FINAL PROJECT REPORT

Date	19 November 2022
Team ID	PNT2022TMID32527
Project Name	Flight Delay Prediction Using Machine Learning

Preview/Index:

INTRODUCTION

1.PROJECT OVERVIEW

Airports are significant nodes of air transportation. The number of airport flight delays has been on increase in recent years. Delayed flights are defined by the Federal Aviation Administration when they arrive or depart more than 15 minutes later than scheduled. In 2019, the arrival delay rate is 19.2% and the departure delay rate is 18.18% in the United States. Flight delays can cause many negative effects, such as passengers' inconvenience, increased airport pressure, and airline losses. Effective flight delay prediction could provide support for flight plan and emergency plan formulation, reduce the economic loss, and alleviate the negative impact (1). Hence, a delay prediction turns out very important. International Civil Aviation Organization (ICAO) has enabled a program called Air Traffic Flow Management (ATFM) with the objective of ensuring that the traffic volume is compatible with the capacities declared by aviation authorities in order to reduce ground and en-route delays. Another application of traffic management is the Free Route Airspace (FRA) concept which consists of using the shortest routes possible in order to reduce flight time, CO2 emissions, and fuel waste. Moreover, several other models have been developed to solve delays problem based on probability, statistics, graph and network representations, operational research studies, and so on (2). The Related Work gives the recent works and research on this topic.

2.PURPOSE:

The main purpose of this project is to early warning of flight delay to the customers, Airport Authorities and Airlines

2.LITERATURE SURVEY

1.EXISTING PROBLEMS

Passengers and and airline wants a way to reduce economic loss, rushes, tension which caused by fight delay and make their travel happy.

2.RELATED WORKS

the principle of the Stacking classification algorithm is introduced, the SMOTE algorithm is selected to process imbalanced datasets, and the Boruta algorithm is utilized for feature selection. There are five supervised machine learning algorithms in the first-level learner of Stacking including KNN, Random Forest, Logistic Regression, Decision Tree, and Gaussian Naive Bayes. The second-level learner is Logistic Regression. To verify the effectiveness of the proposed

method, comparative experiments are carried out based on Boston Logan International Airport flight datasets from January to December 2019. Multiple indexes are used to comprehensively evaluate the prediction results, such as Accuracy, Precision, Recall, F1 Score, ROC curve, and AUC Score. The results show that the Stacking algorithm not only could improve the prediction accuracy but also maintains great stability (1). Multi Layer Perceptron (MLP) to train and test data applied. The neural network MLP was able to predict flight arrival delay with a coefficient of determination R2 of 0.9048, and the selective procedure achieved a time saving and a better R2 score of 0.9560. To enhance the reliability of the proposed method, the performance of the MLP was compared with that of Gradient Boosting (GB) and Decision Trees (DT). The result is that the MLP outperformed all existing benchmark methods (2). Here present the first data-driven systemic study of air transport delays in China, of their evolution and causes, based on 11 million flights between 2016 and 2018. A significant fraction of the delays can be explained by a few variables, e.g., weather conditions and traffic levels, the most important factors being the presence of thunderstorms and the season of the year. Remaining delays can often be explained by en-route weather phenomena or by reactionary delays. This study contributes towards a better understanding of delays and their prediction through a data-driven methodology, leveraging on statistics and data mining concepts (3). Recognize useful patterns of the flight delay from aviation data and perform accurate delay prediction. The best result for flight delay prediction (five classes) using machine learning models is 89.07% (Multilayer Perceptron). A Convolution neural network model is also built which is enlightened by the idea of pattern recognition and success of neural network method, showing a slightly better result with 89.32% prediction accuracy (4). Explores a broader scope of factors which may potentially influence the flight delay, and compares several machine learning-based models in designed generalized flight delay prediction tasks. Compared with the previous schemes, the proposed random forest-based model can obtain higher prediction accuracy (90.2% for the binary classification) and can overcome the overfitting problem (5). The model demonstrated to reduce by 30% the take-off time prediction errors of the current system one hour before the time that flight is scheduled to depart from the parking position and presents an extension of the model, which overcomes this look-ahead time constraint and allows to improve take-off time predictions as early as the initial flight plan is received. In addition, a subset of the original set of input features has been meticulously selected to facilitate the implementation of the solution in an operational air traffic flow and capacity management system, while minimising the loss of predictive power. Finally, the importance and interactions of the input features are thoroughly analysed with additive feature attribution methods (6). The designed prediction tasks contain different classification tasks and a regression task. Experimental results show that long short-term memory (LSTM) is capable of handling the obtained aviation sequence data, but overfitting problem occurs in our limited dataset. Compared with the previous schemes, the proposed random forest-based model can obtain higher prediction accuracy (90.2% for the binary classification) and can overcome the overfitting problem (7).

