

# **Machine Learning-Based Predictive Analytics for Aircraft Engine**

**PROJECT REPORT**

*Submitted by*

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# CHAPTER-I

## INTRODUCTION

### 1.1 Project Overview:

- You'll be able to understand the problem to classify if it is a regression or a classification kind of problem.
- You will be able to know how to pre-process/clean the data using different data pre-processing techniques.
- Apply different algorithms according to the dataset
- You will be able to know how to find the accuracy of a model.
- You will be able to build web applications using the Flask framework.

### 1.2 Project Flow:

You will go through all the steps mentioned below to complete the project.

- Download the dataset.
- Preprocess or clean the data.
- Analyze the pre-processed data.
- Train the machine with pre-processed data using an appropriate machine learning algorithm.
- Save the model and its dependencies.
- Build a Web application using a flask that integrates with the model built.

## **CHAPTER-2**

### **LITERATURE SURVEY**

#### **2.1 Introduction :**

The aviation industry is capital intensive, and is subject to stringent environmental and safety regulations. To minimize risk, technological improvements of aircraft engines are generally made incrementally, drawing heavily from experiences and lessons learned. Engine companies have generated and collected large amounts of data over the years. These big data, from various sources such as the database of currently manufactured engines, current development projects, previously completed development projects, and the designs that were not manufactured, are valuable resources of intelligence that can support new engine development. With increasing computational power and employing machine learning, data can be mined to provide valuable insights that could bring high levels of efficiency to engine conceptual design.

#### **2.2 literature Review:**

##### **SURVEY 1: Machine Learning- Based Predictive Analytics for Aircraft Engine Conceptual Design (Author - Michale T.Tong).**

Big data and artificial intelligence/machine learning are transforming the global business environment. Data is now the most valuable asset for enterprises in every industry. With that, the adoption of machine learning-based data analytics is rapidly taking hold across various industries, producing autonomous systems that support human decision-making. This work explored the application of machine learning to aircraft engine conceptual design. Supervised machine learning algorithms for regression and classification were employed to study patterns in an existing, open-

source database of production and research turbofan engines, and resulting in predictive analytics for use in predicting performance of new turbofan designs.

***SURVEY 2: Approach And Landing Aircraft on-board Parameters Estimation with LSTM Networks (Author - Gabriel Jarry).***

This paper addresses the problem of estimating aircraft on-board parameters using ground surveillance available parameters. The proposed methodology consists in training supervised Neural Networks with Flight Data Records to estimate target parameters. This paper investigates the learning process upon three case study parameters: the fuel flow rate, the flap configuration, and the landing gear position. Particular attention is directed to the generalization to different aircraft types and airport approaches. From the Air Traffic Management point of view, these additional parameters enable a better understanding and awareness of aircraft behaviors. These estimations can be used to evaluate and enhance the air traffic management system performance in terms of safety and efficiency

***SURVEY 3: Monitoring Of Aircraft Operation Using Statistics and Machine Learning (Author - Fazel Famili and Sylvain Letourneau***

This paper describes the use of statistics and machine learning techniques to monitor the performance of commercial aircraft operation. The purpose of this research is to develop methods that can be used to generate reliable and timely alerts so that engineers and fleet specialists become aware of abnormal situations in large fleet of commercial aircraft that they manage. We introduce three approaches that we have used for monitoring engines and generating alerts. We also explain how additional information can be generated from machine learning experiments so that the parameters influencing the particular abnormal situation and their ranges are also identified and reported. Various benefits of fleet monitoring are explained in the paper.

***SURVEY 4 :Aircraft Engine Reliability Analysis Using Machine Learning Algorithms(Author -***

**Deepnkar Singh)**

In the aviation industry, the reliability analysis of aircraft engines is essential for ensuring the smooth functioning of each component of an aircraft engine. The reliability analysis is also important to predict their scheduled maintenance event and the Remaining Useful Life (RUL) of engine parts. Existing approaches for engine reliability are based on numerical methods, which do not predict RUL accurately. Hence, a more accurate model is required for predicting maintenance events. The reliability of an aircraft engine can be measured using readings of different sensors. In this work, the performances of different machine learning algorithms are studied, and finally, a better algorithm is suggested for predicting RUL. Additionally, a classification approach is proposed to classify the health state of an engine. The experimental results show that the XGBoost gives the best prediction accuracy in terms of root mean square error. The proposed LightGBM-based classifier further enhances the maintenance prediction based on the health state of the aircraft engine. Thus, the proposed analysis shows that XGBoost and LightGBM is a better choice for predicting the RUL, and for classifying the health state of the aircraft engine.

#### **SURVEY 5: Predictive Maintenance and Performance Optimisation in Aircrafts using Data Analytics.**

Airline industry has provided a significantly conventional, faster and reliable mode of transportation for passengers and freight over the decades in which the industry has been in service despite the pressure being applied especially in maintaining operational affordability. The study critically reviews the techniques and tools, infrastructure and general application architecture for discussing the applicability of data analytics based on both batch processing and real time stream data in general aviation for health monitoring and predictive analysis in order to predict maintenance and optimize the performance of aircrafts. In this respect, the study further evaluates the significant capability in addressing contemporary problems which are uniquely addressed by data analytics system.

