile vehicle expert system that is designed to diagnose and advice on how to repair a diagnosed fault of a vehicle, can aid a vehicle owner or driver to try and repair faults that develops on the vehicle at anywhere and anytime.

* 1. **AIM AND OBJECTIVES OF THE STUDY**

The aim of this project is to design/develop and propose a mobile expert system for vehicle owners and drivers in order to detect and diagnose automobile fault, whenever time is limited and the human expert, also known as mechanical engineer, is not available at that time of vehicle fault.

The objectives are:

1. To help improve knowledge of vehicle owners and drivers in diagnosing the problem of vehicle that, which will in turn reduce the level of problem severity and costs of vehicle maintenance.
2. To help mechanical engineers diagnose serious faults and repair vehicles at a faster rate through the pre-diagnosis and advice of a mobile vehicle expert system.
3. To develop the mobile vehicle expert system as a tool for the training and reference guide to inexperienced mechanical engineer.
   1. **SCOPE OF THE STUDY**

Our project work will be focused on creating a rule based expert system that will diagnose and suggest possible solutions to automobile fault.

The expert system may contain certain limits and flaws, as it is only a prototype. We commonly know that a car has many parts on its body and even in the body itself. However, the system will only deal with problems that are normally or commonly found in the engine area of the car as the system is just a prototype, which means the function will be expanded through time. The system will also deal with only 5 models/brands of cars.

* 1. **SIGNIFICANCE OF THE STUDY**

The proposed system will assist in reducing the stress car owner and automobile expert goes through when diagnosing a vehicle. This work is contributing to knowledge on the use of expert system in diagnosis and fault detection

In addition, the system has the following benefits:

* It improves productivity: it enable mechanics to do more work in less time.
* It captures the knowledge of company experts who someday will retire, resign or die thereby giving young and inexperienced mechanic leverage.
* It will train new employees to solve problem the way experienced professionals do.
* It gives consistent result.
  1. **DEFINITION OF TERMS**

**Artificial Intelligent:** Artificial Intelligence (AI) is a program that behaves like human expert

**Rule Based:** It is an approach used in expert system development to store and manipulate knowledge to interpret information in a useful way.

**Expert System:** This is system which uses databases of knowledge expert to offer advice, make decisions or proffer solution to problem.

**Inference:** It is a conclusion reached on the basis of evidence, fact and logical reasoning.

**Actuator**: This is a device in a car that uses electricity to do sort of automated mechanical movement such as power door locks or a remote trunk opener.

**Car Sensor**: This is a technological device that dictates or senses a signal or a physical condition in a car.

**Car Diagnosis:**  Is the identification of the nature and causes of problem in a car.

**Car Brain Box:** This is an electronic device that incorporates microprocessors5 for the monitoring and control of various functions in a vehicle.

**Anti-lock Braking System (ABS):** The Anti-lock Braking System ABS helps the driver maintain the steering control during hard braking.

**Alternator:** An alternator supplies the electric power for the vehicle’s electric systems and charges the battery when the engine is running.

**Crankshaft Position Sensor (CKP):** This is the primary sensor of the electronic fuel injection and ignition system.

.**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 AUTOMOBILE DIAGNOSIS**

An automobile like any other machines is created to make things easier for man as it serves his purpose for his convenience. A car when purchased is usually in near perfect working condition. However over time, due to continuous use, neglect or wear or environmental influence the vehicle begins to experience some fault. This can be the most stressful period for most vehicle owners, especially those who don’t have any idea on what to do.

There are also situation in which auto technicians are either unavailable or costly to hire. A motorist with a broken down vehicle on a long, empty stretch of road in the middle of the night is unlikely to get any help from a mechanic. It would also save a lot of money if vehicle owners could carry out minor repairs on their cars themselves, and even if the situation arises that the vehicle be taken to the repair shop, the car owner could avoid being bamboozled if he or she has an idea of the internal fault.

We have some testing equipment and procedures which are necessary to any effective diagnosis of automobiles faults example are;

* + **Digital Multi-Meter:** It is use to test for basic voltage (alternate current and direct current) resistance, frequency duty cycle, temperature etc. it is also adequate for detecting electrical faults.
  + **Exhaust Gas Analyzer:** It measure the types of gases presented in the exhaust pipe (oxygen, carbon dioxide and hydrocarbons). It is used to diagnose fault in ignition, fueling and various mechanical engine problems.
  + **Jump Lead:** It provides emergency power to the battery.
  + **Fuel Pressure Test Kit:** IT measures fuel pressure up to 7.0 bars.
  + **Vacuum Gauge:** It takes the pulse of the engine from a connection to the inlet manifold and is useful for diagnosing timing and mechanical faults.
  + **Spark Jumper:** It use to checks for a spark from plugs whilst cranking the engine.