References

1. *Flight Delay Classification Prediction Based on.* **Jia Yi, 1 Honghai Zhang ,.** [ed.] Chi-Hua Chen. Honghai Zhang; zhh0913@163.com : Wiley, 2021. p. 10.

2. *A Multilayer Perceptron Neural Network with Selective-Data.* **Hajar Alla, Lahcen Moumoun , and Youssef Balouki.** [ed.] Jianping Gou. Settat, Morocco : Hindawi, 2021. Hindawi Scientific Programming. p. 12.

3. *Characterization and Prediction of Air Transport.* **Massimiliano Zanin 1, * , Yanbo Zhu 2,3, Ran Yan 3.** 2020, MDPI Journals, p. 15.

4. *Applying Machine Learning to Aviation Big Data.* **Yushan Jiang, Yongxin Liu,Dahai Liu,Houbing Song.** 2020. 2020 IEEE Intl Conf on Dependable,Intl Conf on Cloud and Big Data Computing. p. 8.

5. *FLIGHT DELAY PREDICTION USING MACHINE LEARNING.* **Sarah Ajmeria, Srushti V,Prof. Kavitha S Patil.** Bangalore, India : IJIREEICE, 2022. DOI: 10.17148/IJIREEICE.2022.10584. p. 5.

6. *An explainable machine learning approach to improve take-off time.* **Ramon Dalmau, Franck Ballerini,Herbert Naessens,Seddik Belkoura.** 2021, Journal of Air Transport Management, p. 12.

7. *Flight Delay Prediction Based on Aviation Big Data.* **Guan Gui, Senior Member, IEEE, Fan Liu, Student Member, IEEE, Jinlong Sun, Member, IEEE,.** 2020, IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. XX, NO. XX, XXX 2015, p. 11.

