Nov. 2014. Vol. 5. No. 06 ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

AN EXPERT SYSTEM FOR DIAGNOSING FAULTS IN MOTORCYCLE

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ABSTRACT

Most of the people especially in the Africa sub-region preferred using a 2-wheeled vehicle to a 4 –wheeled vehicle personally or for commercial purpose because it is easily affordable and the cost of maintenance is very cheap. This is so because of the poor state of economy in the region.
The principle of thermodynamics has proved that a functioning engine could at times develop one fault or the other and there is therefore a need to diagnose such fault in order to repair or rectify it. This research work presented an expert system for diagnosing faults and profound possible solution using artificial intelligence principles.
Different rules are defined using forward chaining and implemented with CLIP programming Language.

Keywords: ***Thermodynamics, expert system, Artificial Intelligence, Forward Chaining, CLIP***

1. INTRODUCTION

One major difference between living and non living things is that living creatures have the ability to move from one place to another whereas non living things cannot. Man is also a typical example of living organism that moves from places to places for one reason or the other especially when struggling for the daily bread. This brings us to the idea of transportation which is defined as the movement of people, animals and goods from one location to another.

For man, there are different types of transportation. These include transportation by land, Water and Air. Transportation by water is only possible where there is a big river through which boats /ships can be used as a means of transportation. Transportation by air is considered too expensive and therefore not affordable by average citizen especially in the Africa sub-region. Therefore transportation by land seems to be the most common type that is easily affordable. For this purpose, commercial cars, buses, Lorries, tankers are available for various transportation services. For comfortability, individuals can also afford to buy a car or bus or motorcycle for private usage. Vehicles used in daily lives are no more considered as a luxury but a necessity. They are very helpful in our movement, logistics and transport activities [5].

Unfortunately, most of the average citizens especially in the Africa sub-region cannot afford to buy a 4-wheeled vehicle on their own because of their poor state of economy. Therefore they prefer buying a two-wheeled vehicle which is popularly referred to as motorcycles. People prefer motorcycle to a four wheeled transport for the following reasons:

It is very cheap and easily affordable by individuals. It has been established that it is very economical in terms of fuel consumption compared to 4-wheeled vehicle. Again when you consider the issue of maintenance, it appears to be very cheap to maintain and the brand new spare parts are very much available and quite affordable. No wonder, most people at lower class can afford to have at least one motorcycle nowadays either for personal or for commercial purposes.

However, the subject of thermodynamics has proved beyond all reasonable doubt that, there is currently no such machine that can work continuously without taking energy from outside [5]. Hence, there are gradual wears and tears of the engine. The machine therefore continues to develop one fault or the other.

Motorcycle just like any other vehicle can develop fault anywhere and anytime. Under such circumstances, it might be extremely difficult to seek for the service of mechanical or automobile engineers. The service of roadside mechanic may not also be readily available.

This research work is out to render a wonderful assistance in such situation. The proposed expert system for diagnosing motorcycle faults will also be of good assistance not only to the owner or the riders but also to engineers and roadside mechanics who might have reason to seek for more knowledge or assistance why they are on the field.

When motorcycle developed fault, the rider will have to call for the service of an Automobile engineers or a roadside mechanic simply because he/she has no technical skill and knowledge required to diagnose such faults. Even when the faults is not a major type, the attention of an engineer or expert is still required otherwise in an attempt to diagnose such fault, a faulty diagnosis may be carried out which further aggravate the problem an ground. Dependence on the expert can be minimized if its expertise can be documented into computer system [6][9].

This research work therefore proposes an expert system for diagnosis of motorcycle faults. Expert system is a branch of Artificial Intelligence which gives the user the opportunity to interact with computer to solve certain problem.

2. LITERATURE REVIEW

Different types of expert system have been developed for various real life applications. A web-based expert system for fish disease diagnosis has been developed by Daoliang, Zetian and Yanqing [3]. The system is being used in North China by fish farmers. Similarly, Ahmad [1] developed an expert system for car failure detection. The systems possess 150 rules to detect different types of failures and their causes. It divides the system into 3-major parts. These are start up state, run stable state, movement state.