Other tools are like spanners and pliers. Apart from having all this testing equipment’s, there are still some necessary basic inspections, required by the car owners to undergo daily. Such inspections are;

* To check the engine oil, level and condition
* To check coolant level and coolant system condition
* To check the automatic transmission fluid level and condition.
* Check battery condition
* Check battery electrolyte level
* Check battery cables and connections
* Check fan belt condition and tension
* Remove spark plays and check the condition renew if necessary.
* Look for cracks and sign of tracking
* Check the rotor condition and measure the resistance where appropriate.
* Checks for freedom from vacuum leaks from the vacuum hoses, inlet manifold, oil dipstick.
* Clean away accumulated sludge, and assure that the hoses are clean.
* Check air filter condition renew if it is slight dirty
* Check exhaust system condition
* Check fuel system condition check for fuel leaks worn or broker components.
* Visually inspect all connections, multi plugs and terminals. Check for corrosion and loose or displayed terminals.
* Check the throttle body for a carbon build-up usually as a result of fumes from the breathing system. The carbon can cause of fumes from the breathing open throttle which can cause idle, cursing and other running problems carburetor clearing fluid usually cleans away the carbon nicely.

**2.2 RULE BASED APPROACH**

Using a rule based approach; a component expert system can be developed to carry out a thorough diagnosis of automobile engine faults, diagnosing the possible faults associated with each symptom and a correctional procedure for each of them. When we are talking of an expert system technology we are referring to a “computer software system that emulates the decision making ability of a human expert”. It performs diagnosis on the problems and gives advice on what the cause of that problem are and can also tell the possible solutions to the problem.

A typical component of a rule- based expert system integrates the following:

1. **Knowledge Base**

This is a problem domain that specifies the knowledge base which stores the encoded knowledge to support one problem domain such as diagnosing why a car won’t start. In a rule based expert system, the knowledge base includes if then rules and additional specifications that control the course of the interview (sell, 2005).

1. **Inference Engine**

A set of rules of making dedications from the data and that implements the reasoning mechanism and controls the interview process (Townsend 2007). The inference engine might be generalized so that the same software is able to process many different knowledge bases.

1. **Users Interface**

This request information from the users as input and give intermediate and final results as output (Edmurals, 2009). In some expert systems, inputs are acquired from additional sources such as data based and sensors. An expert system shell consists of a generalized inference engine and user interface designed to work with a knowledge base provided in a specific format (Liebowitz, 2008). A shell often includes tools that help with the design development and testing of knowledge base with the shell approach expert system representing many different problem domains may be developed and delivered with the same software environment (Basri H, 2008).

The user interacts with the system through a user interface which may use means natural language or nay other style of interaction. Then an interface engine is used to reason with both the expert knowledge (extracted from our friendly expert) and data specific to the particular problems being solved. The expert knowledge will typically be in the form of a set of if – then rules.

The case specific data includes both data provided by the users and partial conclusions (along with certain measures) based on this data. In simple forward chaining rule based system the case specific data will be the elements in working memory.

**Expert**

**Knowledge Engineer**

**Data**

**User Interface**

**User**

**Knowledge Engine**

**Inference Engine**

Fig 2.1: **structure of a rule base expert system model**

* Knowledge base models a human’s long term memory as asset of rules.
* Working memory- models a human’s short term memory and contains problems facts both entered by the firing of the rules.
* Inference engine- model human reasoning by combining problem facts contained in the working memory with rules contained in the knowledge base to infer new information.

Based on these concepts of reasoning which emulates the human problems solving strategies the expert system is structured accordingly to the fundamentals of it.

As used in the paradigm of problem – solving by this expert system for car faults diagnosis, the expert system has four basic elements which are adapted from the model of rule based system. Once the user logs in to the expert system, they will be asked questions which should be modeled according to the current problems. These new information will be entered to the working memory where the system will match this information with the knowledge contained in the knowledge base to infer new facts.