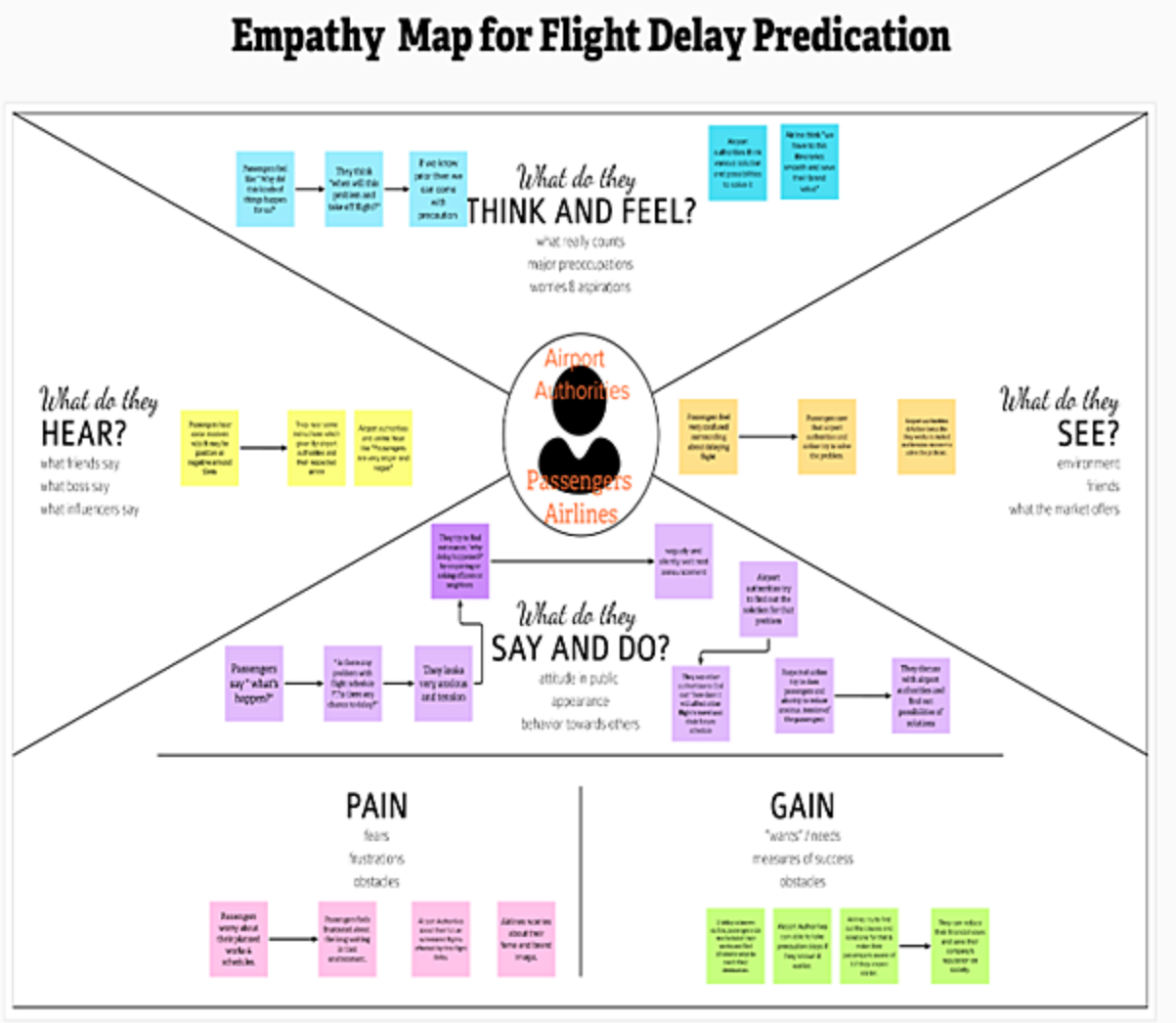
3.PROLEM STATEMENT DEFINITION

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	Passenger	Reach my destination with nice and happy travel experience	Sometimes rushes and tensions happen	Flight delay, diversion and cancelation	Frustrated and upset.

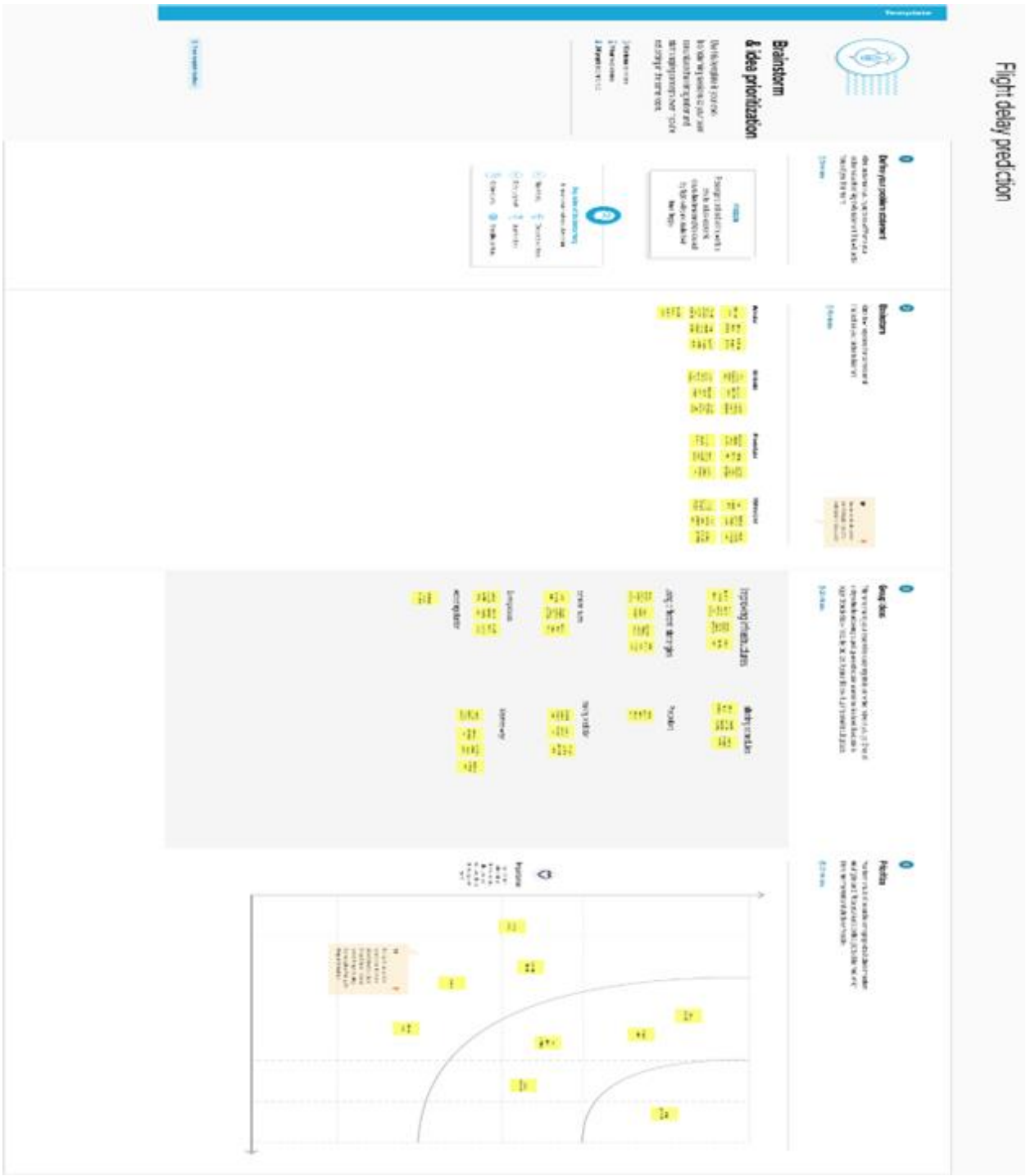
PS-2	Airlines and Airport companies	Gives best and pleasant experience for passengers	Sometimes became a one of worst experience for passengers	Flight delay, diversion and cancelation causes economic losses and damage the brand value in market and society	Discourage, less effective and vague

