

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.
- You will be able to predict and report the failure and the working condition of the aircraft engine using Machine Learning (ML).
- Apply different algorithms according to the dataset.
- A hybrid data preparation model is proposed to improve the success of failure count prediction in two stages:
 - i) In the first stage for the effective and ineffective parameters a Relief feature is used.
 - ii) In the second stage a K-means algorithm is used.
- Methods like PDM are used.
- The tools developed in the python language with appropriate libraries play a key role.
- 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 Purpose:

Aircrafts are plays very important role in day to day life. Aircrafts are capable of transferring things as well as people from one side of the world to the other side of the world in considerably less time compared to other physical transport mediums. Aircrafts are extensively used in defense systems as well as in public transport. Therefore, problems related to safety and security are the main concern in the aircraft.

In this modern era the number of aircrafts that are in use are increasing exponentially. In a rough survey, it is studied that there are always 7000 to 8000 aircrafts flying in the air. This gives us a heavy Air traffic in the sky. We have many types of aircrafts like goods , private jets and public aircrafts. This project is mainly focused on the public aircrafts and on the commercial planes. By implementing this Machine learning tool the probability of aircraft engine failure Reliability and availability of aircraft components have always been an important consideration in aviation. Accurate Prediction of possible failures will increase the reliability of aircraft components and systems.

There are three main types of maintenance for equipment: corrective maintenance, preventive maintenance, and predictive maintenance which are helpful in prevention.

1.3 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 main element of the aircraft design is turbofan engine, which has difficult structure and needs high loyalty which lead costs of aircraft system to significant maintenance. It is a variant of jet engine which outputs using a combination of bypass air which has been controlled by a ducted fan which is taken by the jet core. According to records, maintenance costs of these turbofan engines usually reach 60 to 75% of the overall costs of their lifespan and it is important to design a proven, reasonable repairs plan to reduce maintenance of the turbofan engine. Because turbofan engine failure occurs, it affects overall functionality of the aircraft system. Therefore, the rescue of a turbofan engine is crucial. Deep learning techniques are used to predict aircraft failure. Predictive analytics is the branch of the analytics used to make predictions about unknown upcoming events.

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.

Deep learning techniques are used to predict aircraft failure. Predictive analytics is the branch of the analytics used to make predictions about unknown upcoming events. It uses many techniques from data mining, modeling, statistics, artificial intelligence and machine learning, to analyze current input data to make predictions about the future. Aircraft identification analytics will measure key parameters like pressure, temperature, physical fan speed etc. to predict lifespan of an aircraft engine and therefore it will help to plan the maintenance accordingly, with very minimal impact to the operations. This helps to avoid the failure of aircraft before it occurs.

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 fleets 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 systems.

SURVEY 6: Application of Machine Learning Techniques to Web_Based Intelligent Learning Diagnosis System.(Author – Chenn- Jung Huang).