#### **SURVEY 6: Application of Machine Learning Techniques to Web-Based Intelligent Learning**

## **Diagnosis System.(Author – Chenn- Jung Huang).**

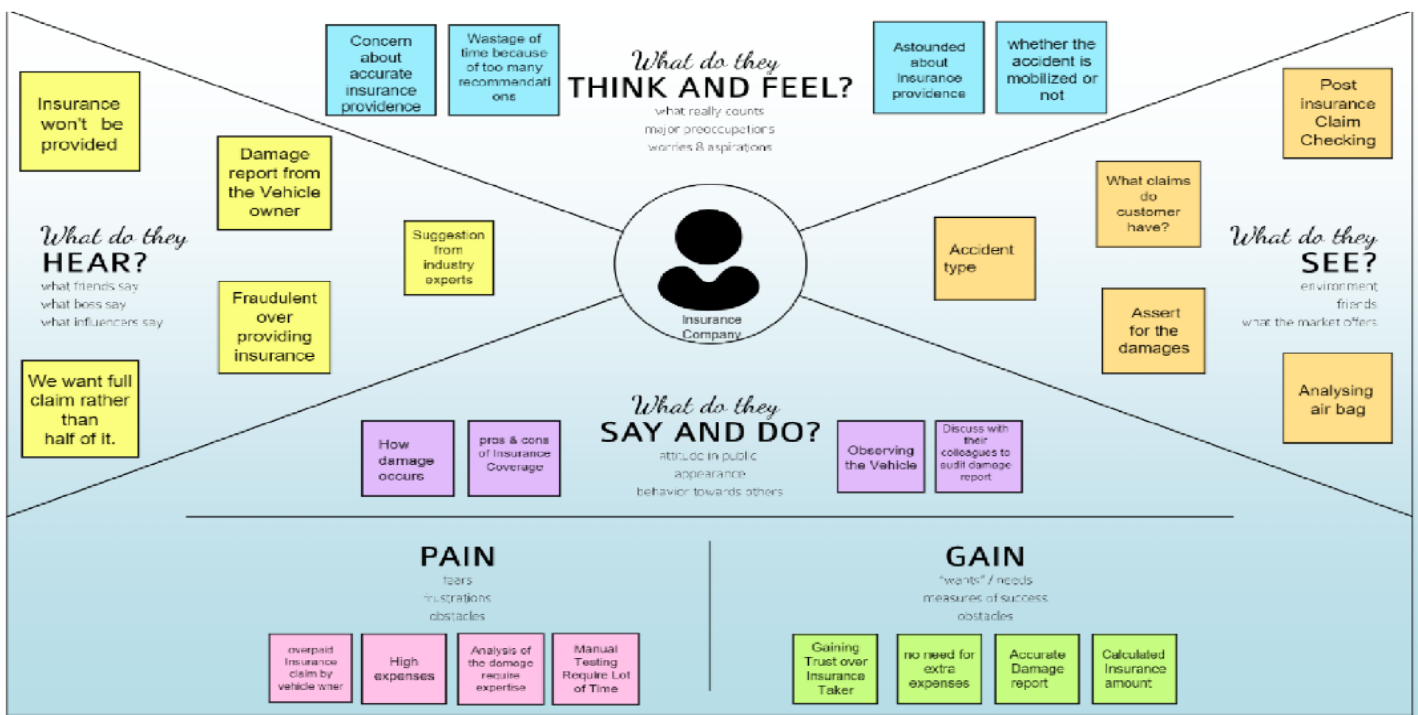
This work proposes an intelligent learning diagnosis system that supports a Web-based thematic learning model, which aims to cultivate learners' ability of knowledge integration by giving the learners the opportunities to select the learning topics that they are interested, and gain knowledge on the specific topics by surfing on the Internet to search related learning courseware and discussing what they have learned with their colleagues. Based on the log files that record the learners' past online learning behavior, an intelligent diagnosis system is used to give appropriate learning guidance to assist the learners in improving their study behaviours and grade online class participation for the instructor. The achievement of the learners' final reports can also be predicted by the diagnosis system accurately. Our experimental results reveal that the proposed learning diagnosis system can efficiently help learners to expand their knowledge while surfing in cyberspace Web-based "theme-based learning" model.



## CHAPTER-3

### IDEATION & PROPOSED SOLUTION


#### 3.1 Empathy Map Canvas:



#### 3.2 Ideation & Brainstorming:

Step-1: Team Gathering, Collaboration and Select the Problem Statement

Template



### Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

10 minutes to prepare

1 hour to collaborate

2-6 people recommended

10

Share template feedback

➔

**Before you collaborate**

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

➔

**Team gathering**

Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

➔

**Set the goal**

Think about the problem you'll be focusing on solving in the brainstorming session.

➔

**Learn how to use the facilitation tools**

Use the Facilitation Toolkits to run a happy and productive session.

Open article ➔

➔

**Define your problem statement**

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

5 minutes

PROBLEM

Causes lot of time and cost more funds to take repair measures

PROBLEM

Causes threat to human life and danger to environment when not observed at correct time

PROBLEM

May lead to increase in customer complaints and affects the company's reputation

PROBLEM

Fuel contamination may occur due to engine malfunction which may leads to biodiversity damage

Step-2: Brainstorm, Idea Listing and Grouping :

2

**Brainstorm**

Write down any ideas that come to mind that address your problem statement.