3.IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas



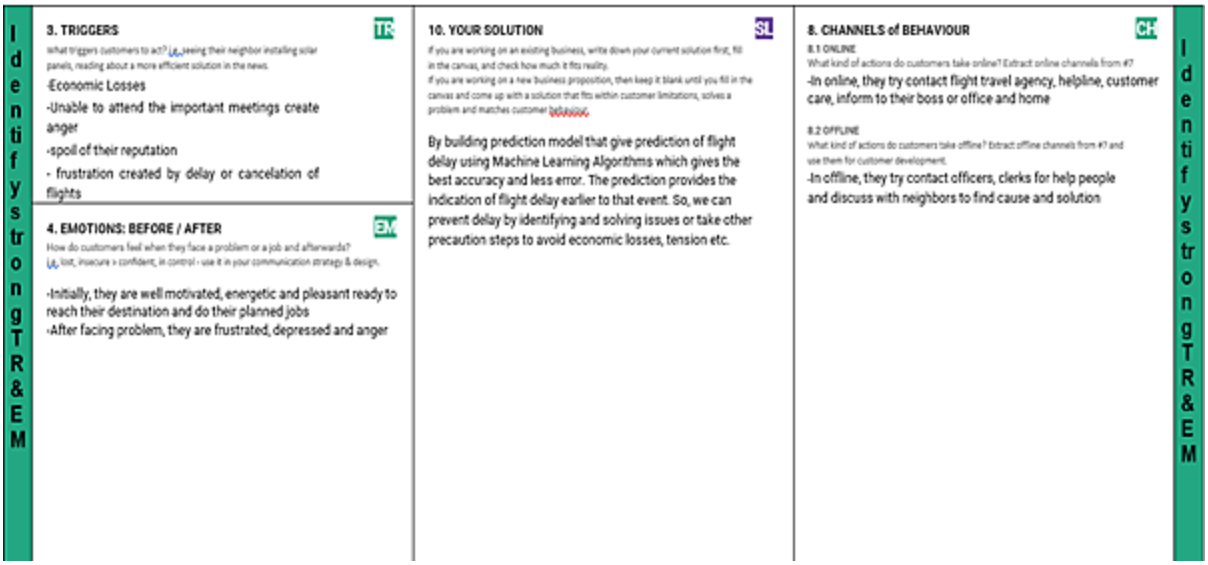
3.2. Ideation & Brainstorming



3.3. Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Passengers and Airlines need a solution to reduce economic loss, rushes, tension which caused by flight delay and make their travel pleasant with happiness.
2.	Idea / Solution description	Proposed solution: By building prediction model that give prediction of flight delay using Machine Learning Algorithms which gives the best accuracy and less error. The prediction provides the indication of flight delay earlier to that event. So, we can prevent delay by identifying and solving issues or take other precaution steps to avoid economic losses, tension etc.
3.	Novelty / Uniqueness	-User friendly web app -anytime accessible -provide accurate prediction -no need to create user account to use this web app -provide approximate delay time range
4.	Social Impact / Customer Satisfaction	-by knowing flight delay earlier, they avoid last minute rushes, other tension and prepared themselves according to that. - by knowing flight delay earlier, Airlines can prevent their economic losses. -Airport authorities make adjustment for flight take off and landing if delayed - with more accuracy of prediction, customer become fulfilment.
5.	Business Model (Revenue Model)	-get revenue by google ads and posting other commercial ads. -sell software to airlines and airport maintaining companies. -make revenue by giving premium services for customers
6.	Scalability of the Solution	-can add extra futures easily using flask. -deploying in cloud gives more scalability and availability, no need worry about hardwares, computation capacity. --by building app using agile methodologies, can make any changes at any time.