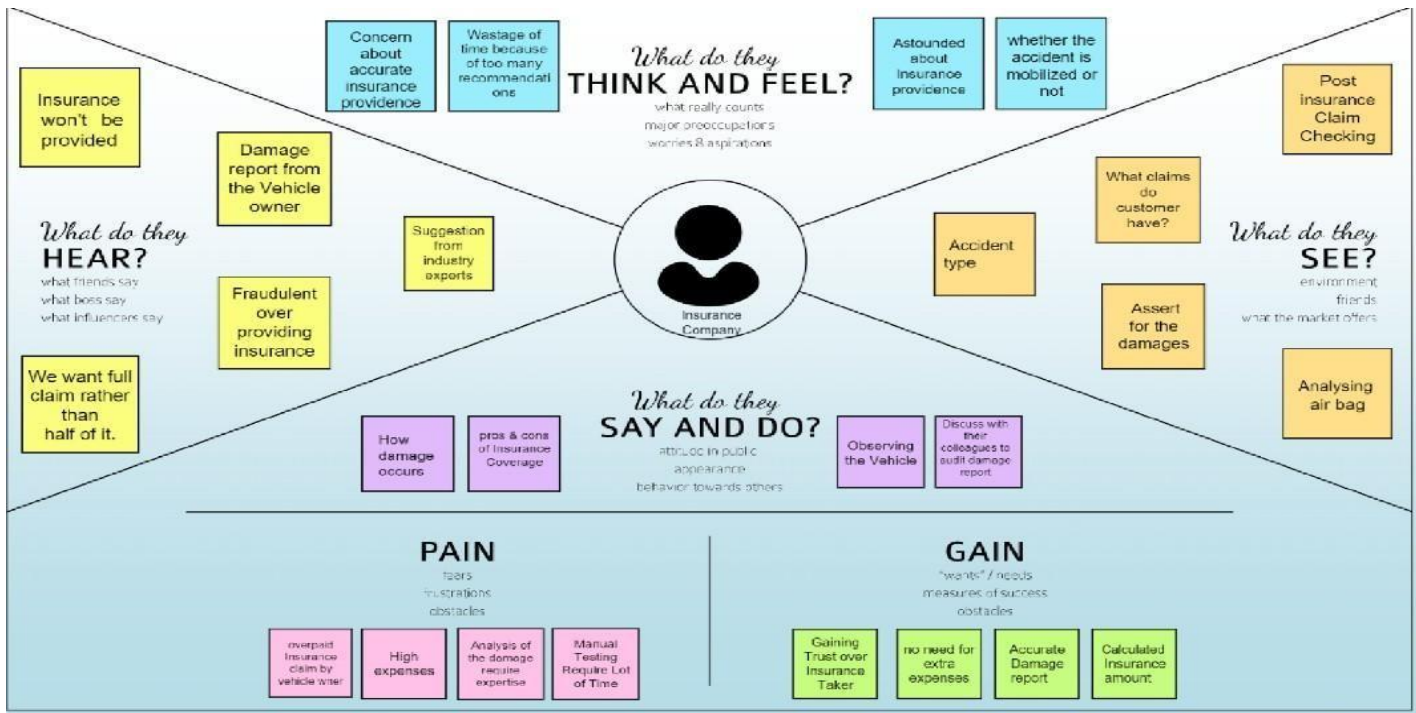
This work proposes an intelligent learning diagnosis system that supports a Web-based thematic learning model, which aims to cultivate learners' ability of knowledge integration by giving the learners the opportunities to select the learning topics that they are interested, and gain knowledge on the 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 behaviors 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
- 2-8 people recommended

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 Tools prompts to run a happy and productive session.
- Open article

- 1 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

Tip
You can attach a sticky note and let the pencil touch to sketch/ write to start drawing!

- 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 can break it up into smaller sub-groups.
- 20 minutes

By using the RTD sensor we can detect excess heat in advance

Elastic-net regression used to compare the values

We can use the random forest algorithm to make the prediction

Using DNN for the engine maintenance

Using the Linear Regression we can make prediction in numerical values

Usage of light GBM classifier

CatBoost recognize the sound and pictures

To ensure the correct level of humidity using sensors

Usage of Ridge regression for finding true value

Ensemble method used to predict the best value

Using the probabilistic reasoning for the prediction

By using the Decision Tree algorithm we can make the yes/no prediction

We can use the Naive Bayes algorithm for the prediction

Lasso regression goal is to acquire a subset

We can use different algorithms for finding the efficient algorithms

Using PCA algorithms which can be used for feature extraction.

