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# A Rule-Based System for Diagnosing Car Air Condition Malfunctions

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***Abstract****: Diagnosing car malfunctions is a complex process that requires a high level of knowledge and skills. Car users need a skilled technician to diagnose car faults. With the development in the automotive industry and the novelty of its components; There is a gap between the knowledge and skills of technicians and what the labor market demands. Therefore, it has become necessary to employ artificial intelligence technology to help technicians keep pace with the huge developments in the automotive industry. The aim of the research is to present a rule-based system for diagnosing various malfunctions of car conditioning; the system was applied to 22 technicians in the Arab Republic of Egypt. They were divided into a control group and an experimental group, and the results showed that the mean score of the experimental group technicians was 58.45, greater than the mean score of the technicians in the Control group 29.18 To confirm the results, the T-test was applied, and its value was 19.721, which indicates the effectiveness of the proposed system in improving technicians' knowledge and raising their skills in accurately diagnosing and fixing car air conditioning (AC) malfunctions, saving time and effort needed for the diagnosis process*

**Keywords—** Rules based systems; Car air condition malfunctions; Artificial Intelligence.

## 1. INTRODUCTION

The experiences of different countries have proved that setting comprehensive development plans, facing challenges and solving problems cannot be achieved without the assistance of qualified human cadres with appropriate scientific qualifications and advanced technological training, in order to be able to keep pace with contemporary challenges [1]. With the trend of countries around the world to manufacture cars that are more fuel-efficient, this trend has brought about a tremendous development in the automotive industry in general and its air conditioning system in particular, as electronic circuits have been introduced to control all car systems, including the air conditioning system [2],[3] which led to the presence of new faults that did not exist before Cars also require special handling, unlike previous periods [4]. Since diagnosing car malfunctions, especially the air conditioning system, is a complex process that requires a high level of knowledge and skills. For this reason, car users need skilled car technicians to diagnose a fault detected in their cars and for maintenance purposes. However, some errors are minor and will not require the services of skilled mechanics. This prompted the researchers to think about designing the proposed system to simulate the different methods used by refrigeration and air conditioning experts and auto electrical experts in diagnosing car air conditioning malfunctions, so that the proposed system helps improve the knowledge and skills of car repair technicians; Which in turn contributes to narrowing the gap between their capabilities and the requirements of the labor market.

## 2. FEELING THE PROBLEM

The researchers noticed a number of problems in the dealings of many technicians in repairing car malfunctions in general, and the air conditioning system in particular. This made technicians follow random methods in the diagnosis process, which leads to a high cost of repair due to the possibility of changing many parts without being the cause of the malfunction; This is as a result of their lack of knowledge of electronics and how to deal with them and apply them in real life, hence the need to think about finding appropriate solutions to this problem in order to help technicians deal with various malfunctions and apply them in the field of car repair. Therefore, researchers conducted a number of personal interviews, with the application of a form A survey of (15) technicians and experts in the field of car repair, to determine the most important problems related to diagnosing and fixing car air conditioning system malfunctions, and identifying the components most vulnerable to malfunctions. All technicians and experts confirmed the following: Often the technician resorts to modifying the electrical connections of the car and making external connections for the electronic control system as a result of his inability to deal with its malfunctions. The tremendous development in the automobile industry and the introduction of electronic circuits as an essential part of its parts, made technicians stand helpless in the face of various malfunctions, unable to deal with them except by using modern expensive devices, which does not conform to the requirements of the labor market. 90% of technicians are unable to diagnose most of the electronic faults in the circuits included in the car air conditioning system and replace the entire part. Wrong handling of some malfunctions may damage the electronic unit of the car's systems control (ECU), which may lead to the whole car stopping. All technicians in the field of car repair and the field of refrigeration and air

conditioning confirmed the high cost of replacing car electronic circuits and their unavailability for many different models. From the above, it is clear that there is a severe shortcoming in the preparation and work of technicians and a low level of knowledge and skills for them in diagnosing and fixing malfunctions of the air conditioning system in modern cars. The current research represents a serious step to help overcome this problem, by designing the proposed system to simulate the thinking of experts in diagnosing car air conditioning malfunctions, and answering the following questions:

- What are the common malfunctions of the car air conditioning system?
- What skills must technicians acquire to diagnose car air conditioning malfunctions?
- What is the proposed design of the rules-based diagnostic system for car air conditioning system malfunctions?
- What is the impact of applying the proposed system on developing the knowledge and skills of car repair technicians to diagnose car air conditioning system malfunctions?