Salama et al [10] implemented an Expert Diagnostic Assistance System for car failure and malfunction. This system will be highly useful in assisting mechanics for diagnosing vehicle faults. The system consists of three (3) major parts. These include – knowledge acquisition which capture knowledge from the domain expert and retain such knowledge in knowledge base, knowledge engineer, external sources of data and system user.

The second part is Graphical user interface which consist of problem solution, Application programming, problem diagnosis. The third phase is the system module which consists of reasoning specification, inference engine knowledge base and user advisor.

Kadarsah [4] developed a decision model for car faults diagnosis where ES was used to assist car owners, drivers and in experienced mechanics.

Milanović et al [2] also developed a motocultivator fault diagnosis model using hybridization of ES and DSS. Nana and Simonov [5] developed a mobile vehicle expert system for automobile industry. The system is made so simple so that vehicle owners and drivers can detect their vehicle faults and problems.

Adsavakulchai [7] developed electric learning (e-learning) expert system for car fault diagnosis using 19 rules of knowledge base collected from different sources - books, journal, engineering website e.t.c. Three knowledge base were used – car start problem, break problem and cooling system problem. Visual Basic and Microsoft Access were used in the implementation of the system.

Nabende [6] in his M.sc thesis developed an expert system for diagnosing heavy duty diesel engine faults. The expert system uses Bayesian network technology to represent faults and their related causes and recommended repair actions.

2.1 ARTIFICIAL INTELLIGENT (AI) METHODS

AI could be defined as a scientific method of making machines such as computer capable of exhibiting intelligent behaviour.

The term intelligence covers many cognitive skills such as the ability to learn, understand, recognize, and categorize in an attempt to solve real life problems**.** Trend of development in the area of AI today reveals that a lot of progress has been made in the area of problem solving-concept and method for developing a system that is capable of reasoning about problem, to arrive at a meaningful solution rather than calculating the solution.

It comprises of different branches such as Expert system, genetic algorithm, fuzzy logic, neural network e.tc.

2.1.1 Artificial Neural Network (ANN)

Human brain consists of 100 billion closely interconnected single processing elements known as neurons. A simplified model of the neuron and their operation gave birth to ANN. Series of data which serve as inputs are used to train the network and hence produce the appropriate solutions. With newish data, the system is able to use its past experience to solve the problem. If Training or learning phase involved human intervention, it can be described as supervised learning or else it is an unsupervised learning.

They are very good at solving problem that are not prone to algorithmic solutions e.g. pattern recognition, decision support etc. It has the ability to handle previously unseen, incomplete or corrupted data.

2.1.2 Genetic Algorithm

This belongs to a field known as evolutionary computation. Process of arriving at meaningful solution includes:

(i) Survival of the fittest
(ii) Cross breeding
(iii) Mutation

In the process,

- ✓ A population of candidate solution is initialized (the chromosomes)
- ✓ New generations of solution are then produced making use of initial population. To produce these solutions, selection, crossover and mutation are used.
- ✓ Next generation are then produced from fitness function which is used to evaluate the fitness of the newly evaluated solution.
- ✓ The steps of generating solutions as well as the evaluation continue until acceptable solution is found.

2.1.3 Fuzzy System

Traditional logic is based on proposition. Any proposition is either true or false. To solve real life problem, there is always a need to make use of partial proposition- partly true or partly false. In such cases, imposing precision may be difficult and may lead to less optimal solution. Situation of this nature is better handled by fuzzy system which is able to make effective use of imprecise information by assigning degree of truth using fuzzy logic. It gives the opportunity of expressing knowledge in vague linguistic terms.

2.1.4 Expert System (ES)

Expert system therefore is one of the major areas of AI that has to do with scientific method of making machines to acquire human expert knowledge to solve a particular problem in a given domain. Expert system can explain why data is needed and how conclusions were reached.

ES can be defined as computer program that combine expert knowledge in a particular domain and disseminate to others. An expert system is a program that emulates the interaction a user might have with a human expert to solve problem in a particular domain [8].

The system continues to ask questions from the end user and expect the end user to supply answers as input by selecting one or more from options provided by the system or by entering another set of data as input. Such interaction will continue until the system reaches the conclusion. The solution arrived at may be an exact solution i.e. single solution or multiple solutions arranged in logical order. The system will equally explain the reason why it arrives at such conclusion.