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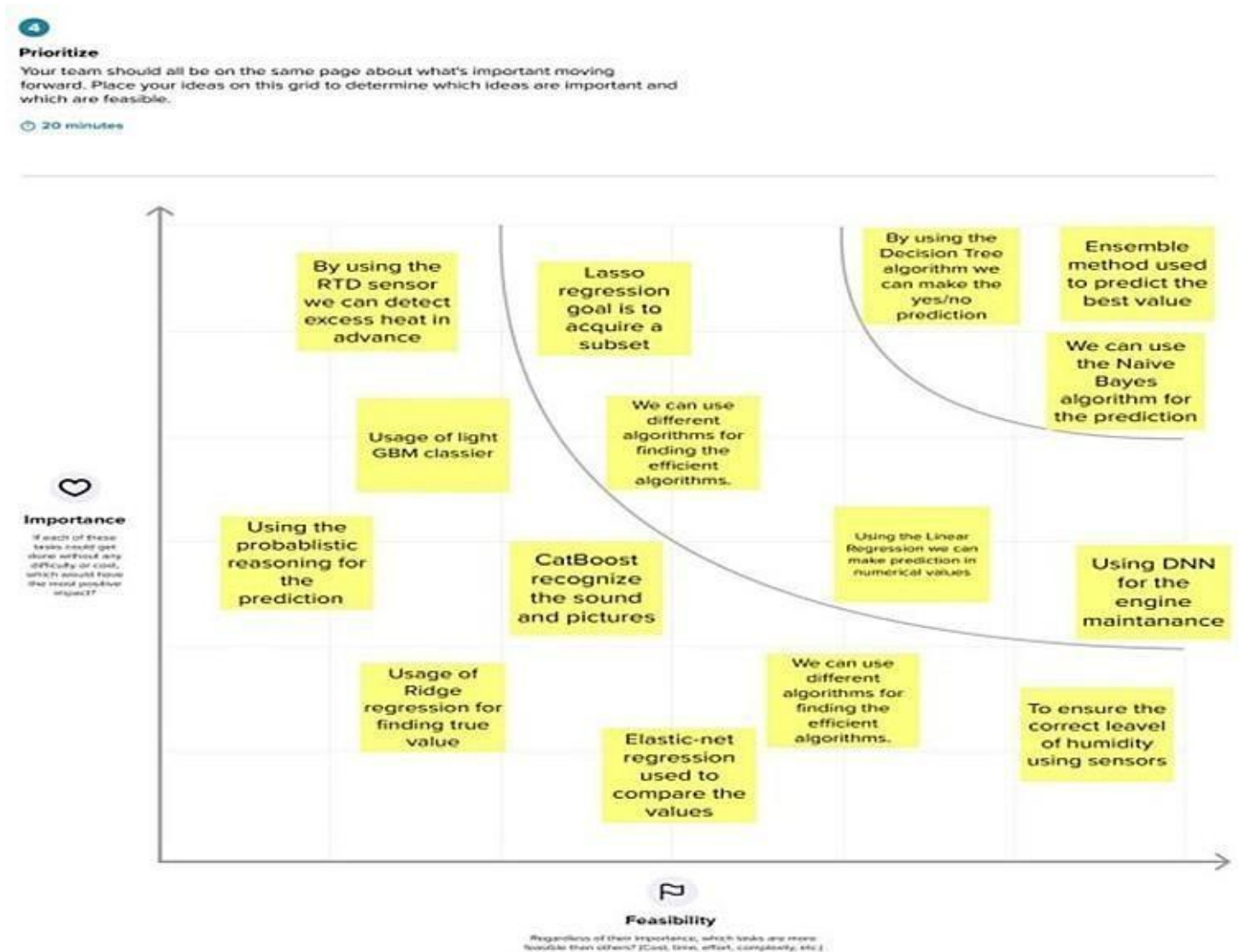
We can use the Naive Bayes algorithm for the prediction

Lasso regression goal is to acquire a subset

We can use different algorithms for finding the efficient algorithms.

Using PCA algorithms which can be used for feature extraction.