10 minutes

TP

You can select a sticky note and hit the pencil icon to start drawing!

By using the  
RTD sensor we  
can detect  
excess heat in  
advanceElastic-net  
regression  
used to  
compare the  
valuesUsing the Linear  
Regression we can  
make prediction in  
numerical valuesUsage of light  
GBM classifierWe can use the  
random forest  
algorithm to  
make the  
predictionUsing DNN  
for the  
engine  
maintenanceCatBoost  
recognize  
the sound  
and picturesTo ensure the  
correct level of  
humidity using  
sensorsUsage of  
Ridge  
regression for  
finding true  
valueEnsemble  
method used  
to predict the  
best valueWe can use  
the Naive  
Bayes  
algorithm for  
the predictionLasso  
regression  
goal is to  
acquire a  
subsetUsing the  
probabilistic  
reasoning for  
the  
predictionBy using the  
Decision Tree  
algorithm we  
can make the  
yes/no  
predictionWe can use  
different  
algorithms for  
finding the  
efficient  
algorithms.Using PCA  
algorithms which  
can be used for  
feature  
extraction.

3

**Group Ideas**

Take turns sharing your ideas while clustering similar or related notes as you go. In the last 10 minutes, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you and break it up into smaller sub-groups.

20 minutes

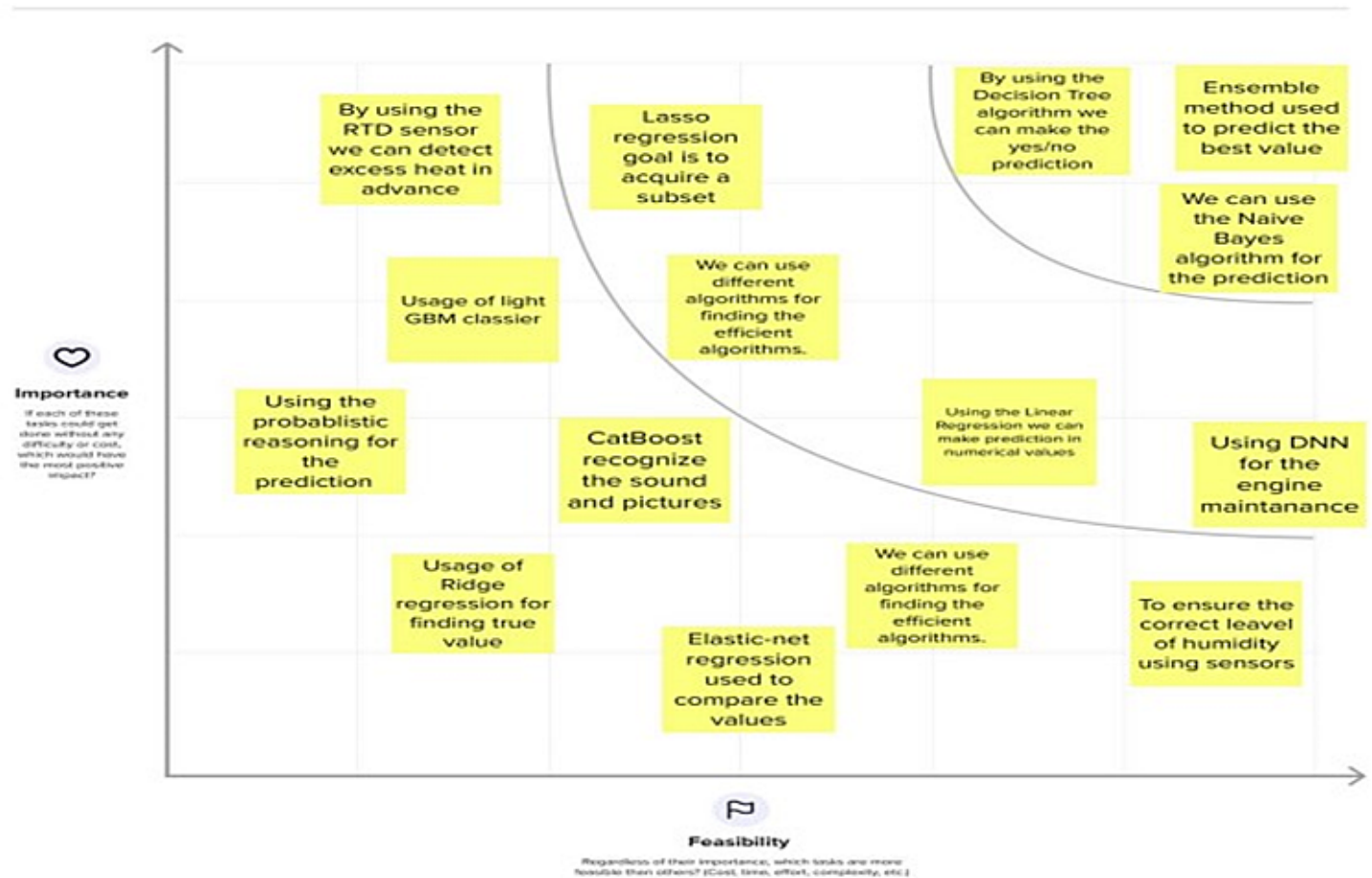
By using the  
RTD sensor  
we can detect  
excess heat in  
advanceElastic-net  
regression  
used to  
compare the  
valuesWe can use the  
random forest  
algorithm to  
make the  
predictionUsing DNN  
for the  
engine  
maintenanceUsage of  
Ridge  
regression for  
finding true  
valueEnsemble  
method used  
to predict the  
best valueUsing the  
probabilistic  
reasoning for  
the  
predictionBy using the  
Decision Tree  
algorithm we  
can make the  
yes/no  
predictionUsing the Linear  
Regression we can  
make prediction in  
numerical valuesUsage of light  
GBM classifierCatBoost  
recognize  
the sound  
and picturesTo ensure the  
correct level of  
humidity  
using sensorsWe can use  
the Naive  
Bayes  
algorithm for  
the predictionLasso  
regression  
goal is to  
acquire a  
subsetWe can use  
different  
algorithms for  
finding the  
efficient  
algorithms.Using PCA  
algorithms  
which can be  
used for feature  
extraction.**Step-3: Idea Prioritization:**