ES has ability to utilize incomplete or incorrect data. In fact, giving only a partial data set, an expert is likely to produce accurate result with high degree of certainty in its conclusion. The degree of certainty can be qualified in relative terms and concluded in knowledge base. The certainty values are assigned by the expert during the knowledge acquisition place of developing a system.

2.1.4.1 Advantage of Expert System

- ➢ With expert system in place, the probability and the frequency of making good decision is high. This facilitates a sort of consistency in decision making. The development of expert system to solve different real life problem has made it possible to distribute human expert.

- In most cases, the development of expert system will reduce the cost of decision making i.e. the availability of ES make proper and effective use of available data.
- It permits objectivity by weighing evidence without bias and without regards to the user's personal and emotional reactions.
- It made it possible for human expert to have free time and mind to concentrate on some other meaningful activities.
- ES support modular structure. This thereafter paves way for high degree of dynalism in solving real life problems.

2.1.4.2 Expert System Methods

ES adopts different types of methods. Some of these methods include:

Heuristic Reasoning: This is the type of method the human expert will adopt in solving problems. It could be referred to as rules thumb or expert heuristics. This method allows the expert to arrive at a good conclusion quickly and efficiently. Unlike human expert, ES adopt symbolic manipulation with heuristic inference procedure that is very close to human thinking process. For the ES to adopt this method, it makes use of the following approach:

Search Control: ES embark on searching in a particular domain. Many techniques have been employed for this purpose. This includes pruning, branch and band, breadth-first search and so on. Because of the importance of search process, it is imperative to use good search control strategy in the ES Inference process.

Forward Chaining Method: In the development of an ES, various rules are put in place. There is therefore a need to check the condition part of the rule to determine truth or false value of such rule. If the condition is true, the action part of the rule is also true.

This process will continue until a solution is arrived at or a dead end is reached. This approach or method is being referred to as data driven reasoning.

Backward Chaining: Unlike the forward chaining, the backward chaining is used to backtrack from a goal to the paths that lead to a goal. Hence, it could be referred to as goal driven. It has been found highly applicable when all outcomes are known and not too large in term of size.

2.1.4.3 Components of Expert System

ES is made up of different components that interact together for proper and efficient functionality of the system. Some of the major components of ES include knowledge base, inference engine, working memory, knowledge engineer etc. the integration of these components are illustrated in fig 1 below:

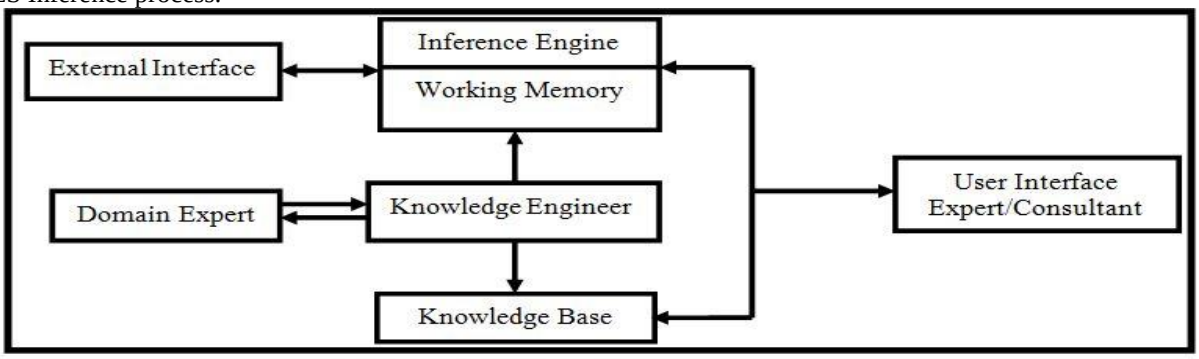

Fig 1: An Integration of Expert System Components

(1) Knowledge Base: different types of rules are set during the development of an ES. The rules are declarative representation of the expertise. It is often expressed in the form of IF…….. THEN. These set of rules form the knowledge base of an ES

(2) Working Storage: one of the major aims of developing an ES is to solve a particular problem in a particular domain. The ES would

have to be provided with specific or relevant data to a problem being solved. Such data constitute the working memory of the ES.