## 3. RESEARCH HYPOTHESES

- There is no statistically significant difference at the level (0.05) between the mean scores of the technicians of the control group and the experimental group in the cognitive level.
- There is no statistically significant difference at the level (0.05) between the mean scores of the technicians of the control group and the experimental group in skill performance and practical efficiency.
- There is no effect of using the proposed system at the level (0.05) on the knowledge and skills of the technicians of the experimental group.

## 4. RESEARCH LIMITS

### 4.1 Geographic boundaries

The research is limited to 22 technicians in the Arab Republic of Egypt.

### 4.2 Time limits

Gregorian year 2021

### 4.3 Human boundaries

The current research is limited to a sample of electrical and AC repair technicians.

## 5. RELATED WORK

Expert systems are computer programs derived from a branch of computer science called artificial intelligence, which uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solutions [5]. Expert systems act as an expert with sufficient knowledge of both the data and rules associated with a particular problem within the computer. Expert systems have a variety of applications and have been widely used in various diagnostic systems. Al-Tani [6] proposed a knowledge-based system for detecting vehicle breakdowns. The proposed KBS was implemented using the CLIPS Expert System tool with a forward sequence inference engine. CLIPS stores knowledge in the form of rules, which contains a logic-based representation as well as production rules. The communication between the user and the system is carried out through the user interface, where the system gives the result of the diagnosis with an explanation. KBS contains about 150 rules for different types of car malfunctions and their causes. Wang & Yin presented a method for fault diagnosis of automobile suspension system based on the set of potential means and characteristic analysis. The pure data-based property of this method allows it to serve as a non-linear monitoring method for the suspension system. Without any model information or previously known error features [7]. Jegadeeshwaran & Sugumaran carried out a diagnosis of hydraulic brake system malfunctions. The effect of feature number was also studied using decision trees as well as Supporting Vector Machines (SVM) [8]. Alkotby 2018, an expert system designed to help automotive students in industrial technical education schools improve their skills in diagnosing and fixing car faults; Which in turn leads to narrowing the gap between the capabilities of students of that specialization and the requirements of the labor market. The study found a statistically significant difference at the level of significance (0.05) between the mean scores of the students of the control group (those with the traditional teaching style) and the experimental group (the ones with the teaching style using the proposed expert system) in the skill performance and practical efficiency in favor of the experimental group. On the effectiveness of using the proposed system, and the need of industrial technical education schools for it [9]. Bakeer 2017, the study aimed to design an expert system for maintaining photocopiers using SL5 language to save the time, effort and cost necessary to do so without the need for a specialized expert in this field. The study found the effectiveness of the proposed system in maintaining the malfunctions of photocopiers, and the agreement of the decisions issued by the system with the decisions approved by the experts in the field regarding these malfunctions [10]. Mostafa et al. 2018, proposed an agent-based inference engine for the development of an Automated Vehicle Fault Diagnostic Assistance (ACFDA) system. The ACFDA system helps the motorist to take the initiative and try to repair the vehicle or at least know the condition of the vehicle [11]. Study of Abu Naser aimed to design a Rule Based System was for diagnosing the wireless connection problems and attains a precise decision about the cause of the problem. SL5 Object expert system language was used in developing the rule-based system. An Evaluation of the rule-based system was carried out to test its accuracy and the results were promising [12],[13]. Study of Tingting Li , 2021 aimed to propose a method develops a diagnostic Bayesian network (DBN) based on both expert knowledge and operational data, also proposes