Eventually the system and the conclusion are also entered into the working memory before displaying to the user through the interface. The four modules involved in the rule- based expert system are;

* Knowledge base
* Working memory
* Inference engine
* Interface

Townsend (2009) noted that an expert system is a computer program that uses knowledge and reference procedures to solve problems that are difficult enough to require significant human expertise for their solution. Simply stated expert systems are computer programs designed to mimic the thought and reasoning processes of a human expert. Expert system can be developed for many kinds of applications involving diagnosis, prediction, interpretation and instruction (Edmunds, 2010). According to Townsend (2009) diagnosis still remain the primary application computers. They are used in application where the procedures or algorithms for the problems do not exist or are poorly defined.

Today, better development tools are available and closer interdisciplinary cooperation is resulting in agricultural researchers gaining more insight into the theory and concepts necessary to build effectives systems (crass Weller, 2011). Several notable expert systems have developed in recent years. For example, CALEX is an expert system which was developed for the diagnosis of peach and nectarine disorder by the University of California, (plant 2006) like most experts systems, CALEX is rule based and uses certainty factors so that the knowledge base consists of production rules in the form of if, then statements. The inference engine pieces together chains of rules in an attempt to reach a conclusion.

The knowledge base of the CALEX peaches and nectarines, representing most of the disorders in California (plant 2006) CITPATH, a computerized diagnostic key and information system was developed to identity five major fungal diseases of citrus foliage and fruit in Florida (Ferguson, 2005). CITPATH also utilizes rule based approaches which provide heretics- linked description and graphics displays of symptoms with reference to chemical control methods. (Ferguson 2005).

The Penn state apple orchard consultant (PSAOC) is an example of another type of expert system which has demonstrated the advantage of using specialist from different areas to develop large integrated modules.

Crass Weller (2009) observed that horticultural applications presently developed include modules for weed control, folia analysis interpretation and trickle irrigation scheduling and visual diagnosis of nutrient deficiencies. VITIS, a grape disease management expert system has also been developed similarly in cooperation with specialist from Pennsylvania, New York Ohio and Michigan. The VITIS model was also used as a model for Austvit, an Australian viticulture management expert system.

Travis (2002) observed that Austvit use the same logic in the approach to decision and integrates viticulture entomological and plant pathological decision making to arrive at an integrated recommendation (Edmunels, 2008, Liebowitz, 2008 plant 2009, sell 2009). The participation of a knowledge expert one who bus received specialized training or gained knowledge through years of experiences is required (Townsend 2007, Jones 2009). The knowledge must be captured and stored in a manner that can be used to make decision. It should require a human expert a limited…of time to solve. A well-developed system should be able to read world problems and be able to communicate information to non- expert users (plant, 2009).

**2.3 THE CONCEPTUAL STRUCTURE OF AN EXPERT SYSTEM**

After reviewing the outcomes of the research, the fundamental and basic concept of expert system was then identified in order to guide the brainstorming for determination of problems domain. Once the problems domain is determined it was used and set to be the title of the system development. Besides that, through the researcher and reviews done, all the underlying concept of the expert system development was recognized which includes the critical elements involved in the development; the technology needed compatible software and hardware as well as the issues of humans’ social life and systems reliability.



**Figure 2.2: Architecture framework of an Expert System (**Source: **Nana Yaw Asabere, Simonov Kusi-Sarpong / International Journal of Engineering Research and Applications (IJERA)**

**2.3.1 PROBLEM ASSESSMENT**

Based on the concept of expert system acquired in the conceptualization phase, the problem domain for the development of the system was then determined.

In this phase the appropriateness of the problem was taken into consideration as to make sure that it is suitable to be solved by expert system.

**2.3.2 KNOWLEDGE ACQUISITION**

Expert system is all about applying human expertise into computer verse, which is based grandly on the integration of human knowledge with the system. Thus knowledge acquisition is the heart of expert system. After the problem domain was determine in the previous phase, the knowledge and information based on the problem was then acquired. Therefore, the knowledge sources have also to be ascertained which could be the experts in the domain itself. But in the development of this expert system for car faults diagnosis most of the information and knowledge gathered was acquired from the internet, the sites that contain quite lots of information on car or automotive maintenance and troubleshooting by various experts namely mechanism.

At the early stage, the information gathered was general and the key concept of car troubleshooting was unearned. Later, information was gained from system testing to explore more detailed information. Knowledge acquisition is a time consuming process in which the knowledge engineer works alongside the participating expert and extracts, structures and organizes the information to be presented in the expert system (Bergsma, 2003).