(3) Inference Engine: set of code in the ES which is developed with central aim of drawing inferences or recommendation from knowledge base and problem specific data in the working memory is referred to as inference engine.

(4) User Interface: ES user interacts with the system. This would not have been possible if there is no link between the system and the user. The code that contains the dialogue between the user and the ES constitute the user interface.

(5) Domain Expert: the ES is meant to solve problem in a particular domain. The main experts are individuals who are expert in solving the problem. They could be described as human expert in the specific domain. The experience/ knowledge of a domain expert will be highly regarded in the development of an ES.

(6) Knowledge Engineer: the individual that encode the expert knowledge in the declarative form (making use of set of rules) that can be used by an ES in solving problem in the domain can be described as Knowledge Engineer.

(7) User: one of the major functions of an expert system is to provide and make possible solution available to the user who will be interacting with the system to get advice/ solution.

3. STATEMENT OF THE PROBLEM

When a vehicle develops faults, mechanical/automobile engineers are usually employed for repair [5]. The gravity of the vehicle fault may at times be minor and not so serious to seek help from an automobile/mechanical engineer.

Just like other vehicles, a 2-wheeled vehicle called motorcycle can also developed faults at any time and hence the attention of a mechanic/engineer is needed for repair. But the service of such engineer or mechanic may not be readily available. Therefore bicycle owners or riders need a system that will provide immediate solution especially when the degree of the fault is quite minimal.

4. OBJECTIVES OF THE STUDY

The objectives of this research work are:

1. To analyzed and design an expert system for diagnosing faults.
2. To implement the system using clips programming language
3. To improve the knowledge of motorcycle owners and riders in terms of diagnosing various faults in motorcycle. This will actually minimize the maintenance cost of the motorcycle.
4. To develop an expert system that can be used as a tool to train inexperienced mechanical/automobile/motorcycle engineers in the area of faults diagnosis and repairs in motorcycle.

5. SCOPE AND LIMITATION OF THE RESEARCH

Some faults in motorcycle are major and cannot therefore be solved by the rider or the owner and hence a mechanical/automobile engineer is consulted. This expert system will serve as a tool to guide the engineers during the diagnosis and repair process. Situations where the fault developed is a minor type, the system will guide the rider or the owner to carry out such basic repair. So, the developed expert system is mostly concerned with minor faults diagnosis and repair. The system will also be found useful to diagnose some common major faults and add to the knowledge of mechanical /automobile engineer in the field. The faults considered by this system are limited into 3 major parts. These are:

1. Faults related to starting of the engine
2. Faults developed while the motorcycle is on motion
3. Electrical faults

6. METHODOLOGY

To develop this system, the following steps were carried out

1. Identification of the possible faults in motorcycle.
2. Relevant information was obtained from series of literatures, experienced mechanics and engineers were also consulted on how to diagnose and repair such faults.
3. The system was designed to categorize the faults into 3 major classes which include: startup, on motion and electrical faults as shown in fig 2.

4. From the information collected, different rules were generated to form the knowledge base of the system as represented in fig 3 and 4.
5. The system was implemented using clip

EXPERT SYSTEM FOR MOTORCYCLE DIAGNOSIS

(A) START UP
(B) ON MOTION
(C) ELECTRICAL

Select your option.....

Fig 2: main menu of the system

```
...=================================
      xpert System For Motorcycle Troubleshooting
,,, This expert system diagnoses some sample problems with a motorcycle
;;;=================================
;;;*********************************
;;;* STARTUP RULES *
;;;*********************************
(Defrule Rule1 "Engine Does not Turn-over"
(Selection A1)
(engine turnover no)
(starter turnover no)
(battery ok)
(positive jumper cable starter cable connected)
(big spark turns starter)
(engine turnover no)
=>(printout t "Problem: starter solenoid is Bad")
(printout t "Solution: Replace starter solenoid))
;;;*************************************
```

Fig3: CLIPS representation of a Rule

Rule1: Engine Does not turn over
IF the Selection is A1 "Run Start up Rules"
AND the engine does not turn over
AND the starter does not turn over
AND the battery is fully charged
AND the battery jumper cable is connected with starter cable
AND there is heavy spark that turns the starter
THEN the starter solenoid is damaged.
Therefore, replace the damaged starter solenoid