a knowledge guided and data-driven fault diagnosis method. A probabilistic framework is developed for determining the prior DBN structures based on expert knowledge. The proposed method is evaluated using the experimental data from the ASHARE Project 1312-RP. The results show that the performance of the proposed method is promising [14]. Ibrahim Said Ahmad 2021 study, developed an expert system for diagnosing vehicle faults for car users. The knowledge base was obtained through interview and observation. The system was evaluated, and the results showed that an expert system for diagnosing vehicle malfunctions could be used by vehicle users. It enables car users to identify the malfunction in their car, fix it if it's a minor fault, or pass it on to a technician when necessary [15]. Tran 2020 study, proposed a new hybrid method for detecting faults in the air conditioning systems in the car. Two models were used in the air conditioning system. Provides a framework for AC fault detection and diagnosis by combining the RBFNN and EWMA model. The results showed that the proposed algorithm detects car air conditioning malfunctions with high accuracy [16]. The study of Ibrahim Saeed and others (2018) aimed to study the car air-conditioning system, especially the malfunctions that the car air-conditioner is exposed to and the methods of diagnosing and fixing them, due to the fact that some car air-conditioners stopped working. The study also aimed to collect data and practical information from car maintenance companies. The researchers used the interview tool, and the study reached results based on theoretical information, and the responses of engineers of maintenance companies, and the study made recommendations to the relevant authorities [17]. The previous studies agrees with this research in using systems to diagnose faults, while it differs from it in that it targets car AC as well as its application in labor market.

## 6. THE DEVELOPMENT STAGES OF THE PROPOSED SYSTEM

### 6.1 The Identification stage

At this stage, the researchers reviewed many previous studies, and read many paper and electronic books to form a general perception of the proposed system and what it should be. The researchers also conducted a number of personal interviews that included the following categories [18],[19],[20],[21],[22]:

- Experts and specialists in the field of car repair.
- Experts and specialists in the field of refrigeration and air conditioning.
- Owners of car air conditioning maintenance and repair workshops.
- Specialists in the field of electronics.

In order to determine the most general and common car air conditioning malfunctions on all car models, the researchers have an initial conception of the proposed system and the logical sequence of the process of diagnosing the malfunction, and then they extract the experts' knowledge and formulate it in the form of a set of if then rules for the various malfunctions covered by the proposed system resolution of these malfunctions, figure (1) show decision tree of malfunctions added in proposed system.

### 6.2 The conceptualization and Formalization stage

In this stage, the researchers identified the languages, programs, and tools used in designing the proposed system. As well as defining ways to represent knowledge within the proposed system. Where the researchers used the combination between forward chaining and backward chaining. He also formulated the methods of dealing with various malfunctions in the form of a set of facts and rules in order to build a knowledge base. The researchers also designed the interface of the proposed system at this stage, and the following is a figure (2) showing the interface of the system.