Knowledge acquisition requires no standard methodology for extracting knowledge. However, it usually involves a progressive number of personal interviews of the experts to record information pertinent to the knowledge-based occasionally, the role of the knowledge engineer can be significantly reduced if the understanding of the development processes by the participating experts are substantial and they are willing able to organize and express all the necessary information to develop facts or rules based on their personal heuristics. Consistency in the naming conventions of facts or rules in vital and the ability to develop a language which is familiar to the end users is also important.

Acquired knowledge should be played back to experts perhaps using a different medium them the one used to acquire it (Townsend, 2007), during the knowledge acquisition phase, the knowledge engineer should identify the conclusions that the experts system should render and verify this knowledge as it is acquired. Knowledge acquisition should also be supplemented with a thorough review of current literature to provide the most available up-to-date information (sell, 2005).

**2.3.3 KNOWLEDGE REPRESENTATION**

A representation is a set of conventions for describing the world. In the parlance of AI, the representation of knowledge is the commitment to a vocabulary, data structures, and programs that allow knowledge of a domain to be acquired and used. This has long been a central research topic in AI (Horn, W., Buchstallcr, W., and Trapp, R.1981).

The results of years of AI research on representation have been used to establish convenient ways of describing parts of the world. No one believes the current representation methods are the final word.

However, they are well enough developed that they can be used for problem solving in inter domains. As pointed out above, a central concern is separation of the choice of vocabulary and data structures from the choice of program logic and language. By separating a program’s knowledge base from the inference procedures that work with the knowledge, we have attained some success in building systems that are understandable and extendable.

Three basic requirements on a representation scheme in an expert system are extendibility, simplicity and explicitness.

1. **Extendibility**

The data structures and access programs must be flexible enough to allow extensions to the knowledge base without forcing substantial revisions. The knowledge base will contain heuristics that are built out of experts’ experience. Not only do the experts fail to remember all relevant heuristics they use, but their experience gives them new heuristics and forces modifications to the old ones. New cases require new distinctions. Moreover, the most effective way we have found for building a knowledge base is by incremental improvement. Experts cannot define a complete knowledge base all at once for interesting problem areas, but they can define a subset and then refine it over many weeks or months of examining its consequences. All this argues for treating the knowledge base of an expert system as an open-ended set of facts and relations, and keeping the items of knowledge as modular as possible.

1. **Simplicity**

We have all seen data structures that were so baroque as to be incomprehensible, and thus unchangeable. The flexibility, simplicity and uniformity of data structures is required so that access routines can be written (and themselves modified occasionally as needed). Once the syntax of the knowledgebase is fixed, the access routines can be fixed to a large extent. Knowledge acquisition, for example, can take place with the expert insulated from the data structures by access routines that make the knowledge base appear simple, whether it is or not. However, new reasons will appear for accessing the knowledge base as in explanation of the contents of the knowledge base, analysis of the links among items, display, or tutoring. With each of these reasons, simple data structures pay large benefits. From the designer’s point of view there are two ways of maintaining conceptual simplicity: keeping the form of knowledge as homogeneous as possible or writing special access functions for non-uniform representations.

There is another sense of simplicity that needs mentioning as well. That is the simplicity that comes, from using roughly the same terminology as the experts use. Programmers often find ingenious alternative ways of representing and coding what a specialist has requested, a fact that sometimes makes processing more “efficient” but makes modifying the knowledge base a nightmare.

1. **Explicitness**

After the domain has been identified and knowledge acquired from a participating expert a model for representing the knowledge must be developed. Numerous techniques for handlings information in the knowledge-based are available; however, most expert systems utilize rule based approaches (Townsend, 2007). The knowledge engineer, working with the expert, must try to define the best structure (Jones, 2009). Other commonly used approaches include decision tress, blackboard system and object oriented programming.

**2.3.4 VERIFICATION**

Prior to testing of an expert system with outside experts, every query response which should lead to a correct conclusion or diagnosis should be systematically verified with the knowledge-based. Experts systems which utilized visual images to supports text should also be verified to ensure each image correctly corresponds to the specific symptoms described.

**2.3.5 VALIDATION**

This should be done by the primary expert who was involved in the systems knowledge based development and knowledge representation. This phase provides the experts with the opportunity to explore the functioning expert system and make suggestions for changes in the interface design, image database or knowledge base. Generally, the system should be challenged by the expert by presenting contrived problems or queries based on past field experience. Again, the system should be adjusted to eliminate any conflicts or design problems.

