# AN EXPERT SYSTEMS FOR DIAGNOSING TRACTOR FAILURE AND MALFUNCTION

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**Abstract- There are some areas in real life where experts are relatively scarce. For this reason and other advantages, expert systems have been developed and implemented to solve real life problems. In fact, series of problems that have to deal with medical, business, geology, engineering etc. have been solved with expert systems. For instance, an expert system has been developed to diagnose different types of diseases, to detect car failure, to identify different type of minerals etc. But despite many research and publications in this field, the aspect of tractor failure and malfunction has not been given due attention. This research work therefore not only explains the need for the application of an expert system in this important area but also design and implements a prototype of such system. The research focused on four wheel tractors that uses petrol engine. Various rules were formed to identify different failure and causes and recommend appropriate solutions. The system was implemented using CLIPS with forward chaining Inference Engine. It has been tested and the results are promising.**

**Keywords - Tractor failure, vehicle diagnosis, expert system , prototype CLIPS**

## I. INTRODUCTION

Artificial intelligence is one of the important branches of computer science. It has become a very useful tool in solving different real life problems. Mostly, it has lead to development of different intelligent systems which can be applied to solve some real life problems, most especially when it is obvious that such problems cannot be solved using algorithmic process.

Artificial intelligence in turn has different branches which include expert systems, computational intelligence, genetic algorithm, Fuzzy logic, Neural Network, etc. Expert systems, therefore, is a branch of artificial intelligence (AI) and were developed by the AI community in the mid 1960s [2]. 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 solution [2][3][9]. There are instances where expert find it extremely difficult to profound a solution to certain problems in their discipline. The expert system uses its knowledge based system and its inference engine to provide solution in such cases [6]. Expert systems not only provide solutions, they can also explain how the solutions were arrived at, draw reasonable conclusions and also make recommendations.

Expert Systems is a knowledge based system that consists of two modules: The knowledge base and inference engine, [13]. It usually has a knowledge acquisition module and explanation module as extra component.

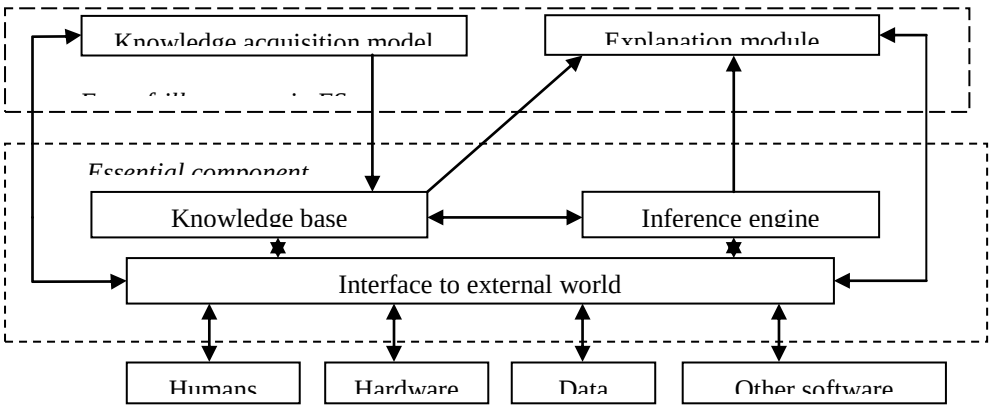


Fig. 1: Main components of expert systems [(A. A. Hopgood (2001)]

Knowledge base consists of rules, procedures and intrinsic data which are relevant to the problem domain in an attempt to solve a particular problem.

Knowledge acquisition is the knowledge obtained from the expert in a particular area of activity where an expert system is to be developed. For instance, such knowledge could be from a medical doctor, agriculturist, mining engineer, mechanical engineer etc. An attempt is made to tap the knowledge of an expert in the area of activity or in a chosen domain.

The inference engine use heuristics method to search for facts that match the condition part of the production rules, then fires the action part of the production rules. The user interacts with the system by issuing queries in quasi-English and the system responds by using its inference engine to infer answer to the query posed by the user.

User interface serves as an intermediary between the user and the expert system. The user interacts with the expert system via the user interface.

The explanation module allows the system to explain its conclusion, recommendations and provide enough explanation on the decision process.