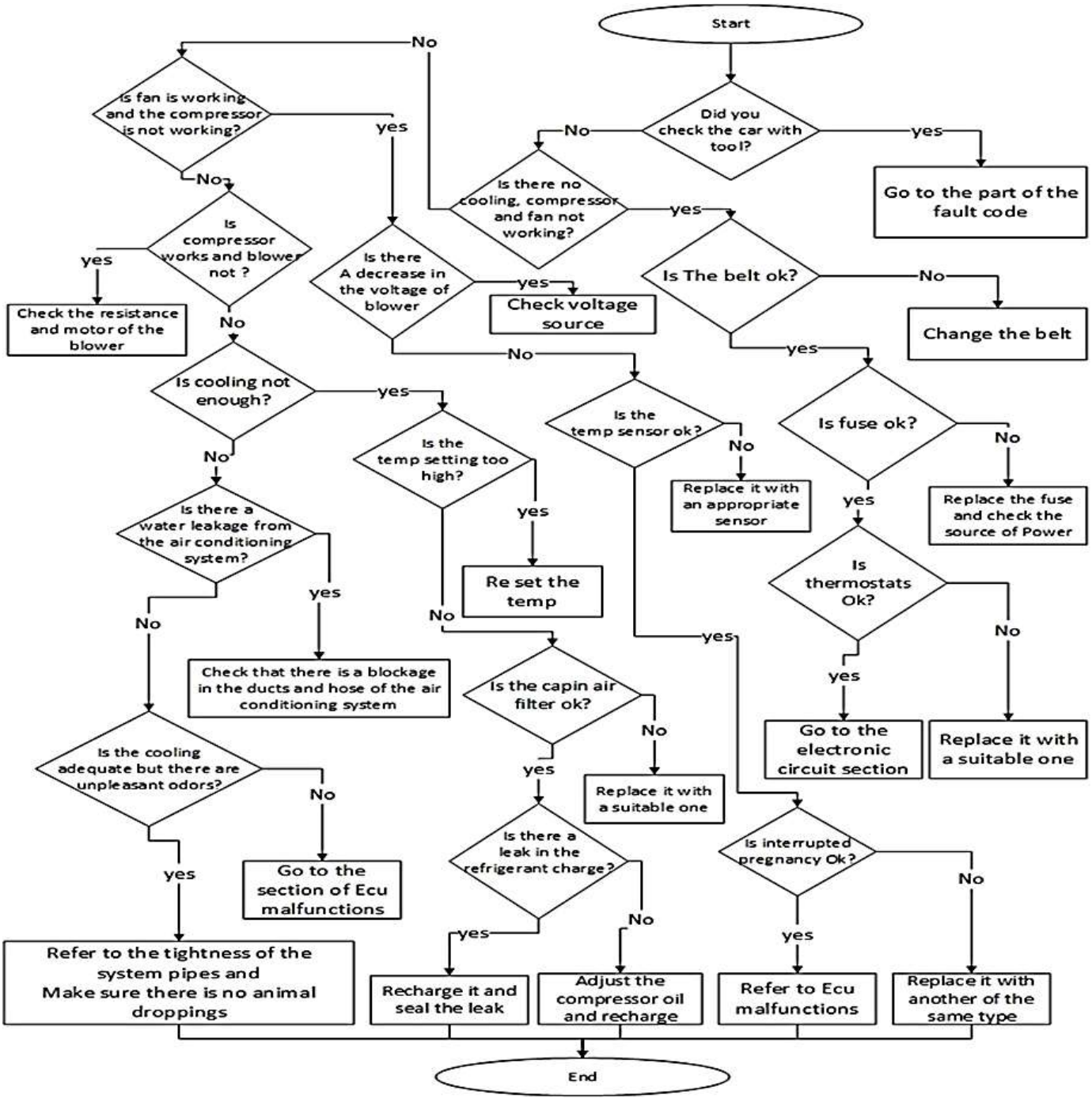


Figure (1) Decision tree of malfunctions added in proposed system


Figure (2) Interface of the proposed system

### 6.3 The system testing stage

Where the researchers presented the proposed system to the experts and technicians. Then modified the proposed system according to their opinions and suggestions, and then compared the results produced by the proposed system with the results approved by experts and specialists in the fields of electronics and car AC repair. The researchers assured the health and safety of work, where the results of the system agreed with the results approved by experts and specialists in various malfunctions and cases.

### 6.4 The Implementation stage

In which the researchers applied the use of the proposed system to the technicians of the experimental group.

### 6.5 The System Maintenance Stage

This stage includes the process of developing and updating the system with the malfunctions that arise in the car's AC. Flexibility taken into consideration during the design of the proposed system. So that the system could be added to or deleted from it in a flexible manner that does not require major software efforts. The researchers also added a set of tools that enable users of the proposed system to communicate with the system designer as auxiliary tools to provide technical support to users through several means of communication such as Facebook, WhatsApp and other applications.