4

**Prioritize**

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

🕒 20 minutes



### 3.3 Problem Statement:

Extracting and modeling the engine symmetry characteristics is significant in improving remaining useful life (RUL) predictions for aircraft components, and it is critical for an effective and reliable maintenance strategy. Such predictions can improve the maximum operating availability and reduce maintenance costs. Due to the high nonlinearity and complexity of mechanical systems, conventional methods are unable to satisfy the needs of medium- and long-term prediction problems and frequently overlook the effect of temporal information on prediction performance. To address this issue, this study presents a new attention-based deep convolutional neural network (DCNN) architecture to predict the RUL of turbofan engines. The prognosability metric was used for feature ranking and selection,

whereas a time window method was employed for sample preparation to take advantage of multivariate temporal information for better feature extraction by means of an attention-based DCNN model.

<i>Statement (PS)</i>	<i>I am (Customer)</i>	<i>I'm trying to</i>	<i>But</i>	<i>Because</i>	<i>Which makes me feel</i>
Problem statement-1	Passenger	Focus on safety and security	I can't focus on huge passenger at the time	Hard to instruct at the same time	Afraid to travel
Problem statement-1	pilot	Get the situation under the control	Due to some technical issues	Improper monitoring	Frustrated
Problem statement-1	Civilians	Trying to see the safety and	Due to some technical issues	Engine beyond the control	Anxiety to travel

