COMPILER
Vol. 10, No. 1, Mei 2021, pp. 27-34
ISSN: 2252-2403 (Print), ISSN: 2549-2403 (On Line)
Accredited Fourth Grade by Kemenristekdikti, Decree No:200/M/KPT/2020
DOI: 10.28989/compiler.v10i1.972

Marchetti type of aircraft engine error detection system using hill climbing heuristic

Anton Setiawan Honggowibowo[1,*], Asih Pujiastuti[2], Yuliani Indrianingsih[3], Dhea Yogi Anugerah[4]
[1,2,3,4] Program Studi Informatika, Institut Teknologi Dirgantara Adisutjipto

Article Info

Article history:

Received June 2nd , 2021
Accepted June 7, 2021
Published June 8, 2021

Keywords:

Aircraft Engine
Expert System
Heuristic Hill Climbing
Fault Detection

ABSTRACT

Transportation has become a human need today, one of which is air transportation, namely airplanes. In order for the aircraft to be used properly and comfortably, it is necessary to carry out routine maintenance, especially before flying. Problems caused by aircraft engines are sometimes small problems that do not require a high level of knowledge. To overcome this, maybe someone who has very basic knowledge of aircraft engines can do it. But sometimes these problems also require a high level of expertise regarding these components so that they require technicians or experts to repair them. Through this application, users can consult the system such as consulting with experts to find out the symptoms that occur on the plane and find solutions to the problems encountered. The expert system built using the Hill Climbing Heuristic method resulted in 72.67% when tested on respondents.

Corresponding Author:

Anton Setiawan Honggowibowo,
Program Studi Informatika,
Institut Teknologi Dirgantara Adisutjipto,
Jl. Janti Blok R, Lanud Adisutjipto, Yogyakarta, Indonesia
Email: *anton_s_h@yahoo.com

1. INTRODUCTION

Air transport is an important part of human life, the necessity of this transport is used to advance various aspects of life such as commerce, education, industry and social aspects. Airplanes are an option for some people who wish to visit or travel to a remote location to accomplish their work or travel agenda [1]. Airplanes will always be the good alternative as they can reach the most remote areas with a relatively short travel time. Therefore, good and comfortable aircraft conditions are necessary to reduce the risk of accidents [2].

Cases of airplane accidents will always be associated with several factors such as: human error, climate and engine. In order to reduce the risk of an airplane crash, an airline must perform maintenance on airplanes. Aircraft maintenance is not cheap, not only for damage detection equipment, but also for paying a technician or expert who can repair the damaged aircraft [3]. In addition to the high maintenance costs, the cost of training a technician is also expensive. Another problem with the limited capacity of a technician, namely the precision of a technician in tracing the problem of damage to the aircraft, there is a need for a system that can be used by a technician to aircraft to identify damage on the basis of existing data that is consistent with the symptoms of damage to the aircraft.

The system which can assist aircraft technicians and which has the capability or expertise of an expert in the field of aircraft is an expert system. An expert system is a computer program that contains the knowledge of one or more human experts in a specific area [4]. Many areas can be addressed by expert systems, including diagnosis of plant diseases and pests [5], pharmacy live plants for alternative medicine [6], dental disease expert systems [7], diseases digestive systems [8], education, machine tools [9], damage to vehicles such as cars [10], diagnostics of damage to other vehicles, including airplanes[11], etc. Several previous studies on expert systems that can help diagnose aircraft damage include a Landing Gear Damage

Identification System on Cessna aircraft [12], an expert system for diagnosing damage on a Cessna Grand Caravan 208B [13], an equipment detection system used to assist work activity activities at airports that are often damaged due to the way the operator uses equipment that is not suitable [14]. Based on research on the performance analysis of the Marchetti SF-260 [15] aircraft, this study chose to use the Marchetti type aircraft test. Meanwhile, several heuristic methods that have been used to solve the problems are in the case of exam planning which is complex and time consuming when done manually [16] [17], and A Hybrid Meta-Heuristic Feature Selection Method for Identification of Indian Spoken Languages From Audio Signals[18]. As with previous research, namely Late Acceptance Hill Climbing Based Social Ski Driver Algorithm for Feature Selection [19] and application of the steepest climb method in games puzzle [20] applied the hill climbing method. In this study, we will build an expert engine damage / fault detection system on Marchetti-type airplanes by applying the Heuristic Hill Climbing method.

