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Research Article

THE DEVELOPMENT OF AN EXPERT SYSTEM FOR THE IDENTIFICATION OF CAUSES, PREDICTIONS, AND REMEDIES IN REGARD TO AIRCRAFT DAMAGE

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ABSTRACT

It is necessary to do routine maintenance, repairs, and upgrades on aircraft whenever possible in order to guarantee that operations run smoothly and to keep the pavements in a satisfactory state. It is possible to prevent aircraft breakdowns and ensure safety by performing periodic maintenance on an aircraft system and detecting failures or defects in the system at an early stage. Consequently, there is a requirement to incorporate cutting-edge technological systems into the process of aircraft repair. The purpose of this article is to contribute to the development of an expert system that can forecast failures, identify the factors that lead to failures, and offer solutions to aircraft failures. The probability tree was utilized in the research project to forecast faults in a selection of aircrafts, specifically the Boeing Aircraft (Year: 2016) and Airbus (Year: 2014) Model (BX2V3). These faults were then diagnosed by the expert system that was developed using the C++ programming language. The purpose of this system was to identify aircraft faults and offer solutions for a variety of faults that were identified.
Keywords: Expert System, Aircrafts, Aviation, Aircraft Faults, Diagnosing Aircraft, Reme-Dies, Aircraft Solutions, Repair and Remedies, Artificial Intelligence, Modeling, Prediction, Maintenance, Aircraft Maintenance, GUI, C++