*In designing the proposed system, the researchers took the following points*

- Simplicity of the graphic interface so as not to confuse system users.
- The system designed in a flexible way. Therefore, it is scalable and updated at any time and from anywhere, related to the presence of a knowledge base on cloud computing.
- Adding tools that allow system users to communicate with the system designer to provide technical support.
- Using Arabic language in the proposed system in proportion to the needs of the current target group in the system (car AC repair technicians).
- Adding general instructions that help ensure the safety and security of system users.
- Providing the system with more than one version to suit different types of devices (computers, Android smartphones, and iPhone devices).

## 7. IMPLEMENTATION

### 7.1 The research sample

The research sample, which was randomly selected to measure the impact of applying the proposed system in helping technicians improve their knowledge and raise their skills in diagnosing and fix car AC malfunctions, was as follows:

(10) Electronics technicians, (12) car AC technicians divided into two groups as follows:

- Control group: (11) technicians who did not use the proposed system.
- Experimental group: (11) technicians who used the proposed system in diagnosing and fixing car AC malfunctions.

### 7.2 Actual application of the experiment

To answer the study questions, the researchers did the following:

- The researchers applied the practical test to the technicians of the control group.
- The researchers applied the practical test to the technicians of the experimental group, after they used the proposed system.
- The researchers compiled the test scores for the

control and experimental groups.

- The researchers listed the degrees of technicians of the two groups separately.
- The researchers performed a number of statistical processing using spss, in order to obtain the average scores of the technicians of the two groups and compare them with the aim of measuring the impact of using the proposed system.

## 8. RESEARCH RESULTS

The results included answering the study questions

- Through personal interviews that were conducted with the experts, the most common car AC malfunctions were achieved and the skills required to deal with them were included in the proposed system and were represented in the malfunctions of (AC compressor, control unit, electronic circuit, thermostats, Freon deficiency).
- The proposed system designed to assist in the diagnosis and fix of car AC malfunctions.
- It is noticed that the technicians' skills in dealing with car AC malfunctions improved after using the proposed system, and thus the proposed system contributes to improve their skills and knowledge as well as saving the time needed for the repair process.
- There is a positive effect of using the proposed system at the level (0.05) on the knowledge and skills of the experimental group technicians.

**These results represented statistically as shown in Table 1.**

**Table 1. The Results**

| Groups | Number of Technicals | mean | std | T | Sig |
|---|---|---|---|---|---|
| Control | 11 | 29.18 | 4.57 | 19,721 | 0.00 |
| Experimental | 11 | 58.45 | 1.80 | | |

**The following is a graph of those results figure (3):**

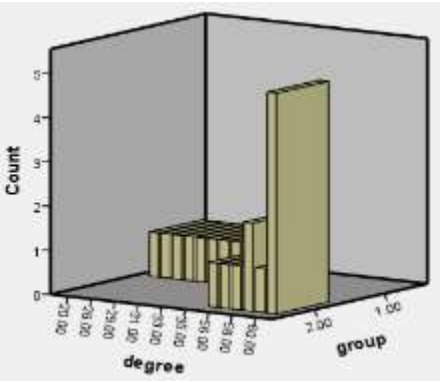


Figure (3) Results

## 9. RESEARCH RECOMINDITION

- The current research recommends the necessity of designing training programs for the service of car maintenance and repair technicians.
- The need to follow up on all new developments in the automotive industry and its AC system and add them to the proposed system.
- There must be a database for workers in the field of car repair and a way to connect them with each other to follow up on everything new to facilitate their work and exchange experiences and knowledge about various malfunctions.
- Expanding the production of fault-diagnosing devices and including systems in them, such as the proposed system, and not stopping at the fault reading level from the control unit of the car.
- Attention should be paid too many studies related to diagnostics for various malfunctions and problems, due to their contributions to saving a lot of expenses and community service, such as [23], [24], [25].

## 10. CONCLUSION AND FUTURE WORK

- An intelligent system to assist in diagnosing of car automatic transmission malfunctions.
- A rule-based system for diagnosing vehicle suspension malfunctions.
- An intelligent system for diagnosing malfunctions of the main control unit of cars.

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