2. RESEARCH METHOD

The methods used in this research are:

1. Interview Method
   The method is by conducting direct interviews with aircraft technicians / experts, namely Mr. Kris Haryanto ST.,MT. From the results of these interviews can be obtained an explanation of the symptoms and causes of damage to aircraft engines. This knowledge is then stored in the computer and used to build an expert system that can solve problems like an expert.
2. Library Method
   Methods of collecting data by taking information from reference books and the internet.
3. Observation Method
   The method of data collection is done by observing directly to the object of research to see closely the activities carried out. Observations were made to find out the implementation methods carried out by aircraft technicians in detecting engine damage on aircraft.
4. System Design Method
   The method is to design an interface form for an expert system for detecting engine damage on aircraft.
5. Trial and Analysis Method
   Testing the system in building an expert system for detecting engine damage on aircraft by applying the Heuristic Hill Climbing method.

2.1. Metode Heuristic Hill Climbing

Heuristic techniques are techniques used to speed up the search for solutions. Heuristic techniques are used to eliminate several possible solutions without having to explore them in full. In addition, heuristic techniques also help decide which possible solutions need to be evaluated first. There are several heuristic search methods, one of which is the hill climbing method. The hill climbing method is one of the many artificial intelligence methods to solve optimization problems. The way the Hill Climbing method algorithm works is as follows:

1. Starting from the initial state, perform the test. If it is a goal, then stop. And if not, continue with the current state as the initial state.
2. Do it until the goal is achieved.
   a. Determine the destination based on the best heuristic value of the existing nodes.
   b. Do this for each node used by the current state.
   c. Use those nodes and form a new state.
   d. Evaluate the new situation. If it is the goal (result), exit. If not, compare the heuristic values with other nodes. If better, make the value of the new state heuristic the goal.
   e. If the goal is better than the current state heuristic value, change the goal to the current state.
   An image of the search process can be seen in Figure 1.

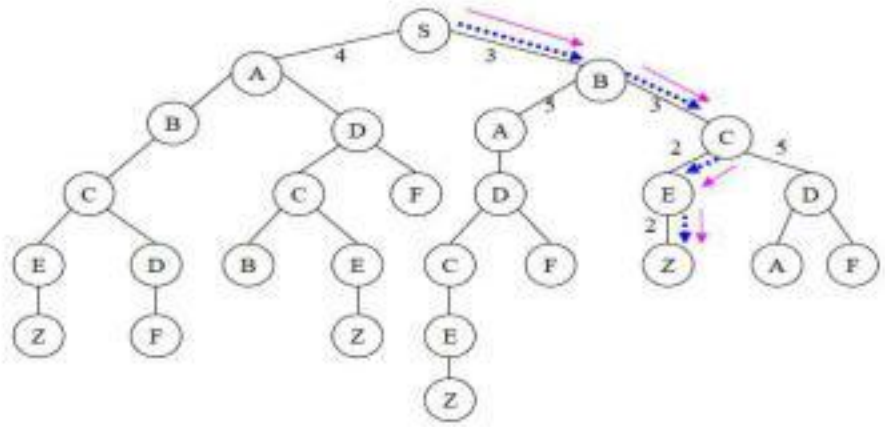

Figure 1. Search Process With Hill Climbing

2.2. Symptoms of Damage to Aircraft Engines

Damage to aircraft can occur due to various things, in this study the symptoms of damage to aircraft can be described as shown in table 1, namely the table of symptoms of aircraft engine damage.

Table 1. Aircraft Damage Symptoms Table

Symptom	Name Symptom	Question
G001	The instrument turns on when on	The instrument cluster turns on when contact position on
G002	Contact starting position	When contact the position start what rotating starter dynamo
G003	Cable plus minus battery	Is the + - cable to the battery properly attached?
G004	Instrument cluster flashing	Is the instrument cluster flashing when the dynamo starter rotates
G005	Bendix dynamo starter	Does bendix work when position start
G006	ACC fuse / relay	Is the AC fuse/relay normal?
G007	Machine can't start	Will the engine start when start
G008	Idle RPM	Is the RPM stable immediately
G009	Spark plugs and spark plug wires	Are the spark plugs and spark plug wires inside good condition
G010	The machine vibrates	At high RPM does the engine vibrate
G011	Ignition timing	Whether the ignition timing is correct
G012	engine mount	Is the engine mount broken?
G013	Carburetor / injector	Is the carburetor/injector in good condition?

