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A Web-based automotive refrigeration troubleshooting system applying knowledge engineering approach

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ABSTRACT

This study describes the generation of Web-based troubleshooting system for automotive refrigeration system using knowledge engineering approach over the Internet. The relevant technologies used in the system are discussed in detail. The aim of the proposed knowledge-based troubleshooting system (KBTS) is to integrate the troubleshooting process of automotive refrigeration system into a single architecture for retrieving knowledge and experience of technicians in automobile repairing field. The application of KBTS guides the novice or learner through different stages of the troubleshooting process enabling the creation of problem-solving list, its contents include the selection of hand tools and instrument, decision of detecting methods, procedure of disassembling/reassembling component, adjusting, and so on. Through the use of web and knowledge approach, the troubleshooting knowledge of automobile refrigeration system can be effectively incorporated into the procedure generation framework and a Web-based troubleshooting procedure generation system can also be implemented.

1. Introduction

Air conditioning has become standard equipment on most vehicles, enhancing traveling comfort and safety. Modern systems feature integrated cooling, heating, demisting and defrosting, air filtering, and humidity control. There are a wide range of factors that affect the global warming contribution of a car, many of which result from how the car is used in practice. The current design of air-conditioning systems require a non-flammable, low toxicity refrigerant like HFC-134a for passenger cars, trucks, trains, and buses. State of the art system design has resulted in improved efficiency, reduced refrigerant charge and minimum refrigerant leakage, dramatically improving the environmental performance of mobile air-conditioning. Besides, for comfort some fresh and cool air must pass through the passenger compartment of the vehicle in the torrid summer. Hence, it is important to keep the refrigeration system in a good condition.

To stay competitive in today's global economy an automotive repair company (or shop) must build on its intellectual capital and create time to innovate and assess more advanced, complex types of tools to eliminate uncertainty and repetition from the troubleshooting process. In other fields, there are new ways to harness the advantages of new technologies and communications tools such as Internet, knowledge-based engineering (KBE) system, etc. becoming an essential part of strategy for improving effectiveness [1–3].

Web-based technology can, through its open architecture, uniform information model, object-oriented structure, distributed cooperation, eliminate the time and space restriction of engineering design, manufacture and information service as well as realize the knowledge share to a maximum extent [4–8]. Meanwhile, KBE is an engineering method that represents a merging of object-oriented programming, artificial intelligence techniques and computer aided technologies, giving benefit to customized or variant automation solutions. The ultimate goal of the KBE system should be to capture the best practices and engineering expertise into a corporate knowledge based (as shown in Fig. 1).

There have been many development methodologies suggested for the KBS domain. The methodologies have been aimed at assisting the developers to define and model the problem in question [9]. The KBE methodology should provide an open framework for formally capturing and defining the process of design creation [10]. Mulvenna and Hughes [11] suggested that the KBS needs to be object-oriented in nature to support an iterative prototyping area such as design. Church [12] recognized the fact that such methods proved difficult for the dedicated expert system (ES) practitioner to use and that this would hinder development by non-dedicated personnel within companies using a multi-skilled workforce. Crowther et al. [13] has recognized that using a

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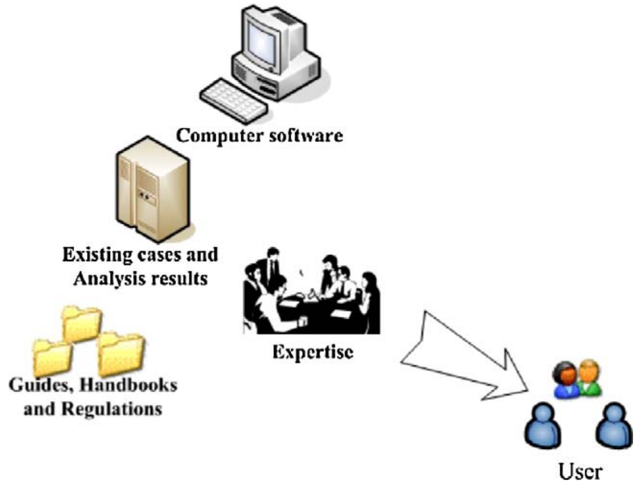

Fig. 1. The diagram of corporate knowledge base.

specialized knowledge engineering to gather and represent knowledge in an engineering domain can lead to frustration due to the possible ambiguity in the problem representation. In the manufacturing field, currently most of the activities and costs related to planning processes (e.g. metal forming, forging and molding) depend strongly on human expertise, creativity and intuition as well as time-consuming experimental, trail and error, work. The numerous variables required to describe processes make the knowledge capture and the encapsulation of the decision-making and process planning rules difficult using conventional methods [14–17]. The automotive repair service has also the above same problems.