Step-3: Idea Prioritization:



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 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. NLP
3. IBM Cloud
4. IBM Watson Assistant
5. Deep Learning
6. Python-Flask

4.2 Non Functional requirement:

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

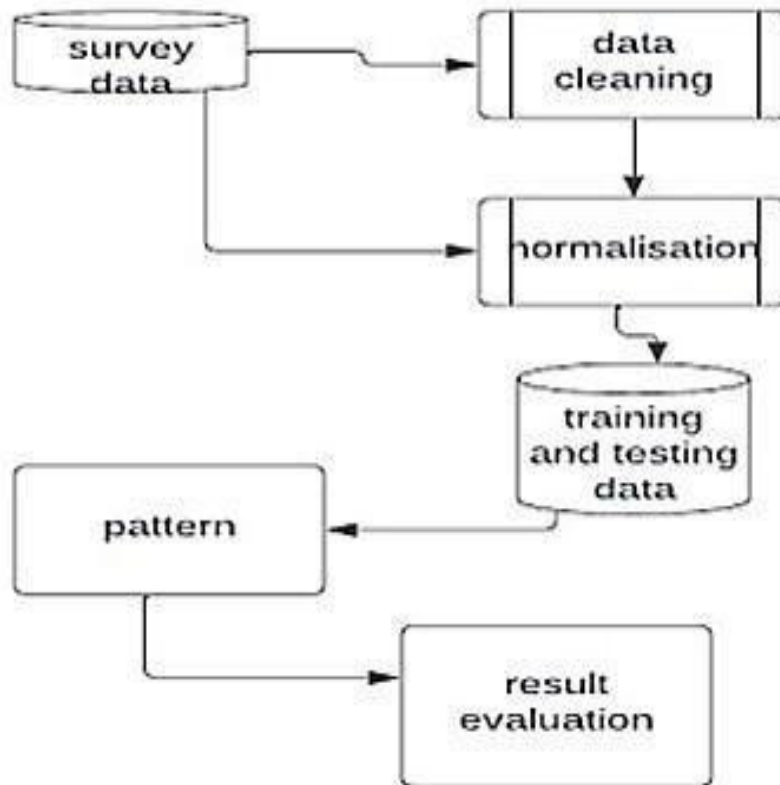
CHAPTER-5

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

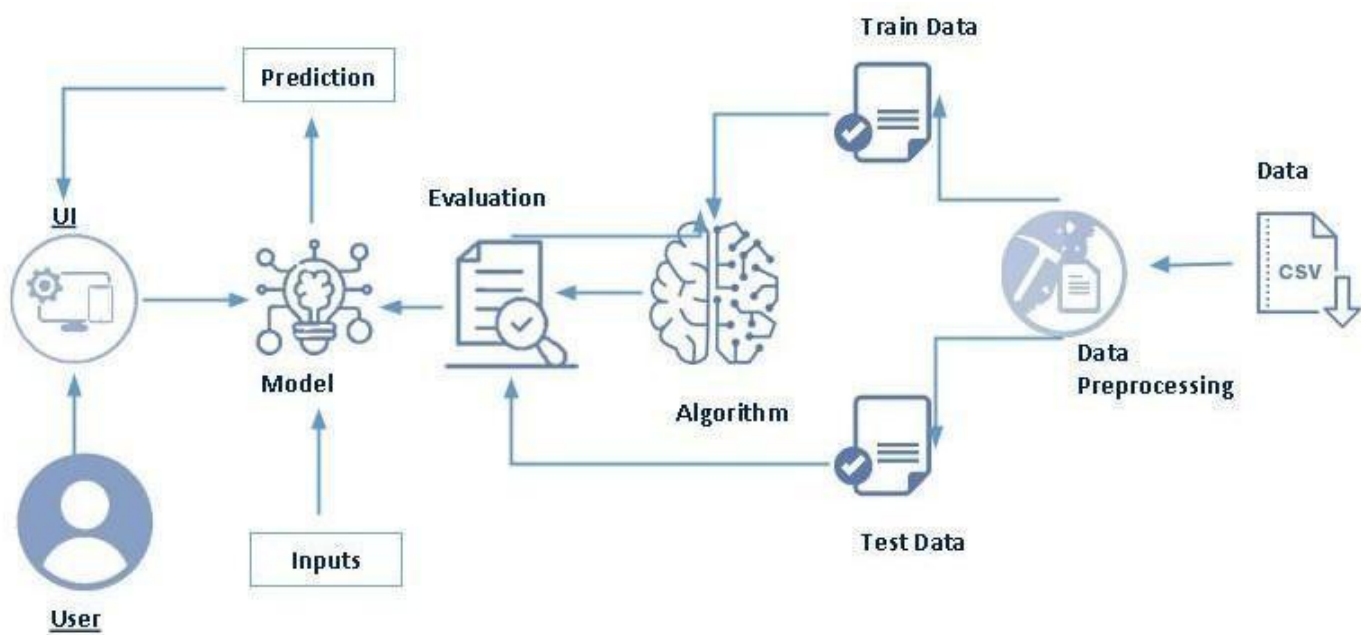


5.2 Solution & Technical Architecture

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 & gathering information by referring the technical papers, research publications etc</i>	03 SEPTEMBER 2022
Prepare Empathy Map	<i>Prepare Empathy Map Canvas to capture the user Pains & Gains, Prepare list of problem statements</i>	23 SEPTEMBER 2022
Ideation	<i>List the by organizing the brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.</i>	23 SEPTEMBER 2022

Proposed Solution	<i>Prepare the proposed solution document, which includes the novelty, feasibility of idea, business model, social impact, scalability of solution,</i>	24 SEPTEMBER 2022
Problem Solution Fit	<i>Prepare problem - solution fit document</i>	29 SEPTEMBER 2022
Solution Architecture	<i>Prepare a solution architecture document.</i>	19 SEPTEMBER 2022
Customer Journey	<i>Prepare the customer journey maps to understand the user interactions & experiences with the application.</i>	01 OCTOBER 2022
Solution Requirements	<i>Prepare solution requirement document for functional and nonfunctional requirements.</i>	02 OCTOBER 2022
Data Flow Diagrams	<i>Draw the data flow diagrams and submit for review.</i>	03 OCTOBER 2022

Technology Architecture	<i>Prepare the technology architecture diagram.</i>	18 OCTOBER 2022