Table 1 is a table of symptoms of damage to aircraft engines, in this study there were 13 symptoms of damage to aircraft.

2.3. Types of Damage to the Aircraft

Damage to aircraft engines occurs due to various symptoms. Symptoms of the damage that resulted in damage to the aircraft. The damage to the aircraft can be seen in table 2.

Table 2. Table of Types of Damage to Aircraft

ID Damage	Name Damage	Solution
K001	Battery cable	Cable + - is damaged
K002	The starter dynamo is broken	Change starter dynamo
K003	The starter dynamo bendix is faulty	Change bendix

K004	Battery damaged	Change the battery
K005	The AC relay fuse is faulty	Replace the ACC fuse/relay
K006	*Defective spark plugs or ignition wire*	Replace spark plugs and spark plug wires
K007	Ignition timing incorrectly	Adjust ignition timing
K008	*Cracked engine mount*	Replace engine mounting
K009	Defective mount bushing	Replace the mounting bushings
K010	*Mixture is too rich or too lean*	Adjust the fuel and air mixture settings
K011	*Carburetor, injection*	Clean or replace the injector carburetor

Table 2 is a table of types of damage to aircraft that have been inputted into the system. There are 11 types of damage to aircraft that exist in the aircraft engine damage detection expert system.

2.4. Table of Relation of Types of Damage to Symptoms on Aircraft

Damage to aircraft engines occurs due to various symptoms. Symptoms of the damage that resulted in damage to the aircraft. The damage to the aircraft can be seen in table 3.

Table 3. Table of Damage Relationship with Symptoms on Aircraft

Id Damage	Damage Name	Symptoms	Solution
K001	Battery cable	G001 G002 G003 G004	Cable + - is damaged
K002	The starter dynamo is broken	G001 G002 G004	Change starter dynamo
K003	The starter dynamo bendix is faulty	G001 G002 G003	Change bendix
K004	Battery damaged	G001 G003 G006	Change the battery
K005	The AC relay fuse is faulty	G001 G003 G006	Replace the ACC fuse/relay
K006	Defective spark plugs or ignition wire	G001 G002 G004 G007 G009	Replace spark plugs and spark plug wires
K007	Ignition timing incorrectly	G001 G002 G004 G007 G008 G009 G011	Adjust ignition timing
K008	Cracked engine mount	G001 G002 G004 G007 G008 G010 G012	Replace engine mounting
K009	Defective mount bushing	G001 G002 G004	Replace the mounting bushings

		G007 G008 G010 G012	
K010	Mixture is too rich or too lean	G001 G002 G004 G007 G009 G011	Adjust the fuel and air mixture settings
K011	Carburetor, injection	G001 G002 G004 G007 G009 G011 G013	Clean or replace the injector carburetor

Table 3 is a table of types of damage to the aircraft. There are 11 types of damage to aircraft that exist in the aircraft engine damage detection expert system. In this table there are also symptoms that arise from a malfunction that occurs in the aircraft engine.

2.5. Hill Climbing Method Diagnostic Process Flowchart

The following is a description of the flowchart design for the diagnostic process of the hill climbing method on an expert system for detecting aircraft engine damage using the hill climbing heuristic as shown in Figure 2. Here is the description:

1. The user performs a diagnosis by answering questions about the symptoms of damage.
2. Checking the appropriate rules.
3. If a suitable fault is found, it will display the type of damage, otherwise it will be forwarded/returned to the next symptom question.
4. Done.