3..4. Problem Solution Fit



4. REQUIREMENT ANALYSIS

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Log In	• Log in with give user credentials
FR-4	Support	• Support option provided for queries and contact customer support team
FR-5	Prediction of delay	• Requesting for prediction by providing details of flight • Shows prediction results

FR-6	Trust ability of prediction	• Gives the confidence percentage about their prediction
FR-7	Notify User	• Notify user with the prediction, if they wish • Notify user about flight arrival before 1 hour
FR-8	Get Feedback	• Get feedback about their experience • Request give rating
FR-9	Log Out	• Log out from the application

Non-functional Requirements:

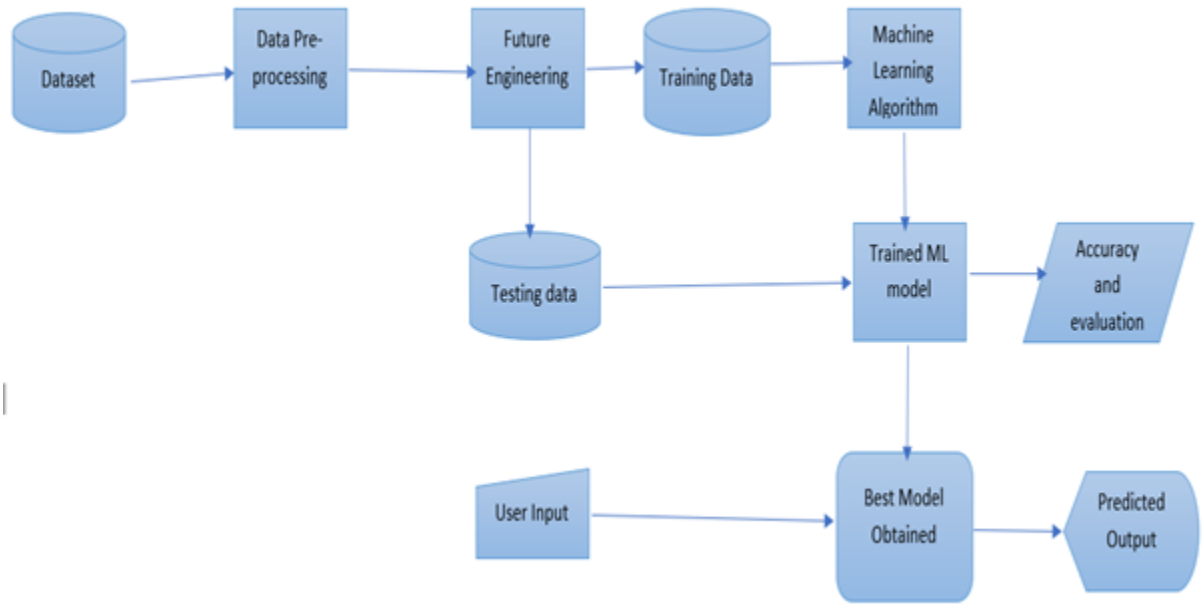
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Web app is provided with smooth and user-friendly GUI.
NFR-2	**Security**	Data security of user is ensured with IBM Cloud security, login with your secured login credentials .
NFR-3	**Reliability**	This web app have reliability by deploying in IBM Watson.
NFR-4	**Performance**	50 request per second is handled.
NFR-5	**Availability**	99% avail with the help of IBM Cloud.
NFR-6	**Scalability**	It had high scalability by having ability to extend there computational resource when request came.

5.PROJECT DESIGN:

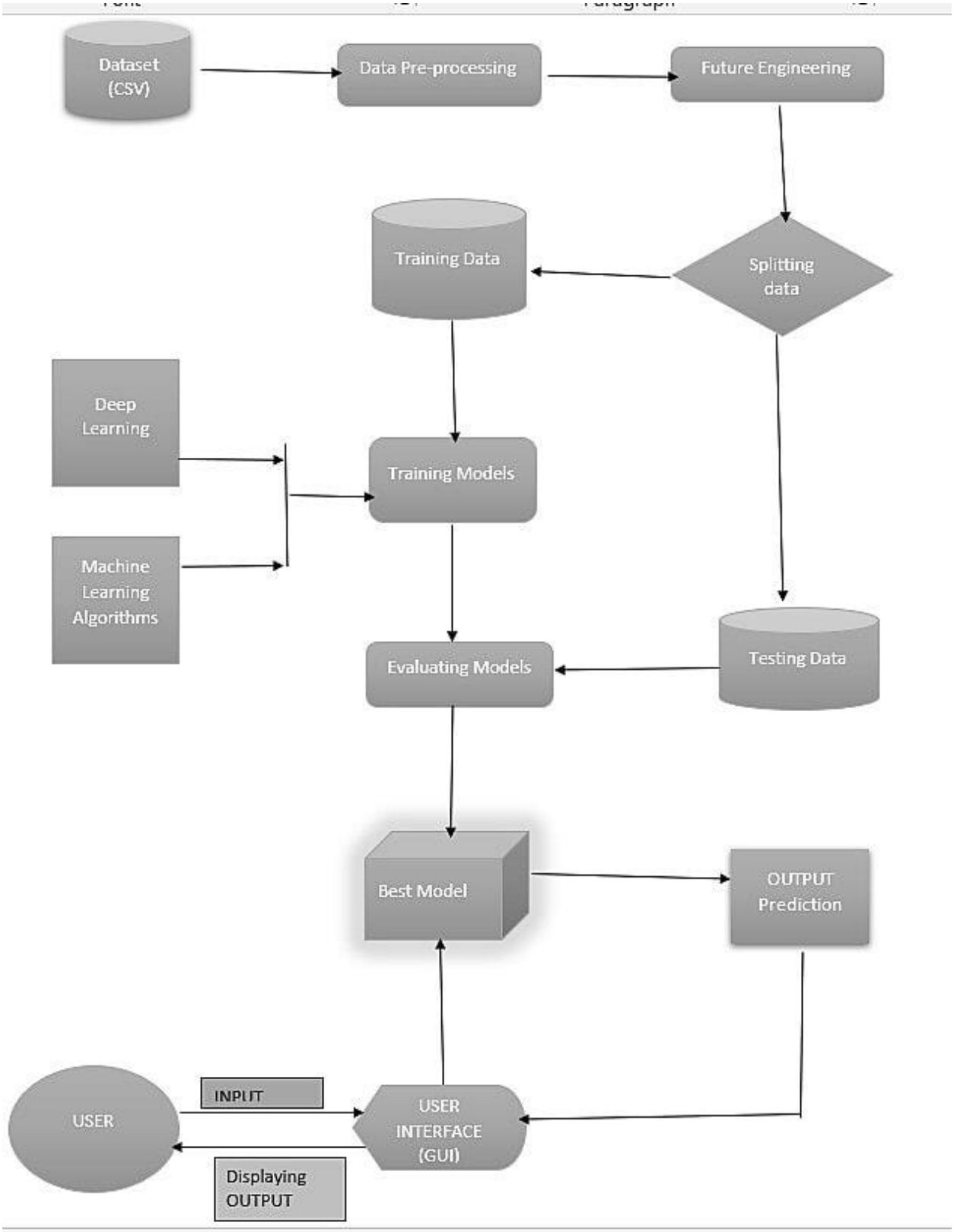
5.1. Data Flow Diagrams

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.



5.2. SOLUTION & TECHNICAL ARCHITECTURE

Solution Architecture



Technical Architecture

Technical Architecture:

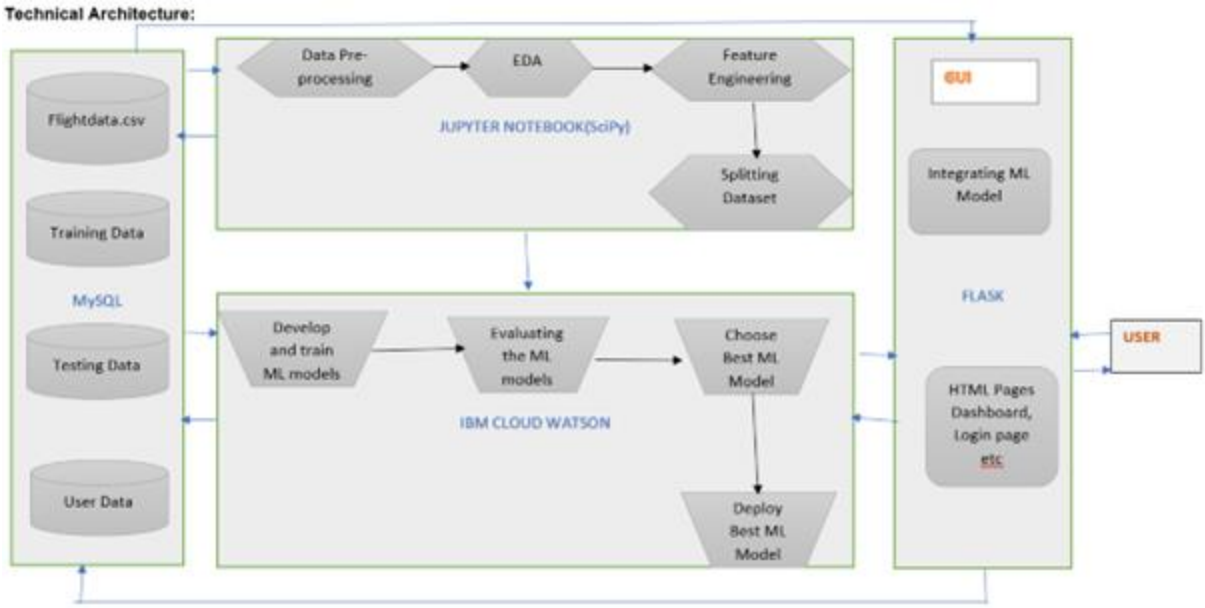


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	How user interacts with application Web UI.	HTML, CSS
2.	Application Logic-1	Develop , Train and find best ML Model	Python
3.	Application Logic-2	Deploy Best ML Model	IBM Watson
4.	Application Logic-3	Integrating ML model with Flask web app	IBM Watson, Flask, python
5.	Database	Structured data	MySQL
6.	Cloud Database	Database Service on Cloud	IBM DB2
7.	File Storage	File storage requirements	IBM Block Storage or Other Storage Service or Local Filesystem
8.	Infrastructure (Server / Cloud)	Application Deployment on Cloud	Cloud Foundry, Kubernetes

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Flask, Scipy, Jupiter Notebook	microframework
2.	Scalable Architecture	3 – tier, Micro-services	Relational database, cloud, GUI
3.	Availability	distributed servers	IBM Cloud
4.	Performance	100 per sec	IBM Watson App Service

5.3.User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Web user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1

		USN-3	As a user, I can register for the application through Gmail	I can register and login by providing Gmail with access permissions	Medium	Sprint-2
	Login	USN-4	As a user, I can log into the application by entering email & password	I can login using my registered email and password(login credentials)	High	Sprint-1
	Dashboard	USN-5	As a user, I can access my dashboard which give way to provide data to predict flight delay	I can provide valid Input data	High	Sprint-2
	Logout	USN-6	As a user, I can logout by clicking logout button	I can logout my account from website	High	Sprint-1
	Prediction	USN-7	As a user, I can prediction result through dashboard by integrated ML Model	I can get prediction by giving valid input	High	Sprint-3
Customer Care / support	Query/ complaint raise	USN-8	As a user, I can raise Query or complaint about technical issues	If raised query valid or true then resolve and response, else explain the missing understanding	Medium	Sprint-4
	Feedback/ rating	USN-9	As a user, I can give feedback and rating to the application	Support team accept the feedback , try to improve application	Medium	Sprint-4
Administrator	Maintain	USN-10	Administrator maintain the database and overall application	Punctual maintenance	High	Sprint-4

Developer	Testing	USN-11	As a developer, I test the application which I have developed	I test the application for checking errors and rectify it	High	Sprint-1,2,3,4

6.PROJECT PLANNING & SCHEDULING

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	Data Collection and Pre-processing	USN-1	As a user, I can't interact anything. Waiting is user's task. User can listen the relationship exist between the various attributes of data by presentation of developer	2	high	Mahendran D, Praveen Kumar
Sprint-1	Model Building	USN-2	As a user, I can predict flight delay by various developed ML models by console	1	high	Mahendran D Praveen Kumar
Sprint-2	Model Evaluation	USN-3	As a user, I can predict flight delay by best Model in various developed ML model by console	2	high	Mahendran D Praveen Kumar
Sprint-2	Model Deployment on IBM Cloud using IBM Watson	USN-4	As a user, I can use the model by requesting the deployed model on Cloud	1	Medium	Mahendran D Praveen Kumar
Sprint-2	Basic user interaction Dashboard	USN-5	As a user, I can use the model or prediction from model by interacting with dashboard	2	high	Mahendran D, Manikandan
Sprint-3	Improved Dashboard and GUI	USN-6	As a user, I can use the model or prediction from model by interacting with improved dashboard	1	Medium	Manikandan Mahendran D

Sprint-3	Registration	USN-7	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	Manikandan, Krishna Kumar
Sprint-3	Registration	USN-7	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	Manikandan, Krishna Kumar
Sprint-3	Login	USN-8	As a user, I can log into the application by entering email & password and I can register .login to the application through Gmail	2	Medium	Manikandan, Krishna Kumar
Sprint-4	Raise query/complaint and give feedback	USN-9	As a user, I can raise complaint or query and give feedback	1	Medium	Manikandan, Krishna Kumar
Sprint-4	Improve overall web app	USN-10	As a user, I can user revised and improved version of web application	1	High	Manikandan, Krishna Kumar, Mahendran D, Praveen Kumar