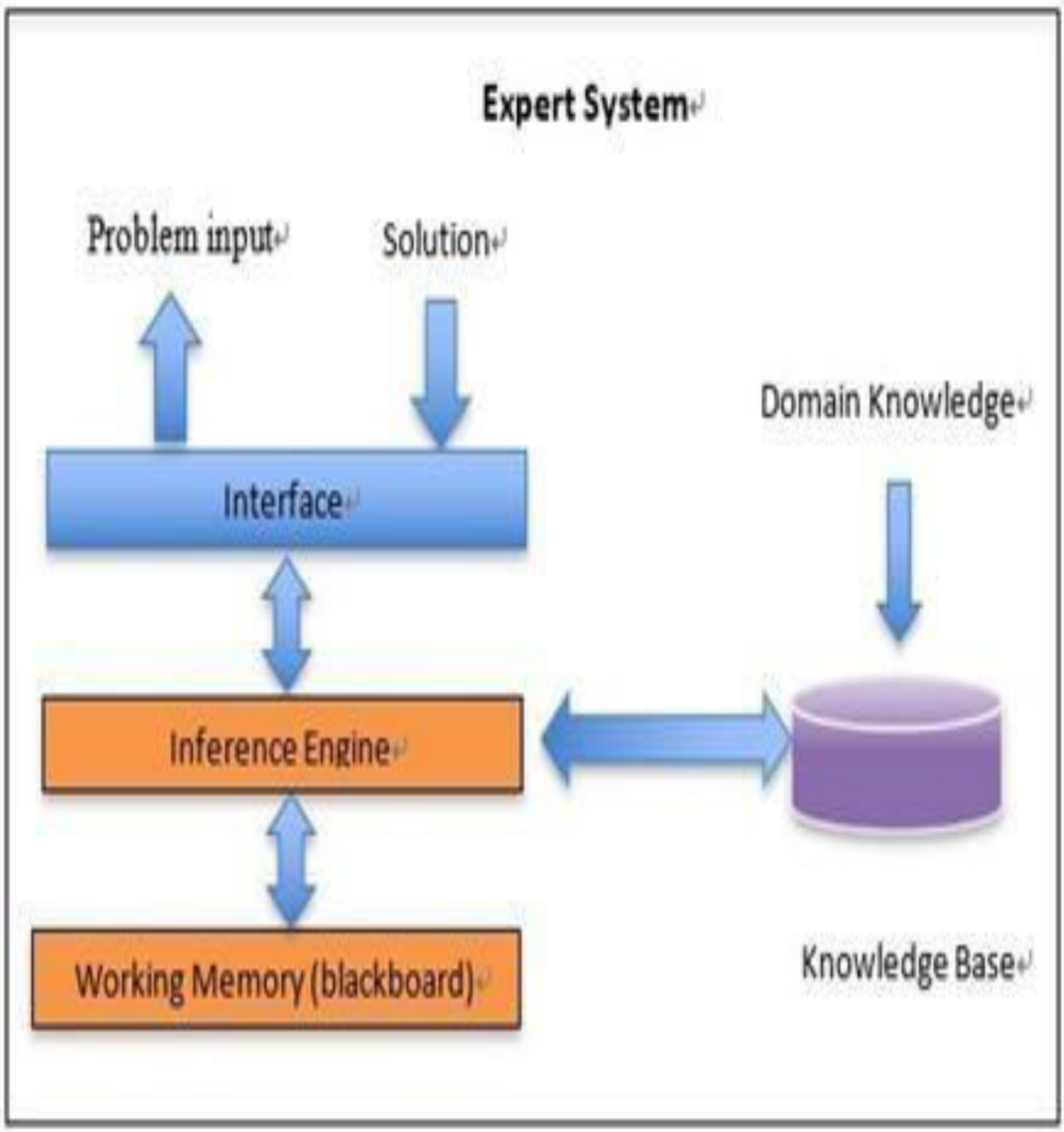
INTRODUCTION

The human activities that are associated with aircraft are referred to as aviation, whereas aeronautics is the science of aviation that encompasses the design and manufacturing of aircraft. When it comes to classifying airplanes, there are a number of different aspects to take into consideration, including the type of lift, the aircraft propulsion, and the usage, amongst others. Therefore, because of degradation, wear and tear, and damage to the aircraft or its components, airplanes require a high level of maintenance in order to achieve optimal performance of the system. This necessitates the execution of responsibilities that are necessary to continually guarantee the airworthiness of their system or parts . In this context, the following are examples of forms of maintenance that can be performed on aircraft at any time: inspections, overhauls, defect rectification, the incorporation of changes in compliance with airworthiness directives, and repairs. In view of the challenges that come with flying at an elevated altitude, the environmental control system is yet another aspect to take into consideration. It is possible that an unexpected failure of the Environmental Control System (ECS) could result in a loss of pressure within the cabin or cause impairment to both the pilot and the passengers.

As a result, a maintenance plan for aircraft is adhered to in a stringent manner in order to ensure that the system is always operating in a safe and appropriate manner.

According to task analysis, the maintenance of an aircraft is a complex technical system that requires collaboration between a variety of work groups and teams. These groups and teams include crew managers, inspectors, hangar managers, commercial and planning, quality, stores, engineering, and other associates such as the manufacturer, airline, and regulators. The goal of this collaboration is to ensure that operations are carried out in a smooth and efficient manner. The maintenance of airplanes is a dynamic and regulated business that is defined by the utilization of highly controlled management systems that guarantee dependability, efficiency, and safety at all times. Artificial intelligence, also known as an expert system, is utilized in order to carry out proper troubleshooting and maintenance of aircraft. This is done in order to guarantee that aircraft are maintained effectively, which in turn helps to ensure that their systems are operating efficiently. Who created an expert system model with the use of an MVC (Model View Controller) and UML (Unified Modeling Language) patterns and backed it up with work related to [8–10] that has emphasized the impact of UML as a modeling language having effective documentation and visualization capabilities. One way to think of the expert system in this study is as a computer simulation of a human expert with an intelligent building block depending on the problem input. This intelligent building block is simulated in a model to produce the solution outputs through the graphical user interface (interface). This idea is illustrated in Figure 1.One type of technology that can be utilized in a variety of contexts is known as an expert system. The inference engine and the knowledge base are the two subsystems that make up how they are constructed. The knowledge base is where rules and information are stored in order to facilitate the comprehension of new facts, while the inference engine is responsible for applying the rules to these facts. In addition, the inference engine includes functions for explaining and debugging, which are designed to assist in the efficient operation of the system. For the purpose of developing an intelligent system, it is necessary to make a careful selection of an application that is suitable for the purpose of the study. Based on the information provided in there are two primary schools of thought that investigate the domain-specific factors that are essential when selecting a problem to center an expert system around. According to their point of view, the degree to which the needs of the domain and the demands of the technology were linked was the key to finding the proper challenge in order to unleash the full potential of expert system technology. In any case, a number of conditions were suggested when the application of the expert system and the domain were brought into alignment.