## **CHAPTER-4**

### **REQUIREMENT ANALYSIS**

#### **4.1 Functional requirement:**

1. Python
2. IBM Cloud
3. IBM Watson studio
4. IBM Watson Machine Learning
5. Python-Flask

#### **4.2 Non Functional requirement:**

- a. Security,
- b. Performance,
- c. Usability, And
- d. Availability

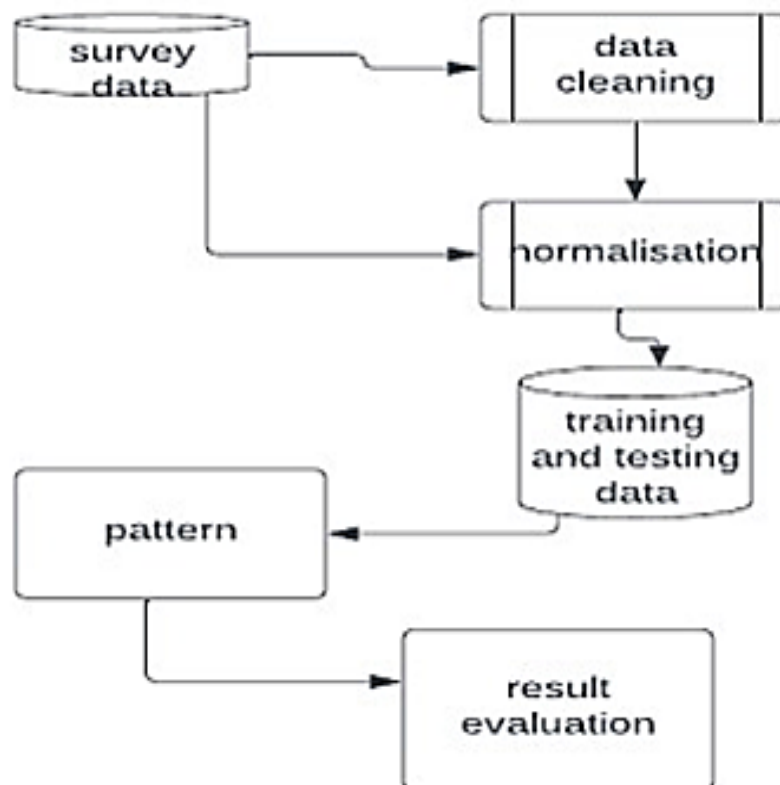
## CHAPTER-5

### PROJECT DESIGN

#### 5.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Example: DFD Level 0

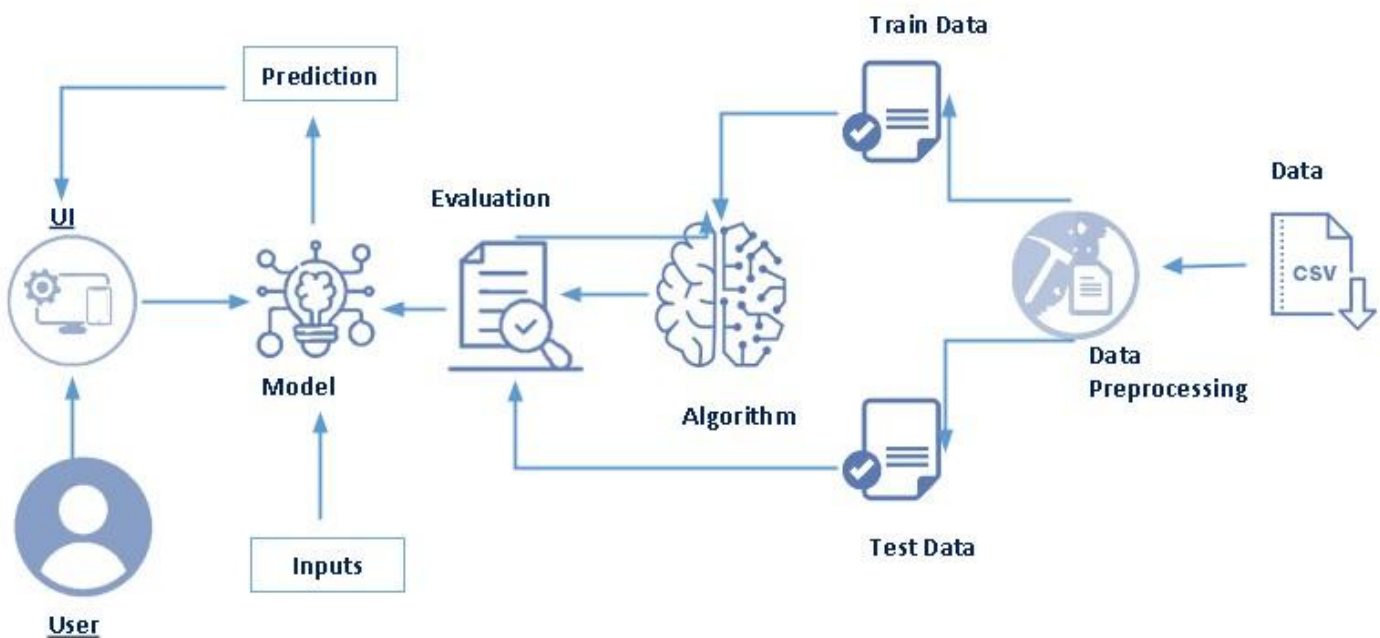


## 5.2 Solution & Technical Architecture

Engine failure is highly risky and needs a lot of time for repair. Unexpected failure leads to loss of money and time. Predicting the failure prior will save time, effort, money and sometimes even lives. The failure can be detected by installing the sensors and keeping a track of the values. The failure detection and predictive maintenance can be for any device, out of which we will be dealing with the engine failure for a threshold number of days.

The project aims to predict the failure of an engine by using Machine Learning to save loss of time & money thus improving productivity.

### Technical Architecture:





## CHAPTER-6

### PROJECT PLANNING & SCHEDULING

#### 6.1 milestone and activity :

TITLE	DESCRIPTION	DATE
Literature Survey & Information Gathering	<i>Literature survey on the selected project &amp; gathering information by referring the technical papers, research publications etc</i>	01 OCTOBER 2022
Prepare Empathy Map	<i>Prepare Empathy Map Canvas to capture the user Pains &amp; Gains, Prepare list of problem statements</i>	01 OCTOBER 2022
Ideation	<i>List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility &amp; importance.</i>	03 OCTOBER 2022

<b>Proposed Solution</b>	<i>Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution,</i>	02 OCTOBER 2022
<b>Problem Solution Fit</b>	<i>Prepare problem - solution fit document</i>	03 OCTOBER 2022
<b>Solution Architecture</b>	<i>Prepare solution architecture document.</i>	08 OCTOBER 2022
<b>Customer Journey</b>	<i>Prepare the customer journey maps to understand the user interactions &amp; experiences with the application.</i>	02 NOVEMBER 2022
<b>Solution Requirements</b>	<i>Prepare solution requirement document for functional and nonfunctional requirements.</i>	02 NOVEMBER 2022
<b>Data Flow Diagrams</b>	<i>Draw the data flow diagrams and submit for review.</i>	02 NOVEMBER 2022

<b>Technology Architecture</b>	<i>Prepare the technology architecture diagram.</i>	02 NOVEMBER 2022
<b>Prepare Milestone &amp; Activity List</b>	<i>Prepare the milestones &amp; activity list of the project.</i>	05 NOVEMBER 2022
<b>Project Development - Delivery of Sprint-1, 2, 3 &amp; 4</b>	<i>Develop &amp; submit the developed code by testing it.</i>	IN PROGRESS... ....