Validation provides the final opportunity to evaluate an expert system prior to testing by additional experts concede to the development of a credible prototype which provides a reasonably accurate ability. Although validation is an essential phase to expert system development, problems of access to expert assistance, time and resources constraints can often make validation procedure impractical or limited.

**2.3.6 TESTING**

When the knowledge engineer and the expert are satisfied that the expert system is complete, the system should be tested against and agreed upon performance criteria. At this time other experts can be invited to evaluate and use the system for testing purpose. Either real world case scenarios or stimulated case can be used for testing purpose. Once the system has been adequately tested and found to meet a defined level of accuracy, efficiency and reliability, a final version can be prepared for distribution and use.

However, in the event, if the system does not perform adequately, further verification or validation and field testing may be necessary before making a final version of the system available to the intended audience.

**2.4 STEPS IN DEVELOPING AN EXPERT SYSTEM FOR DIAGNOSIS**

The biggest obstacles in developing expert system is extracting knowledge from the human experts and transferring into computer code. For this reason, the process of constructing an expert system is known as knowledge engineering and the system builder is referred to as knowledge engineer (Feigenbewin, 2007).

Expert system development includes five-step phases:

1. **Problem identification**

Problem identification corresponds to the first step in expert system development life cycle. Generally, all accounts of expert system projects have assumed that the problem has already been identify and have gone on to describe the development and architecture of the system detail. However, as with another information system project, there are typically numerous business problems existing concurrently that could be potential candidates for expert system solution. Thus, selection decision must be based on essentially a subjective evaluation of the feasibility of the system, its critically in terms of addressing a pressing business concern and the opportunity costs of not having such a system.

1. **Problem conceptualization**

An initial discussion between the knowledge engineer and the expert helped clarify the scope of the system, its basic feature in more detail, and to identify a sub-problem that could be implemented relatively quickly in order to obtain feedback from the expert system.

1. **Formalization**

Knowledge for developing an initial understanding of the domain and its subsequent refinement was acquired from two individuals: a design engineer who was the designated ‘expert’ on the project, and another expert who was currently performing the task on a daily basis. These techniques helped extract the ‘private’ knowledge of the expert that was not explicitly documented.

1. **Implementation**

A clarification with respect to terminology is appropriate here. Implementation, relates to the translation of domain concept into machine manipulate form, in traditional system that activity is frequently called programming, and implementation has a much broader connotation in that it specifies what happens after the system has been completely developed, we will use the term implementation here in the manner that it was intended to be used in ES development and later expand its coverage to include the issues of handing over the system to its clients.

1. **Testing**

Performance verification for expert system is critical as the risks inherent in a system that delivers incorrect advice can be enormous. It has been recommended that multiple feature of an expert system, including its recommendations, the reasoning modeled in it, the user interface and the expiations facilities are subject to testing and validation.

**2.5 REPAIR STRATEGIES IN A DIAGNOSTIC EXPERT SYSTEM**

From the work of Clancey, it is recommended that test repair is a straightforward selection tool that can aid a successful diagnostic application in expert system. The author also state that the overview of Troubleshooting Expert System Tool, TEST in the repair strategies included overview of verification, alternative diagnostic and sequencing. Few other researchers agreed with the work of Clancey and they differently concluded that the repair strategy of the Expert System is keyed to a successful and systematic diagnostic flow process and conclusion. In a few cases, supplementary repair or treatment modules have been developed to provide customized or special case recommendations. However, apart from the work of Hoffman, none of this work has attempted to formulate an approach which permits the degree of integration of diagnosis and repair tasks required to effectively troubleshoot faults in complex machines.

Pepper and Kahn, proposed the Troubleshooting Expert System Tool, TEST, as a diagnostic tool that recognizes a large class of integration issues and provides a representation more easily customized to differences in repair strategy, even within the same application domain. TEST is an application shell that provides a domain-independent diagnostic problem solver together with a library of schematic prototypes. Tedesco reported that the largest application of TEST since 1985 is that of Ford Motor Company’s Service Bay Diagnostic System. Other applications include factory floor machine diagnosis, online monitoring of generator equipment, computer performance tuning, PLC controlled manufacturing equipment, etc. TEST strategy has also been implemented in Common Lisp using Knowledge Craft.