Fig. 1 Problem Input and Solution Output of an Expert System



The most successful application of artificial intelligence in decision-making has been recorded over the course of the years by the development of Decision Support Systems (DSS), particularly expert systems. This system serves and acts as a guide or adviser to those who are responsible for making decisions. In light of this, numerous types of expert systems have been developed throughout the course of time for a wide variety of applications in the real world. A web-based expert system has been developed by Daoliang et al. for the purpose of diagnosing diseases that affect fish bodies. Fish farmers in North India make use of this technology in order to keep track of the behavior of their fish. In addition, Ahmad developed an expert approach for detecting automobile defects in 2005.This method was supplied with 150 criteria that were designed to identify different types of problems and the underlying causes of such faults. Automotive engineers are able to diagnose and identify faults in automobile vehicles with the assistance of the diagnostic system that has been installed for automotive failure and automobile flaws. As a consequence of this, an expert system was developed in Nabende, P. (2006), M.Sc. research for the purpose of identifying issues that are associated with heavy-duty diesel applications. For the purpose of ensuring that diesel engines are maintained effectively, the technology is able to diagnose defects within the machine. On the other hand, Adsavakulchai et al. constructed an electric learning model for diagnosing aircraft faults and suggesting solutions with the application of Bayesian network technology in the aviation industry. They did this by using 19 knowledge base rules that were gathered from a wide variety of sources, such as books, journals, engineering websites, and other sources. In light of this, it is reasonable to assert that airplanes need to undergo continuous maintenance and repairs, and they also need to have their expert systems upgraded in order to guarantee that their operations run smoothly and to keep the pavements in a satisfactory condition. With the assistance of a probability tree and a built C++ model with a graphical user interface, this article produces an expert system for the causes of failures in airplanes, the forecast of these failures, and the available treatments for these failures. This expert system is developed in order to achieve the aforementioned goals.

METHODOLOGY

The identification of potential flaws in aircrafts is the first essential step in the process of developing this expert system which is being developed. When this was taken into consideration, a great number of literature reviews were carried out in order to collect pertinent information and understanding concerning the topic area. In addition, experienced technicians and engineers were called in order to inquire about the process of diagnosing and repairing the issues that were discovered. As a result, rules were devised to regulate the foundation knowledge of the produced expert system, and these rules were inspired by the information that was obtained.

A. Prediction of faults

1. The forecasting of aircraft malfunctions by determining the likelihood of the factors that led to them

Within the scope of this investigation, a probability tree is utilized to make predictions and to carry out projections. In accordance with the Development of an Expert System for Aircraft Failures Causes, Predictions, and Remedies, the probability is calculated by calculating the probability of the common faults by using the many types of symptoms that are linked with each fault that the aircraft engine experiences.

Table 1 Probability tree table

FAULTS	No of causes	Probability
Compressor surge	5	$\frac{5}{43} = 0.12$
Flame out	5	$\frac{5}{43} = 0.12$
Engine seizure	5	$\frac{5}{43} = 0.12$
Leaks	3	$\frac{3}{43} = 0.07$
Bearing failure	5	$\frac{5}{43} = 0.12$
Oil pump failure	4	$\frac{4}{43} = 0.09$
Contamination of oil system	6	$\frac{6}{43} = 0.14$
No thrust lever response	3	$\frac{3}{43} = 0.07$
Vibration	7	$\frac{7}{43} = 0.16$
TOTAL	**43**	**1.0**

1. Identification of the causes of the problem based on their symptoms

It was determined that the fault prediction according to [21] using symptoms with respect to the causes of each fault was established over a period of one year, and the total number of faults that were established was 97. In light of this, the probability of a few of the errors that were examined is presented in Table2.