6.2 Sprint Planning & Estimation:

Use the below template to create product backlog and sprint schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	5	High	4
Sprint-1	Facebook Registration	USN-2	As a user, I can register for the application through Facebook	4	Medium	4
Sprint-1	Gmail	USN-3	As a user, I	3	Low	4

	registration		can register for the application through Gmail			
Sprint-2	login	USN-4	As a user, I can log into the application by entering email & password	5	High	4

Sprint-2	Facebook	USN-5	As a user, I can log in into this application through Facebook	4	Medium	4
Sprint-2	Email	USN-6	As a user, I can log in into this application by entering my Google Account	3	Low	4
Sprint-3	Analyzing / Detecting Problems	USN-7	As a user, I can able analyze the defects in Aircraft Engine	5	High	4
Sprint-3	Analyzing / Detecting Problems	USN-8	As a user, I can able to view the repeated problems occurs in Aircraft Engine	4	Medium	4
Sprint-3	Analyzing / Detecting Problems	USN-9	As a user, I can able to find the defects occurs in Aircraft	4	Low	4
			Engine			
Sprint-4	Solution	USN-10	As a user, I can view the solution for minor problems of the Aircraft Engine	3	Medium	4

Sprint-4	Solution	USN-11	As a user, I can view the solution for major problems of the Aircraft Engine	5	High	4
Sprint-4	Solution	USN-12	As a user, I can find the solution and suggestion to maintain for regular services	4	Low	4

# CHAPTER-7

## TESTING

### 7.1 TEST CASE:

The final predictive analytics, built with the parameters determined during the preliminary training and with all 137 training data (i.e., no cross validation), were then used to predict the engine TSFC and core sizes in the testing dataset (the 46 engines unseen by the analytics)

ELITE CODERS - MKCE

PREDICTIVE ANALYSIS FOR AIRCRAFT ENGINE  
USING MACHINE LEARNING

Enter Engine Parameters

Engine ID	S5	S14-A
Cycle	S6	S14-B
Setting 1	S7	S15
Setting 2	S8	S16
Setting 3	S9	S17
S1	S10	S18
S2	S11	S19
S3	S12	S20
S4	S13	

Evaluate

## CHAPTER-8

### RESULT

ELITE CODERS - MKCE

#### PREDICTIVE ANALYSIS FOR AIRCRAFT ENGINE USING MACHINE LEARNING



THE ENGINE REQUIRES IMMEDIATE SERVICE

ANOMALIES FOUND IN THE GIVEN DATA - ENGINE MAY ENCOUNTER ISSUES WITHIN 30 DAYS

[GO BACK](#)



## **CHAPTER-9**

### **ADVANTAGES & DISADVANTAGES**

#### **ADVANTAGES:**

- High power to weight ratio.
- Very high speed therefore save time.

#### **DISADVANTAGES:**

- High fuel consumption.
- Require labor
- Cost increasing

# CHAPTER-10

## CONCLUSION

### conclusion:

The author developed two machine-learning predictive analytics for turbofan TSFC and core-size predictions, respectively. The development used the database of 183 manufactured engines and engines that were studied previously in NASA aeronautics projects. The TSFC predictive analytics has an average accuracy of 98.3 percent, with 3.5 percent uncertainty. The engine core-size predictive analytics has an overall accuracy of 100 percent, with 4.3 percent uncertainty. Overall, both predictive analytics show remarkable prediction accuracy. To further improve the accuracy (and reduce the uncertainty) of TSFC prediction, the database needs to be expanded. However, the limitation of publicly available engine data is a challenge to overcome.

### References:

1. Tong, M.T., "Using Machine Learning To Predict Core Sizes of High-Efficiency Turbofan Engines," GT2019-91432, ASME Turbo-Expo 2019, June 17-21, 2019.
2. Daly, M., "Jane's Aero-Engine," 2017-2018.
3. Meier, N., "Civil turbojet/turbofan specifications." <http://www.jet-engine.net/civtfspec.html>. Accessed August, 2018
4. GE Aviation. <https://www.geaviation.com/commercial>
5. Pratt and Whitney. <https://www.pw.utc.com/products-and-services/products/commercial-engines>
6. Rolls Royce. <https://www.rolls-royce.com/products-and-services/civil-aerospace>
7. CFM International. <https://www.cfmaeroengines.com/>
8. International Civil Aviation Organization, "ICAO Aircraft Emissions Databank." May, 2018.
9. Guynn, M.D., Berton, J.J., Fisher, K.L., Haller, W.J., Tong, M., Thurman, D.R., "Engine Conceptual Study for an Advanced Single-Aisle Transport," NASA/TM-2009-215784, August 2009.
10. Guynn, M.D., Berton, J.J., Fisher, K.L., Haller, W.J., Tong, M., Thurman, D.R., "Analysis of Turbofan Design Options for an Advanced Single-Aisle Transport Aircraft," AIAA 2009-6942, September 2009.
11. Guynn, M. D., Berton, J.J., Fisher, K.L., Haller, W.J., Tong, M., Thurman, D.R., "Refined Exploration of Turbofan Design Options for an Advanced Single-Aisle Transport," NASA/TM-2011-216883, January 2011.