In diagnostic and repairing architecture, Angel and Chatzinikolaou [18] depicted a hydraulic fault diagnosis in an IF-THEN rule-based knowledge system. Stefano et al. [19] adopted the concept of Web-based sensing and a collaborative diagnostic system for the industry. Liang [20] proposed a troubleshooting task model of automobile chassis. It integrates a task implementation method with virtual interactive techniques. Meanwhile, this system allows learners to operate a practical task module for troubleshooting through the Internet. Lee [21] laid out the framework for remote diagnostic and maintenance for manufacturing equipment. It has become a standard for others to follow. Besides, the Web allows universal access by having independent connectivity for different kinds of platforms using open standards for publishing (HTML, XML), messaging (HTTP), and networking (TCP/IP) [22]. Internet browser plug-ins should be able to handle new data types and allow different applets to be downloaded and run on any browser. Since the Web enables multi-media support, both interactivity and extensibility, it can seamlessly include new forms of content and media [23]. Therefore, Web-based diagnosis should employ multi-media to a large extent. The developments in database and object technologies, such as CORBA, IIOP and component-ware concepts, enable users to connect to back-end databases and legacy applications via user-friendly Web interfaces [24].

Therefore, in the present investigation a knowledge-based engineering approach is proposed and a Web-based troubleshooting system is developed to support the troubleshooting planning of automotive refrigeration system in this study. In the developed system, various sequences can be generated according to the introduced technologies, and the system also gives a method to realize the drawing display on the Web. Through the use of Web and intelligent approach, a Web-based troubleshooting knowledge model can be generated and implemented for automobile refrigeration system in this study.

2. Conventional organization for troubleshooting of automotive refrigeration system

The automotive air conditioner is basically a mobile mechanical vapor-compression refrigeration system. It provides refrigeration by mechanically compressing a vapor. Fig. 2 shows the basic refrigeration system and its main components in a simplified automotive air conditioner. Cooling begins at the evaporator. This is a small tube-and-fin heat exchanger located in the vehicle passenger compartment. As this low-pressure liquid refrigerant enters the evaporator, the refrigerant absorbs heat and vaporizes. This cools the evaporator and the surrounding air. The compressor takes in low-pressure refrigerant vapor and pressurizes it to a much higher pressure. Compressing the vapor causes its temperature to go up. The compressor then forces the hot high-pressure vapor out the outlet side and into the condenser. This is another small tube-and-fin heat exchanger. The temperature of the refrigerant vapor entering the condenser is now hotter than the outside air. The cooler air passing through the condenser carries away heat from the vapor. As the vapor cools, it condenses into liquid. The high-pressure liquid then flows into an accumulator. It adsorbs and removes any water vapor or moisture in the refrigerant. The high-pressure liquid leaves the accumulator and flow into expansion valve. This lowers the pressure of the liquid refrigerant flowing into the evaporator. The basic refrigeration cycle begins to repeat itself. During this process, the refrigerant carries heat out of the passenger compartment.

As illustrated in Fig. 3 the conventional organization of automotive refrigeration system troubleshooting process contains several stages starting with the inspection of problem and concluding with the confirmation of original function. Each stage is composed of many important detailed steps. For example, in the inspection stage, technicians first need to ask the client about what went wrong and inspect the trouble. Then in the diagnosis stage, they need to apply their professional experiences and know-how, e.g. engineering knowledge, data and information sources, together with suitable tools and instruments in order to diagnose and find out the real cause of the trouble. In the repair stage, they solve the trouble and check if the system functions normally to complete the whole troubleshooting process. There are many different automotive refrigeration system troubles. Learning from existing cases and using repair experiences can certainly help technicians reduce time for troubleshooting. However, when the trouble is unprecedented or covers too many aspects, the troubleshooting process will be prolonged. Inefficient

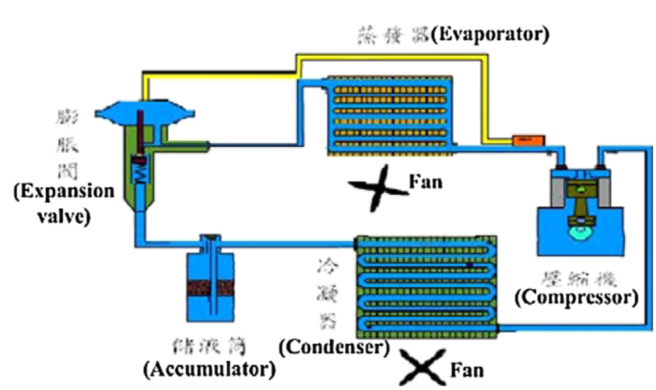

Fig. 2. Main components in an automotive refrigeration system.