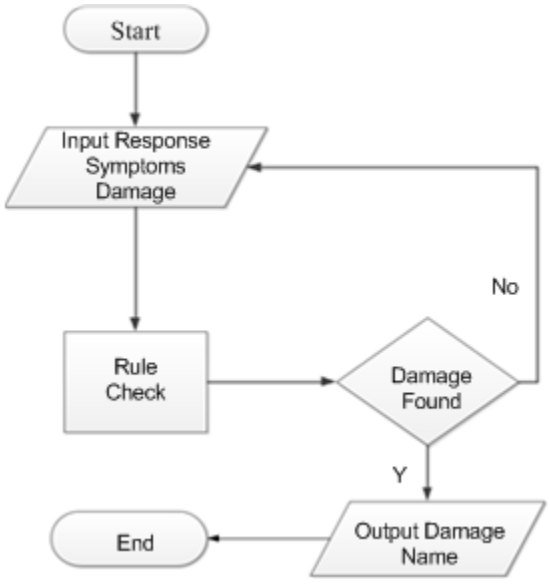

Figure 2. Program Flowchart

3. RESULTS AND ANALYSIS

Based on the analysis of the system design that has been carried out, a damage detection system has been implemented using the heuristic hill climbing method to detect engine damage on aircraft. The implementation of this system aims to detect damage to aircraft.

3.1. Process Menu Implementation

Implementation of the Process Menu is a display that is used to carry out the process of the Hill Climbing method, before carrying out the process of diagnosing damage, the user is required to select the aircraft that will be checked for the engine. The process menu display can be seen in Figure 3.

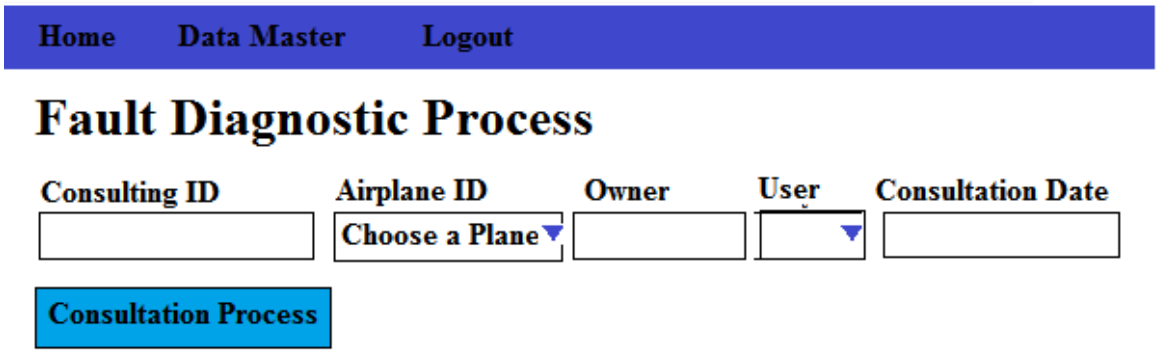

Figure 3. Process Menu Display

3.2. Binary Tree Function Test

In testing the binary tree function, initial symptoms will be included which will be used as the first step for inspection on aircraft. Binary tree search flow using the Heuristic Hill Climbing method according to the cases that were solved at the application function test stage can be shown in Figure 4.

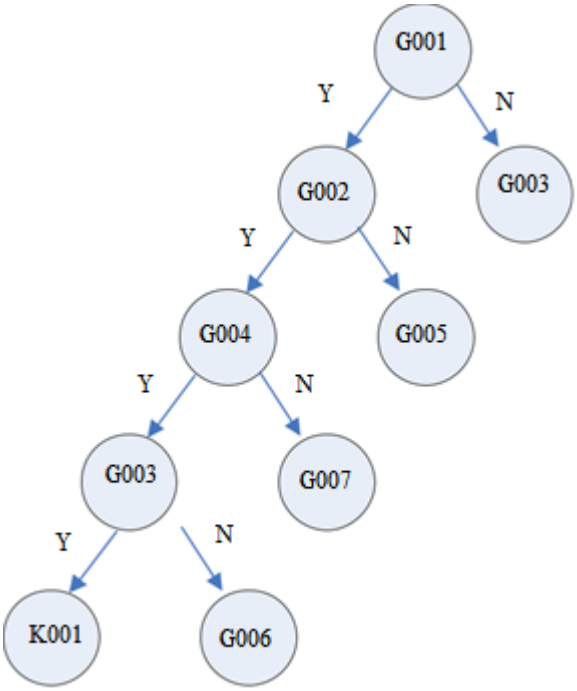

Figure 4. Fault Diagnostic Flow

Information :
G00x : Symptom ID
K00x : Damage ID

Can be seen in Figure 3. G001 is an early symptom that should be checked. In this binary tree function the Heuristic Hill Climbing method is used, so it can be seen in Figure 3. The process goes down until a fault is found. The picture shows that the damage has been found after the 4th symptom question. In the fourth symptom question, it can be seen that there is a similarity with the second question on the left,

namely G003, using the Heuristic Hill Climbing method, it is not allowed to go back up so that the iteration will continue down until find a solution.