Construction equipment range from the very heavy equipment to the portable and mobile lighter equipment, some of them with a precise description of their fuel functions. A crawler, which is very powerful and attached with a blade, is called a bulldozer. Even though any heavy engineering vehicle is known as bulldozer, it is actually a tractor with a dozer blade in this case. Diagnostic applications remain the most heavily explored area of expert systems technology, but little attention has been given to the selection, sequencing and interactive verification of repairs. These aspects of diagnostic behavior, collectively referred to in this paper as repair strategy, are critical to the success of a real world machine diagnosis expert system. While it is easy to imagine a prototypical diagnostic system that identifies a single cause for observed symptoms, and recommends the corresponding, inevitably successful repair, this is an ideal but unlikely case. More often, technicians make repairs during the diagnostic process itself, and are prepared to:

1. Select from among competing repair alternatives.

2. Delay making certain repairs until deeper causes is identified.

3. Continue with the diagnosis if the repair does not succeed.

**2.6 RELATED WORKS**

Expert system has been used as a diagnostic tool in many fields such as medicine, agriculture and automobile

**2.6.1 MEDICINE**

MedFrame/KBuilder a Web-Based Knowledge Acquisition System for Medical Expert System by K. Boegl, K.-P. Adlassnig was created by Department of Medical Computer Sciences, Section on Medical Expert and Knowledge-Based Systems, University of Vienna Medical School, Spitalgasse 23, A-1090 Vienna, Austria.

Knowledge acquisition is a central concern in the development of medical expert systems. Beside the fact that the elicitation and acquisition of expert knowledge is a difficult and time-consuming task , one of the major difficulties in building medical knowledge bases are the lack of time and the limited availability of medical experts.

The goal was to develop a knowledge acquisition tool, the MedFrame/KBuilder Toolkit that allows a collaborative construction of medical knowledge bases by multiple experts via the Internet. The experts should be enabled to perform this task in a collaborative manner and without support by a mediating knowledge engineer.

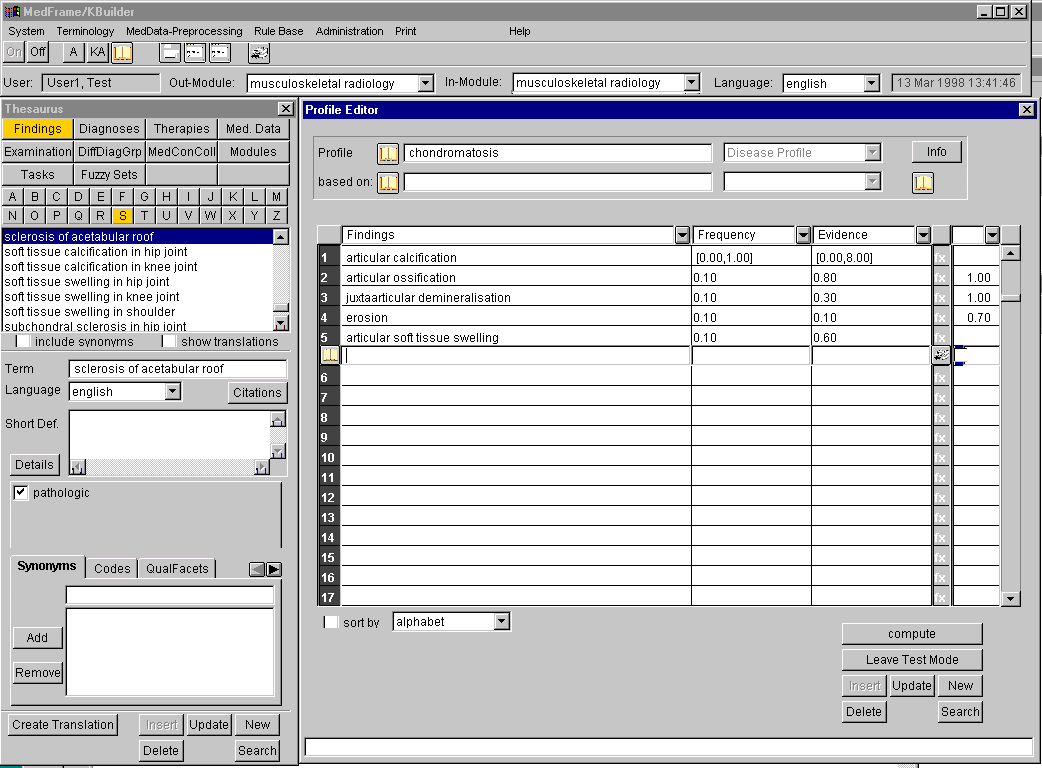
The MedFrame/KBuilder Toolkit is a Java application that is integrated in the MedFrame system, which is a common platform for a variety of medical consultation systems that are designed to support diagnostic and therapeutic decision making in various medical domains.