Obviously, expert systems provides powerful and flexible means for obtaining solutions to a variety of problems that cannot be dealt with by other, more traditional and orthodox method, [14]. The term expert system and knowledge based system are often used synonymously, [2]

According to Jaryani [8], the advantages of AI- Expert Systems are classified below:

- *Reproducibility* - Many copies of an expert system can be made, but training new human experts is time consuming and expensive.
- *Permanence* - Expert systems do not forget, but human experts may.
- *Consistency* - With expert systems, similar transactions can be handled in the same way. The system will make comparable recommendations for like situations. Humans are influenced by recent effects (most recent information having a disproportionate impact on judgment) and primacy effects (early information dominates the judgment).
- *Efficiency* - Expert systems can increase throughput and decrease personnel costs. Although expert systems are expensive to build and maintain, they are inexpensive to operate. Development and maintenance costs can be spread over many users. The overall cost can be quite reasonable when compared to expensive and scarce human experts.
- *Completeness* - An expert system can review all the transactions, a human expert can only review a sample.
- *Consistency of Decision Making*
- *Achieve Expertise*
- *Breadth* - The knowledge of multiple human experts can be combined to give a system more breadth that a single person is likely to achieve.
- *Documentation* - An expert system can provide permanent documentation of the decision process.
- *Timeliness* - Fraud and/or errors can be prevented. Information is available sooner for decision making.
- *Differentiation* - In some cases, an expert system can differentiate a learning material from other materials.

## II. TRACTORS

Tractor is a heavy, high powered vehicle that performs variety of important jobs [11]. For instance, tractor can be used in agriculture, road building, moving heavy loads from one place to another and for construction.

A farmer can also use a tractor in a multidimensional ways. For example, it could be used to get the soil ready for planting e.g. soil tillage, making ridges, etc. A tractor called backhoe loader can both load and dig at construction site [4]. Whereas, lawn tractors are designed for versatility and dependability to complete tasks around the yard [15]

Tractor comes in different sizes and this will determine where and how they could be used. For instance, compact utility tractors are smaller models that people can use for yard work while others are big enough to pull other large engines [11].

Most modern tractors are powered by internal combustion engines running on gasoline, kerosene or diesel fuel. Power is transmitted through a propeller shaft to a gear box having 8 or 10 speed and through the differential gear to the two large rear-drive wheels [5].

## III. LITERATURE REVIEW

Different types of expert system have been designed and implemented in medical diagnosis domain. S. Samly, Abu, A. O. (2008), P. Santosh, K. Patra, P-Sahu and I. Mandal (2010), J. G. Robin and M. Mareto (2011).

Expert Systems were also developed to diagnose different types of engine problems. This includes:

Nana [12] developed a mobile vehicle expert system for the automobile industry. The research work was divided into 2 classes: problems that deals with starting the engine and the cooling system. Fifteen (15) rules were defined and the system was tested and found to be promising

Again, Salama [13] developed an expert System for car failure and malfunction. The system was implemented using Win-prolog logical programming language. The work focused on help and advice. If the user is not being able to solve the problem, then the system provide advice and help window which contain names of different cities in Malaysia which in turn provide the address of automobile service shops with their phone numbers

Kadarsah [1] also designed an Expert System for car fault diagnosis. The model was developed with the aim of helping inexperienced drivers. The model consist of inference engine, knowledge base, database, user interaction and adaptive mechanism

The inference engine uses backward chaining because there is small number of outputs with many possible inputs. The user interaction section was designed such that the system could receive feedback. The feedback results are stored in the database. The system processes the stored data and extracts additional rules with the goal of improving the knowledge base.

Ahmad [2] developed an Expert System to diagnose different types of car failure. In fact, the paper describes a proposed knowledge base system for car failure detection. The system has about 150 rules for diagnosing different failures. CLIPS with forward chaining Inference Engine was used for the implementation.

## IV. SCOPE OF THE RESEARCH

The focus of this research work is on four wheel tractors that uses petrol engine such as Lawn tractors, Agricultural tractors etc

## V. RESEARCH OBJECTIVES

The objective of this research work is to design and implement an expert system for tractor failure detection. The research work will detect possible tractor failure and recommend appropriate solutions.

Therefore the specific objectives of the research include: To investigate related work in expert systems that has to do with engine faults

i. Build an expert system architecture for tractor failure detection
ii. Develop an expert system to implement the design
iii. Test the expert system and ensure its functionality

## VI. METHODOLOGY

Experts in the field of automobile engineering, mechanical engineering, agricultural engineering, and experienced mechanics, tractor troubleshooting chart made available on the internet were consulted to acquire the knowledge in the area of tractor faults detection and possible solutions. An expert system was designed based on the acquired knowledge. The expert system was implemented using CLIPS with forward chaining Inference Engine.

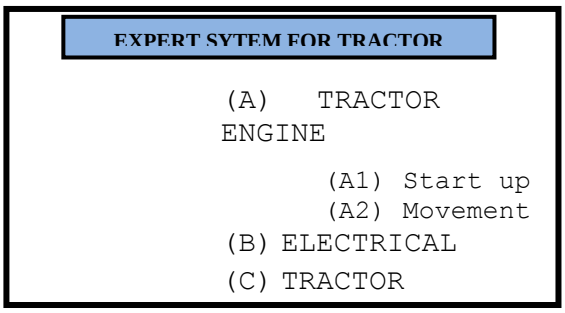


Fig 2: The Main Menu of the System

## VII. DESCRIPTION OF MODULES CREATED

Three different modules are created .It includes:

TRACTOR ENGINE MODULE which is specifically concerned with problems associated with the

(1). Starting up of the engine especially when the engine refuse to start and when the engine is hard to start.