3.3. Discussion

Based on the results of application testing and binary tree testing, it can be seen that the diagnosis of damage using the Heuristic Hill Climbing method can be used to determine the damage that occurs to aircraft engines by using questions that arise from the symptoms experienced by the engine more quickly because the process only explores possibilities. from the symptoms experienced only and eliminate some of the possible symptoms that are not experienced until the type of damage is found.

3.4. User Trial

User trials were conducted using a questionnaire which involved 30 aeronautical engineering students. The forms of questions used in the questionnaire are as follows:
Give your opinion regarding the use of the Aircraft Engine Damage Detection Expert System application using the Heuristic Hill Climbing Method (1 is the lowest rating to 4 the highest rating).

1	Interface (Display) Program	1	2	3	4
2	Ease of use	1	2	3	4
3	Clarity of information and data	1	2	3	4
4	Program Use	1	2	3	4
5	Overall Program Assessment	1	2	3	4

Table 4. Questionnaire Results

No	Questionnaire	Total Value			
		1	2	3	4
1	Interface (Display) Program	0	1	23	6
2	Ease of use	0	4	21	5
3	Clarity of information and data	0	3	24	3
4	Program Use	0	3	17	10
5	Overall Program Assessment	0	0	24	6
	Total	0	11	109	30
	Percentage	0 %	7,33 %	72,67 %	20 %

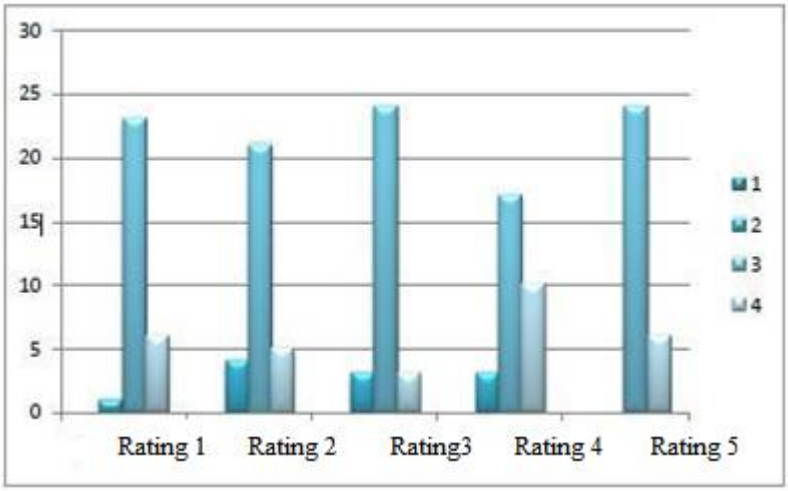

Figure 5. Diagram of the Percentage of Questionnaire Results

By using the questionnaire data that has been obtained, the percentage value of 1 is 0%, the value of 2 is 7.33 %, the value of 3 is 72.67%, and the value of 4 is 20%. The calculation is done by adding up the value data on the questionnaire obtained from 30 students, then the sum of each value is divided by 150. The value of 150 is obtained by multiplying the 30 questionnaire data with the 5 available questions. From the addition process like this, so that the percentage of each value is obtained which is then made into a diagram.

4. CONCLUSION

1. This application is designed to be useful to make it easier to find damage to aircraft engines, so that aircraft repair times can be shortened so that the aircraft can immediately return to the air.
2. The results of the application test and binary tree test show the conclusion that the damage diagnosis application using the Heuristic Hill Climbing method can provide information about the damage that has occurred to an aircraft.
3. The test results of 30 respondents on the application of an expert system for detecting engine damage on aircraft using the Heuristic Hill Climbing method are 72.67%.

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