The MedFrame/KBuilder Toolkit supports all subtasks of knowledge acquisition: The definition of medical concepts (findings, diseases, therapies), of (fuzzy) logical rules, of ‘disease profiles’, of data-to-entity conversion rules (translation of “raw” observational and measured quantitative data into symbolic concepts), the encoding of medical concepts (SNOMED, ICD-10), and many others.

The MedFrame/KBuilder Toolkit was tested at the Department of Radio diagnostics of the Vienna General Hospital . Knowledge bases in the fields of diagnostic radiology were established. It was shown that the experts were able to transfer their knowledge into a “computerized” form with little or no support by a knowledge engineer.

MedFrame/KBuilder was programmed in Java (Java Development Kit (JDK) 1.1.7) and was tested on Windows95/NT and UNIX platforms.

The availability of the program via Internet and the intuitive and easy-to-handle graphical user interface are highly appreciated by the medical experts. As a result, building medical knowledge bases is accelerated and the maintenance cycles of existing knowledge bases can be shortened.

Boegl, K. (1997) Design and Implementation of a Web-Based Knowledge Acquisition Toolkit for Medical Expert Consultation Systems.

**Figure 2.3: (K. Boegl (1997). Section on Medical and Knowledge-Based Systems** Retrieved from **http://www.meduniwien.ac.at/mes/medframe\_e.html)**

**2.6.2 AGRICULTURE**

Another example is an Expert System of Extension Developed By Indian Agriculture Research Institute & Indian Agricultural Statistics Research Institute.

This Project is meant to provide required information and expert advice to the farmers and extension workers at Krishi Vigyan Kendra’ s according to their needs & available resources. For example: - On the basis of symptoms supplied by the farmer, diseases affecting the crop can be detected which practices should be adopted according to the geographical locations or climate for a better yield, etc.

To categorize agriculture in sub-areas & collect relevant information of these areas to feed into database to make decision rules to process the information. To design & develop the web based expert system in extension. To provide required information to the farmers and extension workers to take decisions before starting the agricultural enterprise. It is an Expert System of Maize Collaborated with Directorate of Maize Research.

Figure 2.4: Disease Diagnosis

**2.6.3 AUTOMOBILE**

The automotive wolf car maintenance schedule software created and designed by professionals for anyone to use with any car, truck or almost any type of vehicle, it is perfect for the average family car owner.

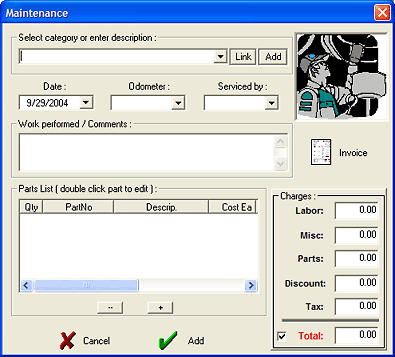
****

Figure 2.5: http://www.lonewolf-software.com/Automotive%20Wolf%20Info.htm

**CHAPTER THREE**

**SYSTEM ANALYSIS AND DESIGN**

* 1. **ANALYSIS OF THE EXISTING SYSTEM**

An expert system to detect and diagnose an automobile fault is typically designed and developed to help vehicle owners and driver proffer solution or give clues on how to repair their faulty vehicles.

Some automobile expert systems are developed as a desktop application operated by an automobile expert to diagnose faulty vehicles using Question & Answer approach. While some automobile expert system uses interface connectivity between the expert system and the vehicle which allows the expert system to perform an underground diagnosis of the vehicle and display the result on a screen. This is also known as on-board diagnosis system (OBDS).

The Mobile Vehicles Expert System (MVES) is another system deployed to diagnose vehicle fault. It uses mobile phone and the front-end allows you to Add New Customer, and customers can also add or subscribe themselves to the system by providing relevant information such as Confidential ID, Name, Address, Mobile Phone Number, E-mail and Type of Car. A wide Area Network connection is needed by the application in order to attain its full functionality which is a setback for the system. Also, there is a need for user authentication before users can make use of the application. It is also limited to the problems of sparking/starting the engine and how to solve the problem of a vehicle’s cooling system.

* 1. **DESCRIPTION/ANALYSIS OF PROPOSED SYSTEM**

The proposed system will constitute the system architecture and the basic flow diagram for Mobile Expert System to Detect and Diagnose Automobile Fault.