Table 2 Symptoms of analyzed faults probabilities

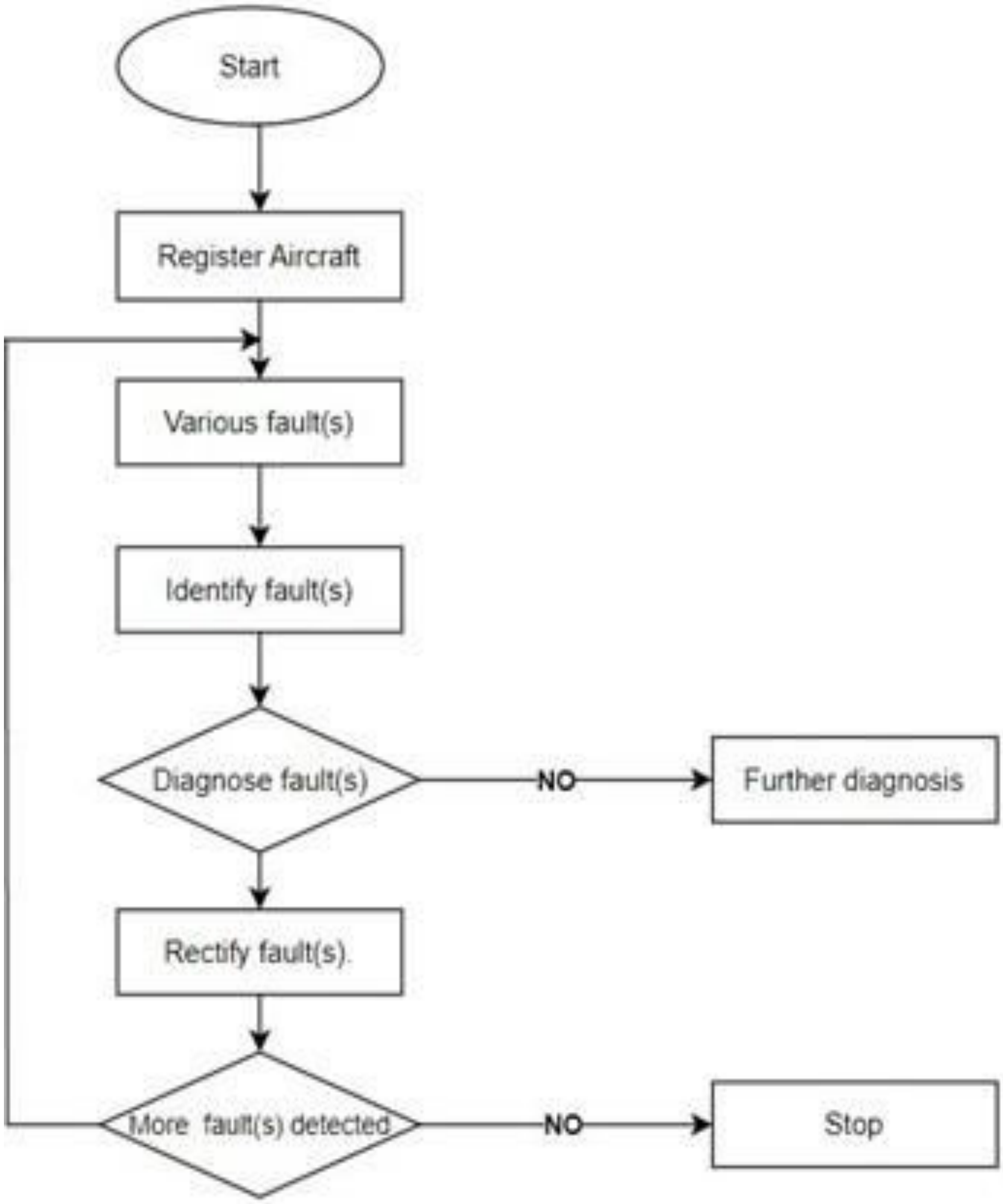
Symptoms	Occurrences probability within a year
Clog message	$\frac{1}{97} = 0.01$
Sudden change in load speed	$\frac{2}{97} = 0.02$
Increase in oil temperature	$\frac{5}{97} = 0.03$
Periodic random failure of instruments	$\frac{4}{97} = 0.04$
Shaking or vibrating panel	$\frac{5}{43} = 0.05$
A drop in EGT, Engine core speed	$\frac{6}{43} = 0.06$

A drop in Exhaust Gas Temperature (EGT) of engine core speed, particles in oil, and fatigue cracks have the highest probability of occurring within a year, according to the analysis of Table 2, while filter clog and difference between primary parameters have the lowest probability of occurring within a year. This is based on the symptoms that have been listed.