(2). Movement of the tractor which has to do with problem that emerge while the tractor is on motion e.g. poor engine performance, engine overheating, black exhaust smoke, etc.

ELECTRICAL MODULE: This module has to do with problems related with electrical fault. For instance, light do not work, battery not charging, etc. TRACTOR ATTACHMENT: This has to do with problems that emanated as a result of attachment of other components to the rear of the tractor e.g. tractor vibrates too much with the attachment

Table 1: TROUBLESHOOTING CHART/ TABLE FOR TRACTOR FAILURE DIAGNOSIS

**Engine**

| If | Check |
|---|---|
| Engine Will Not Start | Brake pedal not depressed.<br>Mower Engagement Lever is in ENGAGED position.<br>Spark plug wire is loose or disconnected.<br>Improper fuel.<br>Plugged fuel filter.<br>Electrical problem - See Electrical Troubleshooting Section |
| Engine Is Hard To Start | Carburetor is not adjusted properly or dirty.<br>Plugged fuel filter.<br>Choke adjusted incorrectly.<br>Faulty spark plug.<br>Stale or improper fuel.<br>Loose or corroded electrical connections.<br>Engine oil viscosity. |
| Engine Misses Under Load | Faulty spark plug.<br>Stale or dirty fuel.<br>Plugged fuel filter. |
| Engine Overheats | Engine air intake screen plugged.<br>Cooling fins plugged.<br>Engine oil low or too high.<br>Engine operated too long at a slow idle speed. |
| Engine Knocks | Stale or low octane fuel.<br>Engine overloaded.<br>Low engine speed. |
| Engine Backfires | Faulty spark plug.<br>Operator raising off of the seat. |
| Engine Loses Power | Engine overheating.<br>Too much oil in engine.<br>Dirty air cleaner.<br>Faulty spark plug.<br>Travel speed is too fast for conditions.<br>Improper fuel. |
| Excessive Fuel Consumption | Choke is not fully open. (Not available on all models.) |
| Black Exhaust Smoke | Air filter is dirty or oil soaked. |

**Electrical**

| If | Check |
|---|---|
| Starter Does Not Work Or Will Not Turn Engine | · Brake pedal is not depressed.<br>· Mower Engagement Lever is in ENGAGED position.<br>· Battery terminals are corroded.<br>· Battery not charged.<br>· Fusible Link in starting circuit is blown - See your John Deere Dealer |
| Battery Will Not Charge | · Dead cell in the battery.<br>· Battery cables and terminals are dirty.<br>· Low engine speed or excessive idling. |
| Lights Do Not Work | · Light plug disconnected.<br>· Loose or burned out bulb. |

**Tractor**

| If | Check |
|---|---|
| Tractor Vibrates Too Much or Rattles Excessively | · Attachment drive belts worn or damaged.<br>· Traction drive belt damaged or worn. |
| Tractor Will Not Move With Engine Running | · Parking brake locked.<br>· Traction drive belt needs adjustment. (See your John Deere dealer.)<br>· Free-wheeling lever not pushed in completely. |