Prepare Milestone & Activity List	<i>Prepare the milestones & activity list of the project.</i>	02 NOVEMBER 2022
Project Development - Delivery of Sprint-1, 2, 3 & 4	<i>Develop & submit the developed code by testing it.</i>	10 NOVEMBER 2022

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	a user ,I can register for the support vector machine As algorithm tool using my email and password	7	High	T.Lakshmanan R.mugesh
Sprint-1		USN-2	As a user, I will receive confirmation email on registering for the support vector machine algorithm tool	6	High	T.Lakshmanan A.munirajan
Sprint-4		USN-3	As a user, I can register for the application through my Gmail	6	Low	M.prakash S.indira
Sprint-1	Login	USN-4	As a user, I can log into the application by entering my credentials	6	High	R.mugesh A.munirajan
Sprint-3	Dashboard	USN-5	As a user, I can see my past records and activities	6	High	T.Lakshmanan M.prakash
Sprint-2		USN-6	As a user, I must enter my pre – engine aircraft test results	7	High	A.munirajan T.Lakshmanan

Sprint-3	Report	USN-7	As a user, I can view the report generated by the tool	7	High	S.indira T.Lakshmanan
Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Solution	USN-8	As a user, I will receive reason to treat my engine	6	Medium	R.mugesh A.munirajan
Sprint-4	Quenes	USN-9	As a users, I must assists that face problems through Q&A	6	Low	T.Lakshmanan M.prakash
Sprint-4	Feedback	USN-10	As a customer care executive, I should get input for the tool's enhancement from users	7	Low	A.munirajan T.Lakshmanan
Sprint-2	Feature importance	USN-11	As an administrator, I should identify the most significant factors that lead to SVM based on the present trend	6	High	M.prakash S.indira
Sprint-2	Engine Model	USN-12	As an administrator, I must use the most suitable ML model for detection of SVM	6	High	T.Lakshmanan M.prakash