1. Flow chart for Aircraft diagnosis and remedies

The programming that will be utilized for the identification of defects in the aircraft is based on the fundamentals that are provided by the flow chart. It is necessary for the aircraft that is going to be diagnosed to be registered within the database; if it is not already registered, it must be registered before any diagnostic can be performed. Following the completion of the registration process, the diagnosis comes next, which is carried out in accordance with the flowchart depicted in Figure 2.

Fig. 2 Aircraft flowchart for diagnosis



RESULTS AND DISCUSSION

A. Results

The diagnostic program that was developed to assist a mechanical aviation engineer in identifying and offering potential solutions to the defects that were identified was utilized in order to make a diagnosis of an aircraft. Using a programming code written in the C++ language, the diagnostic software was developed, and it is organized according to the flowchart depicted in Figure 2. An examination was carried out on two distinct categories of aircraft by utilizing some presumed (standard) registered attributes prior to faults and properties that were present after faults. Detailed information regarding the outcomes of the analysis may be found in Tables 3 and 4.

Table 3 Details of analyzed results for Boeing 737 (2015) Model (UI890IJ)

Properties	Assumed standard registered properties	After faults assumed properties
Indicated exhaust temperature	30.0	60.5
Indicated engine pressure ratio	45.7	50.3
Indicated EGT	25.0	10.5
Indicated core speed	120	75.0
Indicated oil pressure	10.0	3.75
Indicated engine temperature	75	105
Indicated oil temperature	35.5	67.3
Indicated vibration	150	190

Fig. 3 Diagnosed interface for the faulty Boeing 737 Aircraft

Development of An Expert System for Aircraft Failures Causes, Predictions, and Remedies

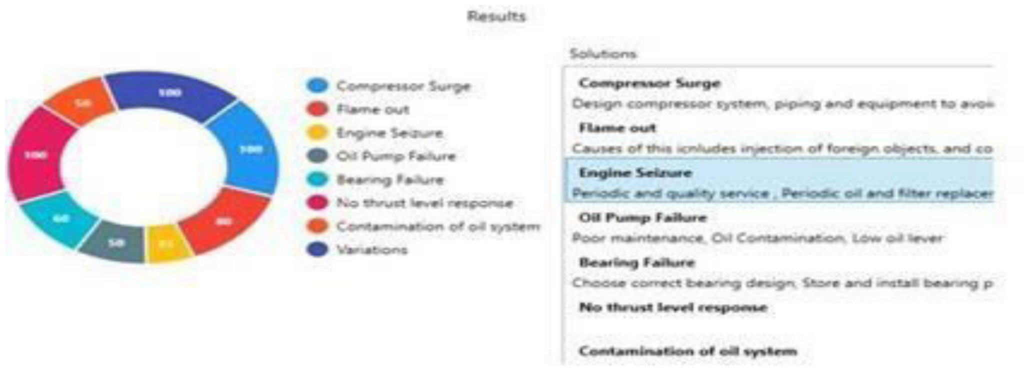


Fig. 4 Result for the diagnosed Boeing 737 Aircraft and the possible solution

Table 4 Details of analyzed results for Airbus (year: 2014) Model (BX2V3)

Properties	**Assumed standard registered properties**	**After faults assumed properties**
Indicated exhaust temperature	50.0	75.45
Indicated engine pressure ratio	25.7	38.4
Indicated EGT	20.0	10.5
Indicated core speed	200	175
Indicated oil pressure	15.0	7.25
Indicated engine temperature	105	125
Indicated oil temperature	55.5	85.8
Indicated vibration	120	250