12. Guynn, M.D., Berton, J.J., Tong, M.T., Haller, W.J., "Advanced Single-Aisle Transport Propulsion Design Options Revisited," AIAA 2013-4330, August 2013.
13. Nickol, C.L. and Haller W.J., "Assessment of the Performance Potential of Advanced Subsonic Transport Concepts for NASA's Environmentally Responsible Aviation Project," AIAA 2016-1030, January 2016.
14. Collier, F., Thomas, R., Burley, C., Nickol, C., Lee, C.M., Tong, M., "Environmentally Responsible Aviation – Real Solutions for Environmental Challenges Facing Aviation," 27th International Congress of the Aeronautical Sciences, September, 2010.
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## CHAPTER-11

### FUTURE SCOPE

- The current engine-weight prediction results, together with those for the TSFC (thrust specific fuel consumption) and core-size predictions that were studied previously by the author, show that machine learning-based predictive analytics can be an **effective, time-saving tool for assessing aircraft engine system performance (TSFC, weight, and core size)** during the conceptual design stage.
- The studies for this case were all performed on conventional aircraft configurations.
- Looking to see if these methods work for unconventional aircraft configurations like Blended wing bodies etc. will be an interesting next step.
- For those configurations, the interactions between the different disciplines are extremely complex and modelling them using regression methods might not work out as well as they did for this case.

# CHAPTER-12

## APPENDIX

### 12.1 source code:

#### Python code:

```
import numpy as np
from flask import Flask, request, jsonify, render_template
import joblib
import random

app=Flask(__name__, template_folder="templates")

@app.route('/', methods=['GET'])
def index():
    return render_template('index.html')

@app.route('/result', methods=['POST'])
def result():
    try:
        if request.method == 'POST':
            l=[]
            l.append(float(request.form['id']))
            l.append(float(request.form['cycle']))
            l.append(float(request.form['set1']))
            l.append(float(request.form['set2']))
            l.append(float(request.form['set3']))
            l.append(float(request.form['s1']))
            l.append(float(request.form['s2']))
            l.append(float(request.form['s3']))
            l.append(float(request.form['s4']))
            l.append(float(request.form['s5']))
            l.append(float(request.form['s6']))
```

```

        l.append(float(request.form['s7']))
        l.append(float(request.form['s8']))
        l.append(float(request.form['s9']))
        l.append(float(request.form['s10']))
        l.append(float(request.form['s11']))
        l.append(float(request.form['s12']))
        l.append(float(request.form['s13']))
        l.append(float(request.form['s14']))
        l.append(float(request.form['s15']))
        l.append(float(request.form['s16']))
        l.append(float(request.form['s17']))
        l.append(float(request.form['s18']))
        l.append(float(request.form['s19']))
        l.append(float(request.form['s20']))
        l.append(float(request.form['s21']))
        print(l)
        if predict(l):
            return
    render_template('result.html', data="problem")
    else:
        return
    render_template('result.html', data="normal")
except:
    return render_template('result.html', data="error")

if __name__ == '__main__':
    app.run(debug=False)

```

## html code:

```

<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">

```

```
<title>Engine - Test</title>
<!-- CSS only
col_name =
['id','cycle','set1','set2','set3','s1','s2','s3','s4','s5','s6','s7','s8']+['s9','s10','s11','s12','s13','s14','s14','s15','s16','s17','s18','
s19','s20']

-->
<link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.0/dist/css/bootstrap.min.css" rel="stylesheet"
integrity="sha384-gH2yIJqKdNHPEq0n4Mqqa/HGKIhSkIHeL5AyhkYV8i59U5AR6csBvApHHNl/vI1Bx"
crossorigin="anonymous">
<style>
#hero{
width: 102%;
height: 25vh;
color: white;
text-align: center;
padding-top: 25px;
}
.formd{
width: 102%;
height: 95vh;
background: linear-gradient( rgba(0, 0, 0, 0.5), rgba(0, 0, 0, 0.5) ), url('../static/full_img.jpg');
background-position:center top;
}
.formd form{
margin-top: 10px;
width: 100%;
border: 1px solid wheat;
border-radius: 10px;
padding: 10px;
}
.form-control{
opacity: 0.7;
}
</style>
</head>
<body style="overflow-x: hidden;">
<nav class="navbar bg-primary navbar-dark">
<a class="navbar-brand" style="margin-left: 15px;">ELITE CODERS - MKCE</a>
</nav>
<div id="hero" class="bg-dark">
<div>
<h2>PREDICTIVE ANALYSIS FOR AIRCRAFT ENGINE</h2>
<h2>USING MACHINE LEARNING</h2>
</div>
```

```

</div>
<div class="formd row">
  <div class="col-md-3"></div>
  <div class="col-md-6" style="text-align: center;">
    <form action="result" method="post">
      <span style="color: rgb(201, 157, 207);"><h5>Enter Engine Parameters</h5></span>
      <div class="row text-center">
        <div class="col-md-4">
          <div class="mb-3" style="color: white;">
            <input name="id" step="any" type="number" class="form-control" id="id"
placeholder="Engine ID">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="cycle" step="any" type="number" class="form-control" id="cycle"
placeholder="Cycle">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="set1" step="any" type="number" class="form-control" id="set1"
placeholder="Setting 1">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="set2" step="any" type="number" class="form-control" id="set2"
placeholder="Setting 2">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="set3" step="any" type="number" class="form-control" id="set3"
placeholder="Setting 3">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="s1" step="any" type="number" class="form-control" id="s1"
placeholder="S1">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="s2" step="any" type="number" class="form-control" id="s2"
placeholder="S2">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="s3" step="any" type="number" class="form-control" id="s3"
placeholder="S3">
          </div>
          <div class="mb-3" style="color: white;">
            <input name="s4" step="any" type="number" class="form-control" id="s4"
placeholder="S4">
          </div>
        </div>
      </div>
    </form>
  </div>
</div>