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	28 oct 2022	2 nov 2022	20	2 nov 2022
Sprint-2	20	6 Days	3 Nov 2022	08 Nov 2022	20	05 Nov 2022
Sprint-3	20	6 Days	09 Nov 2022	14 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	15Nov 2022	20 Nov 2022	20	19 Nov 2022



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 saves 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:

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CHAPTER-11 FUTURE SCOPE

- The current engine-weight prediction results, together with those for the TSFC (thrust specificfuel 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 modeling them using regression methods might not work out as well as they did for this case.

CHAPTER-12 APPENDIX

11.1 source code:

Python code:

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

In [14]:

app = Flask(__name__)
In [15]:

@app.route('/') def index():
    return render_template('/content/index.html')
In [16]:

@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('/content/result.html',data="problem")
    else:
        return render_template('/content/result.html',data="normal")
except:
    return
    render_template('/content/result.html',data="error")
In [17]:

```

runfile

Out[17]:

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-gH2yIJqKdNHPEq0n4Mqa/HGKIhSkIHeL5AyhkYV8i59U5AR6csBvApHHNI/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">

```

```

placeholder="Cycle">
    </div>
    <div class="mb-3" style="color: white;">
        <input name="cycle" step="any" type="number"
            class="form-control" id="cycle"

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 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>

```

```
<div class="mb-3" style="color: white;">
  <input name="s7" step="any" type="number"
  class="form-control" id="s7"
```

placeholder="S7">

placeholder="S8">

placeholder="S9">

placeholder="S10">

placeholder="S11">

placeholder="S12">

placeholder="S13">

placeholder="S14-A">

placeholder="S14-B">

placeholder="S15">

placeholder="S16">

</div>

<div class="mb-3" style="color: white;">
<input name="s8" step="any" type="number"
class="form-control" id="s8"

</div>

<div class="mb-3" style="color: white;">
<input name="s9" step="any" type="number"
class="form-control" id="s9"

</div>

<div class="mb-3" style="color: white;">
<input name="s10" step="any" type="number"
class="form-control" id="s10"

</div>

<div class="mb-3" style="color: white;">
<input name="s11" step="any" type="number"
class="form-control" id="s11"

</div>

<div class="mb-3" style="color: white;">
<input name="s12" step="any" type="number"
class="form-control" id="s12"

</div>

<div class="mb-3" style="color: white;">
<input name="s13" step="any" type="number"
class="form-control" id="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"

</div>

<div class="mb-3" style="color: white;">
<input name="s15" step="any" type="number"
class="form-control" id="s14-B"

</div>

<div class="mb-3" style="color: white;">
<input name="s16" step="any" type="number"
class="form-control" id="s15"

</div>

<div class="mb-3" style="color: white;">
<input name="s17" step="any" type="number"
class="form-control" id="s16"

```
</div>  
<div class="mb-3" style="color: white;">
```

placeholder="S17">

```
<input name="s18" step="any" type="number"
class="form-control" id="s17"
```

```
</div>
```

placeholder="S18">

```
<div class="mb-3" style="color: white;">
  <input name="s19" step="any" type="number"
class="form-control" id="s18"
```

```
</div>
```

placeholder="S19">

```
<div class="mb-3" style="color: white;">
  <input name="s20" step="any" type="number"
class="form-control" id="s19"
```

```
</div>
```

placeholder="S20">

```
<div class="mb-3" style="color: white;">
  <input name="s21" step="any" type="number"
class="form-control" id="s20"
```

```
</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 : PNT2022TMID41447

GitHub Project: <https://github.com/IBM-EPBL/IBM-Project-36446-1660295086>