Fig. 5 Diagnosed interface for the faulty Airbus Aircraft

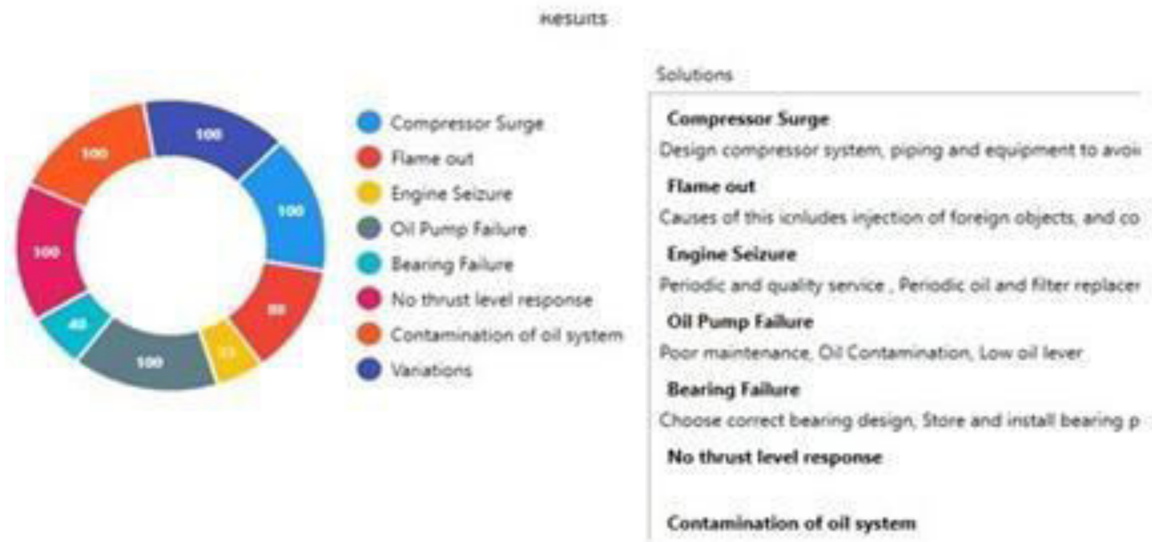


Fig. 6 Result for the diagnosed airbus aircraft and the possible solution

B. Discussion

1. Discussion on Prediction of Faults in Aircraft

In the section of the research that dealt with prediction, the probability that was examined in chapter three was utilized to make a prediction regarding the frequency with which the errors that were centered on this project occurred. When considering the few causes of each defect that were available in this project, the probability that was derived in chapter 2 was used to determine the probability. After conducting the research, it was discovered that vibration and oil contamination have the highest probability, whereas the lowest probability is associated with the absence of a push lever reaction and oil pump failure. In addition, prediction was accomplished by predicting with their symptoms, taking into consideration a certain airplane (Boeing), and a specific year, and analyzing the frequency with which these symptoms happened inside that specific year. After this, it is utilized to make a prediction about the frequency with which these defects will arise in the years to come.

Development of an Expert System for Aircraft Failures Causes, Predictions, and Remedies

2. Discussion on Faults Diagnosis and Possible Remedies in Aircraft

I. A diagnosis was made on a Boeing 737 aircraft as well as an Airbus aircraft that had acquired standard registered properties. The properties that were presumed to exist after the defect was recorded were also registered. The aircraft was diagnosed after a few questions were answered before the diagnosis was made. The diagnostic program then provides the probability of which of the issues the aircraft might be experiencing, as well as the possible solution to each of the faults identified by the software. The probability diagram and the potential remedy that ought to be applied to the defects that were developed for a Boeing 737 and an Airbus aircraft, respectively, are depicted in Figures 4 and 5, respectively.

CONCLUSION

The findings of this study have led to the effective installation of an expert system in aircraft. This system is capable of diagnosing defects in aircraft and offering potential recommendations or solutions to the issues that have been identified. Using knowledge of probability trees, this system is able to diagnose problems, find solutions to those problems, and present the answer to fix those problems. Therefore, the expert system that was developed offers quick access for the maintenance engineers who are in charge of aircraft troubleshooting and maintenance. This allows them to easily access and diagnose faults with minimal or no effort and it also suggests possible solutions to the problems that were diagnosed by the system through the Graphical User Interface (GUI).

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