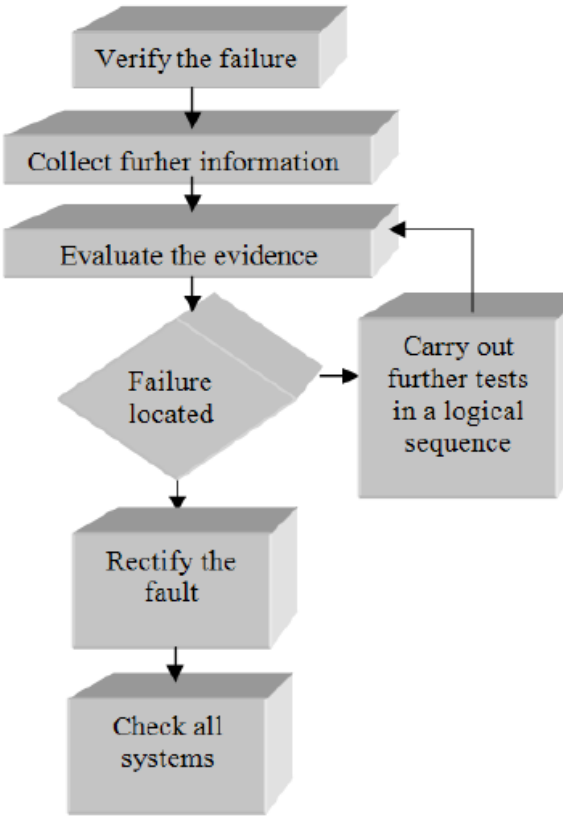


Fig 3: Flowchart of a tractor failure diagnosis system

```
;;;==============================
;;;   Tractor Expert System
;;;  This expert system diagnoses some
 ;;;  sample problems with a   tractor.
;;;==============================
;;;**********************************
;;;*          STARTUP RULES          *
;;;**********************************
(Defrule Rule1 "Engine Does not Start"
              (Selection A1)
              (Brake Pedal Depressed)
              (Mower Engagement Lever Disengaged)
              (Spark Plug wire Connected)
              (Fuel Yes)
  =>
    (printout t "Plugged Fuel fitter")
            (printout t "Solution: Replace the Fuel fitter))
;;;**************************************
```

Fig 4: CLIPS representation of a Rule

Rule1: Engine Does not start

IF the Selection is A1 "Run Start up Rules"
AND Brake Pedal is Depressed
AND Mower Engagement Lever Disengaged
AND Spark Plug wire is Connected
AND there is fuel in the Tank
THEN
The Fuel fitter is damaged. Therefore, replace the damaged fuel fitter.

Fig 5: English representation of the above rule

## VIII. SAMPLE RULES FOR KNOWLEDGE BASE

TRACTOR ENGINE

1. **IF** the engine will not start **THEN** brake pedal not depressed, Depress the brake pedal
2. **IF** the brake pedal is depressed **AND** the engine still does not start **THEN** Mower Engagement Lever is in ENGAGED position, DISENGAGE the mower engagement lever
3. **IF** the brake pedal is depressed and the Mower Engagement Lever is DISENGAGED **AND** the engine does not start **THEN** Spark Plug wire is loose or disconnected, tighten the spark plug wire
4. **IF** the Brake Pedal is depressed and the Mower Engagement Lever is DISENGAGED **and** the Spark Plug wire is connected **AND** the engine still does not start **THEN** there is improper fuel, add more fuel
5. **IF** the Brake Pedal is depressed and Mower Engagement Lever is DISENGAGED and the Spark Plug is connected and there is enough fuel **AND** the engine does not start **THEN** the fuel fitter is bad, replace the fuel fitter
6. **IF** the Brake Pedal is depressed and Mower Engagement Lever is DISENGAGED and the Spark Plug is connected and there is enough fuel and the fuel fitter is replaced **AND** the engine still

does not start **THEN** check the electrical module

7. **IF** the Brake Pedal is depressed and Mower Engagement Lever is DISENGAGED and the Spark Plug is connected and there is enough fuel and the fuel fitter is replaced and there is no electrical problem **AND** the engine still does not start **THEN** consult An Expert (AGRICULTURAL /Mechanical Engineers)

TRACTOR ATTACHMENT

8. **IF** the tractor vibrates too much or rattles extensively **THEN** the attachment Drive Belt is damaged, replace the attachment drive belt
9. **IF** the Attachment Drive Belts is replaced **AND** the tractor still rattles extensively **THEN** the Traction Drive Belt is damaged, replace the traction drive belt
10. **IF** the Attachment Drive Belts is replaced and the Traction Drive Belt is replaced **AND** the tractor still rattles extensively **THEN** consult An Expert(Agricultural/Mechanical Engineers)
11. **IF** the tractor does not move with Engine running **THEN** Parking Brake is locked, unlock the parking brake
12. **IF** the Parking Brake is unlocked **AND** the tractor still does not move with Engine running **THEN** Traction Belt needs adjustment, adjust traction belt
13. **IF** the parking brake is unlocked and the traction belt is adjusted **AND** the tractor still does not move with Engine running **THEN** free-wheeling lever not is in the right position, push in the free-wheeling Lever completely
14. **IF** the parking brake is unlocked and the traction belt is adjusted and free-wheeling lever is pushed in completely **AND** the tractor still does not move with Engine running **THEN** consult an Expert (Agricultural/Mechanical Engineers).

## IX. CONCLUSION

An expert system for diagnosing tractor failure and malfunction is hereby presented. Though, there are different types of tractors, the focus of this research work is on four wheel tractors that uses petrol engine e.g. Lawn tractors, Agricultural tractors etc. Various rules were defined which formed the basis of the knowledge base. The system was finally implemented using CLIPS with forward chaining Inference Engine. The system is made up of 3 different modules which are Tractor Engine, Electrical and Tractor (Attachment) module. The tractor Engine module is subdivided in two modules. These are start up and movement module. The system have been tested and found promising.

## X. SUGGESTION FOR FURTHER RESEARCH

There is still a need to develop an expert system or a knowledge based system for diesel engine tractors failure and malfunction.

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