Fig4: English representation of the above rule

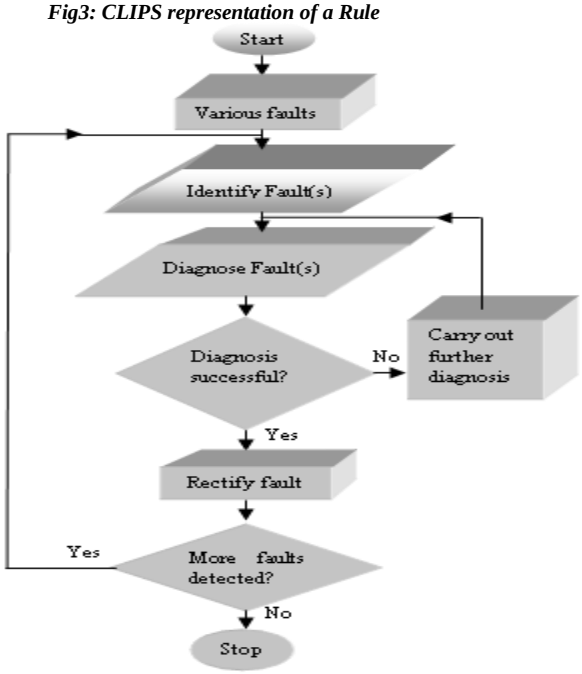

Fig 5: Fault diagnosis flowchart

SAMPLE RULES FOR KNOWLEDGE BASE

(A) START UP

1. **IF** the motorcycle rider kick the engine over or lit the starter button **AND** the engine does not turn over **THEN** check the starter solenoid.

2. **IF** the starter solenoid clicks and the motorcycle rider kicks the engine over or hits the starter button **AND** the engine still does not turn over **THEN** the check the charge of the battery..

3. **IF** the battery is fully charged **AND** the engine still do not turn over **THEN** check the jumper cable, connect the positive jumper cable to the starter cable.

4. **IF** there is a big spark with the connection in 3, and starter turns **AND** the engine still does not turn over **THEN** the solenoid is bad and should be replaced.

5. **IF** the solenoid has been replaced **AND** the engine still does not turn over **THEN** the starter cable is broken and should be replaced.

6. **IF** the starter cable has been replaced **AND** the engine still does not turn over **THEN** the starter is bad and should be replaced.

7. **IF** the starter has been replaced **AND** the engine still does not turn over **THEN** connect the positive jumper cable to the starter motor

8. **IF** there is a big spark with the connection in 7, and the starter turns **THEN** the starter gear is bad, replace the starter gear

9. **IF** the starter gear has been replaced **AND** the engine still do not turn over **THEN** the starter clutch is bad and should be replaced

10. **IF** the starter clutch has been replaced **AND** the engine still does not turn over **THEN** the engine is struck. Seek for the assistance of an experienced mechanical or automobile engineer with reports from rule 1 to 10

11. **IF** the motorcycle rider turns the key or hit the start button to start the engine **AND** the engine is cranking slowly making it impossible for the engine to start **THEN** check the battery probably it is weak

12. **IF** the battery is charged **AND** the engine is still cranking slowly when ignited **THEN** replace the battery with a new one.

13. **IF** the battery has been replaced **AND** the engine is still cranking slowly **THEN** seek for assistance of assistance of an experienced mechanical or automobile engineer with reports from rule 11 to 12.

(B) MOTION

14. **IF** the motorcycle is shaking or jerking while on motion **THEN** the spark plugs are bad and should be replaced.

15. **IF** the spark plugs have been replaced **AND** the motorcycle is still shaking or jerking while on motion **THEN** check if there is free flow of fuel from the carburetor to the engine.

16. **IF** there is no leakage of fuel from carburetor to the engine **AND** the motorcycle is still jerking or snaking on motion **THEN** check for air leakage between the carburetor and the in-let manifold.