```



```
<div class="col-md-4">
  <div class="mb-3" style="color: white;">
    <input name="s5" step="any" type="number" class="form-control" id="s5"
placeholder="S5">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s6" step="any" type="number" class="form-control" id="s6"
placeholder="S6">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s7" step="any" type="number" class="form-control" id="s7"
placeholder="S7">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s8" step="any" type="number" class="form-control" id="s8"
placeholder="S8">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s9" step="any" type="number" class="form-control" id="s9"
placeholder="S9">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s10" step="any" type="number" class="form-control" id="s10"
placeholder="S10">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s11" step="any" type="number" class="form-control" id="s11"
placeholder="S11">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s12" step="any" type="number" class="form-control" id="s12"
placeholder="S12">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s13" step="any" type="number" class="form-control" id="s13"
placeholder="S13">
  </div>
</div>
<div class="col-md-4">
  <div class="mb-3" style="color: white;">
    <input name="s14" step="any" type="number" class="form-control" id="s14-A"
placeholder="S14-A">
  </div>
  <div class="mb-3" style="color: white;">
    <input name="s15" step="any" type="number" class="form-control" id="s14-B"
```

```

placeholder="S14-B">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s16" step="any" type="number" class="form-control" id="s15"
placeholder="S15">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s17" step="any" type="number" class="form-control" id="s16"
placeholder="S16">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s18" step="any" type="number" class="form-control" id="s17"
placeholder="S17">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s19" step="any" type="number" class="form-control" id="s18"
placeholder="S18">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s20" step="any" type="number" class="form-control" id="s19"
placeholder="S19">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="s21" step="any" type="number" class="form-control" id="s20"
placeholder="S20">
    </div>
</div>
</div>
</div>
<center> <input style="opacity: 0.85;" type="submit" class="btn btn-success"
value="Evaluate"/></center>
</form>
</div>
<div class="col-md-3"></div>
</div>
</body>
<script>

```

```

function test_pass(){
    document.getElementById("id").value = 1;
    document.getElementById("cycle").value = 7;
    document.getElementById("set1").value = 0;
    document.getElementById("set2").value = 0.0002;
    document.getElementById("set3").value = 100.0;
    document.getElementById("s1").value = 518.67;
    document.getElementById("s2").value = 642.11;

```

```
document.getElementById("s3").value = 1583.34;
document.getElementById("s4").value = 1404.84;
document.getElementById("s5").value = 14.62;
document.getElementById("s6").value = 21.61;
document.getElementById("s7").value = 553.89;
document.getElementById("s8").value = 2388.05;
document.getElementById("s9").value = 9051.39;
document.getElementById("s10").value = 1.30;
document.getElementById("s11").value = 47.31;
document.getElementById("s12").value = 522.01;
document.getElementById("s13").value = 2388.06;
document.getElementById("s14-A").value = 8134.97;
document.getElementById("s14-B").value = 8.3914;
document.getElementById("s15").value = 0.03;
document.getElementById("s16").value = 391;
document.getElementById("s17").value = 2388;
document.getElementById("s18").value = 100.00;
document.getElementById("s19").value = 38.85;
document.getElementById("s20").value = 23.3952;
}
function test_fail(){
document.getElementById("id").value = 6;
document.getElementById("cycle").value = 88;
document.getElementById("set1").value = 0.0011;
document.getElementById("set2").value = -0.0005;
document.getElementById("set3").value = 100.0;
document.getElementById("s1").value = 518.67;
document.getElementById("s2").value = 642.39;
document.getElementById("s3").value = 1592.67;
document.getElementById("s4").value = 1415.76;
document.getElementById("s5").value = 14.62;
document.getElementById("s6").value = 21.61;
document.getElementById("s7").value = 553.89;
document.getElementById("s8").value = 2388.12;
document.getElementById("s9").value = 9059.83;
document.getElementById("s10").value = 1.30;
document.getElementById("s11").value = 47.56;
document.getElementById("s12").value = 521.30;
document.getElementById("s13").value = 2388.07;
document.getElementById("s14-A").value = 8131.43;
document.getElementById("s14-B").value = 8.4262;
document.getElementById("s15").value = 0.03;
document.getElementById("s16").value = 393;
document.getElementById("s17").value = 2388;
document.getElementById("s18").value = 100.00;
```

```
document.getElementById("s19").value = 39.01;
document.getElementById("s20").value = 23.3342;
}
</script>
</html>
```

## 12.2 GitHub & Project Demo Link:

**github:**

**TEAM ID : PNT2022TMID45543**

**GitHub Project Link** : <https://github.com/IBM-EPBL/IBM-Project-54339-1661851835>

**Project demo vedio Link :**

<https://user-images.githubusercontent.com/113543704/202865909-0fd0f7ee-4870-4429-9bb2-f9290b8291e0.mp4>