The project assist vehicle owners and drivers to detect and diagnose fault related to vehicle engine when automobile expert services is not available. It will also allow the automobile expert to have pre-diagnosis report before tackling any fault and serves as a reference guide to both experts and mechanical engineering students.

The proposed system provides user friendly interfaces, which allows easy interaction between the users and the system. The project comprises of five (5) main menus namely;

1. **Mechanical Engineering Dictionary:** A repository for technical terms relating to mechanical engineering field.
2. **Automobile Doctor:** An interactive interface of Question and Answers in the knowledge engine provided domain by the domain expert (Rule Base Approach).
3. **Tip of the day:** A daily routines pop up dialog box or notification that instruct the user to perform routine check on vehicle.
4. **Search Engine:** This can be used to search for a particular fault; the result will be the cause of the fault and possible solution to the fault. This is just to ensure if the diagnosed result of the automobile expert or vehicle owner from the **automobile doctor** is correct.
5. **Report/Diagnosis Log:** This helps to track the entire fault associated to a vehicle. It will also enable automobile expert to know the history of fault associated with the vehicle which will be very helpful in the actual repair.

**Diagnosis**

**Problems cause**

**Corrective measures**

**Interface**

**Mechanical Engineering Dictionary**

**Automobile Doctor**

**Tip of the Day**

**Report/Diagnosis log**

**Search Engine**

**DB**

**Figure 3.1: System Architecture of Mobile Expert System to Detect and Diagnose Automobile Fault**

**3.1 RESEARCH APPROACH**

The research method involved in this project is through personal interview, observation, discussion and gathering of information on the internet.

**3.1.1.1 OBSERVATION**

Observation of the function of the existing system gives the idea for the design of the new system. This will figure out the pitfalls of the current system. It is helpful to understand and study the entire current system. By observation we can point out the changes needed to the existing system. It also validates the data gathered by other means. It also gives a better understanding of the workloads & pressures faced.

**3.1.1.2 INTERVIEW**

The main objective of the interview is to gather informationregarding the system from the domain expert (automobile expert) in order to obtain a knowledge base for the expert system. This may be an oral interview or by use of a questionnaire.

The interviewer must be careful to ensure that the actual thoughts of the domain experts are captured in order to ensure an expert system that would run effectively.

**3.1.1.3 DISCUSSION**

The discussion is to transfer the ideas or knowledge received from the interview between the domain expert and the system developer. Through discussions, the problem faced by the user during data entry, data retrieval, report generation can be understood.

* 1. **System Design**

The system design is set of interacting or interdependent pages forming an integrated framework.

A system design is also a network of interdependent components that work together to accomplish the aim of the system. A system must have aim. No single component can survive in isolation but a sub system can survive on its own. A sub system is a group of interrelated and interactive parts that performs an important function or task as a component of a large system.

System design is the process of defining the architecture, interfaces, modules and data for a system to satisfy specified requirements. The elements of a system are inputs and outputs, processor, control, environment, feedback, boundaries and interface.

The proposed project is expected to be a mobile application which will be tested on a device using android operating system which will be made up of several pages and modules. The project uses interfaces that are interactive with the back end program known to be the database server called Xampp which contains Mysql database (My Structured Query Language) while the interface were develop using java android technologies, Xml fragments and activities.

**3.3.1 Input Design**

The database requires tables of entities that contain different fields and attributes that define the entity. We have tables populated with selected vehicle’s faults relating to car engine, their symptoms and corrective measures to the problem. Also, there is a mechanical engineering dictionary where users can type in words to look up technical terms and terminologies and a search engine that allows users to read up on their diagnosed results.

**3.5.2 Output Design**

This is where the designed form on which our desired output is displayed and it has to do with the actual interface. In the output design, we have report such as:

* Diagnosed report
* Diagnosed report log
* Searched result from the mechanical engineering dictionary and search engine
* Tips of the pop up notification dialog

**3.3.3 Database Design**

The database use will be designed using MySQL technology. This database makes use of tables for retrieval and insertion of information. Appropriate data fields (data structure and validation rules) were formulated to serve as tools. It is also used to facilities queries, hold records as well as create queries and reports. The database is populated with few selected vehicle’s faults relating to car engine, their symptoms, and corrective measures to the problem. Also, the diagnosed report is mapped to its corresponding fault based on the input of the users.

**3.3.4 System Flowchart**

The system flowchart diagrammatical describes the stages involved in the student’s phase for selecting a particular exam, evaluating it and displaying the result.