17. **IF** there is no air leakage air leakage between the carburetor and the in-let manifold **AND** the motorcycle is still jerking or snaking on motion **THEN** seek for assistance of assistance of an experienced mechanical or automobile engineer with reports from rule 14 to 16.

18. **IF** the rider apply the clutch **AND** the clutch will not disengage **THEN** the clutch plates has struck together and should be loosed.

19. **IF** the clutch plates are struck and making it impossible for the clutch to disengage **THEN** the loose the plate by running in first or second gear, pulling-in the clutch and locking up the rear brake.

20. **IF** rule 18 and 19 cannot free the clutch plate **THEN** consult Mechanical or automobile engineer to take the clutch apart and oil the plate.

(C) ELECTRICAL

21. **IF** the rider turns off the engine **AND** the headlight is still on THEN there is an electrical problem, battery terminal should be removed.

22. **IF** the motorcycle rider fixes the battery terminal back, switches off the headlight **AND** the light is still on **THEN** the fault is not a minor type, an expert should be consulted with report 21 and 22

CONCLUSION

Just like any other engine, a motorcycle engine can also develop one fault or the other. The type of fault developed might not be a serious type and hence can be handled by the rider or the owner. An expert system for diagnosing motorcycle fault has been presented in this research work to serve as a guiding tool to the owner or the rider especially when the automobile or mechanical engineer is not readily available. The automobile or mechanical engineer will also find the system useful.

Though, the cost of maintaining a motorcycle is cheaper compared to a 4-wheeled vehicle, the developed system will further reduce the maintenance cost since the rider or the owner can carry out some of these activities with the assistance of the developed system.

This will encourage more people to buy motorcycle for personal or for commercial use and hence boosting the economy of the country.

REFERENCES

[1]. Ahmad T. Al-Taani. An Expert System for Car Failure Diagnosis. World Academy of Science Engineering and Technology, 12(2005):4-7.

[2]. D. D. Milanović, M. Misita, D. Tadić and D. L. Milanović, "The Design of Hybrid System for Servicing Process Support in Small Businesses, FME Transactions", 2010, 38, 143-149.

[3]. Daoliang Lia, Zetian Fua, Yanqing Duanb (2002). *Fish-Expert: a webbased expert system for fish disease diagnosis,* Expert Systems with Applications, 23, 311-320.

[4]. Kadarsah. S. E. Ricardo Nurzal, "A Decision Support System for Car Fault Diagnosis Using Expert System", International Journal of Information Sciences for Decision Making, N 2, 1998

[5]. Nana Yaw Asabere, Simonov Kusi-Sarpong. (2012). Mves: A Mobile Vehicle Expert System for the Automobile Industry. International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Available at http://www.ijera.com/papers/Vol2_issue6/FH2611081123.pdf. Vol. 2, Issue 6, November-December 2012, pp.1108-1123

[6]. P. Nabende (2006). An Expert System for Diagnosing Heavy Duty Diesel Engine Faults. A Project Report submitted to School of Graduate Studies in Partial Fulfillment for the Award of Master of Science in Computer Science Degree of Makerere University.

[7]. S. Adsavakulchai, N. Ngamdumrongkiat and E. Chuchirdkiatskul "E-Learning for Car Faulty Diagnosis", International Journal of Information and Communication Technology Research, Vol. 1, No. 1, pp. 20-26, 2011.

[8]. S. Samy, Abu Naser, Abu Zaiter and A. Ola, "An Expert System For Diagnosing Eye Diseases Using Clips", Journal of Theoretical and Applied Information Technology, 2008.

[9]. S. T. Deepa and S. G. Packiavathy "Expert System for Car Troubleshooting", International Journal For Research In Science & Advanced Technologies, Vol. 1, Iss. 1, pp. 46-49, 2012.

[10]. Salama A. Mostafa1, Mohd Sharifuddin Ahmad1, Mazin Abed Mohammed1 and Omar Ibrahim Obaid. Implementing an Expert Diagnostic Assistance System for Car Failure and Malfunction. IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 2, No 2, March 2012 ISSN (Online): 1694-0814. http://www.ijcsi.org/papers/IJCSI-9-2-2-1-7.pdf

[11]. The Basics of Expert (Knowledge Based) Systems. Copyright @ 1997 by JM & Co/AJRA