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	24 Oct 2022	29 Oct 2022	20	31 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	07 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let’s calculate the team’s average velocity (AV) per iteration unit (story points per day)

1. ## CODING AND SOLUTIONING

SPRINT-1:

Outline:

1. Data Pre-processing
2. EDA/Data Analysis
3. Feature Engineering
4. Model Building
5. Saving Best Model

Required Libraries:

- Pandas - Data Pre-processing
- Numpy - Data Pre-processing, Analysis
- Matplotlib - Visualization
- Seaborn - Visualization
- Imblearn - Balancing Data
- Sklearn - Model Building
- Pickle - Model saving

Software/Tool:

- Anaconda- Jupyter Notebook
- Used Language Python

Data Pre-processing:

Data Collection:

Dataset is collected from the IBM career smartinternz portal in Guided Project.

Dataset description:

The dataset contains 31 variables with various data types such as string, object, time, integer, float.

Data columns (total 31 columns):

#	Column	Non-Null Count	Dtype
0	YEAR	11231 non-null	int64
1	QUARTER	11231 non-null	int64
2	MONTH	11231 non-null	int64
3	DAY_OF_MONTH	11231 non-null	int64
4	DAY_OF_WEEK	11231 non-null	int64
5	UNIQUE_CARRIER	11231 non-null	object
6	TAIL_NUM	11231 non-null	object
7	FL_NUM	11231 non-null	int64
8	ORIGIN_AIRPORT_ID	11231 non-null	int64
9	ORIGIN	11231 non-null	object
10	DEST_AIRPORT_ID	11231 non-null	int64
11	DEST	11231 non-null	object
12	CRS_DEP_TIME	11231 non-null	object
13	CRS_DEP_TIME.1	11231 non-null	int64
14	DEP_TIME	11124 non-null	object
15	DEP_TIME.1	11124 non-null	float64
16	DEP_DELAY	11124 non-null	float64
17	DEP_DEL15	11124 non-null	float64
18	CRS_ARR_TIME	11231 non-null	object
19	CRS_ARR_TIME.1	11231 non-null	int64
20	ARR_TIME	11116 non-null	object
21	ARR_TIME.1	11116 non-null	float64
22	ARR_DELAY	11043 non-null	float64
23	ARR_DEL15	11043 non-null	float64
24	CANCELLED	11231 non-null	int64

```
 25  DIVERTED             11231 non-null  int64
 26  CRS_ELAPSED_TIME1    11231 non-null  object
 27  ACTUAL_ELAPSED_TIME1 11231 non-null  object
 28  CRS_ELAPSED_TIME     11231 non-null  int64
 29  ACTUAL_ELAPSED_TIME  11043 non-null  float64
 30  DISTANCE             11231 non-null  int64
dtypes: float64(7), int64(14), object(
```

Columns Description:

Dest means Destination Airport.

Crs_dep_time and crs_arr_time is planned departure and arrival time.

Crs_elapsed _time is estimated travel time as per plan.

Arr_time and dep_time are actual arrival and departure time.

Actual_elapsed_time is actual travelled time

To pre-process our dataset, we need to import above mentioned required libraries, then import data using pandas.

This data does not contain any duplicated values and null values except in arrival , departure time columns, because these left empty when flights are cancelled.

Descriptive Analytics:

```
In [19]: data1.describe()
```

Out[19]:

	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_NUM	CRS_DEP_TIME.1	DEP_DELAY	DEP_DEL15	CRS_ARR_TIME.1	ARR_DEL
count	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11231.000000	11124.000000	11124.000000	11231.000000	11043.000
mean	2.544475	6.628973	15.790758	3.960199	1334.325617	1320.796326	8.460266	0.142844	1537.312795	-2.573
std	1.090701	3.354678	8.782066	1.995257	811.875227	490.737845	36.762969	0.349930	502.512494	39.232
min	1.000000	1.000000	1.000000	1.000000	7.000000	10.000000	-16.000000	0.000000	2.000000	-67.000
25%	2.000000	4.000000	8.000000	2.000000	624.000000	905.000000	-3.000000	0.000000	1130.000000	-19.000
50%	3.000000	7.000000	16.000000	4.000000	1267.000000	1320.000000	-1.000000	0.000000	1559.000000	-10.000
75%	3.000000	9.000000	23.000000	6.000000	2032.000000	1735.000000	4.000000	0.000000	1952.000000	1.000
max	4.000000	12.000000	31.000000	7.000000	2853.000000	2359.000000	645.000000	1.000000	2359.000000	615.000

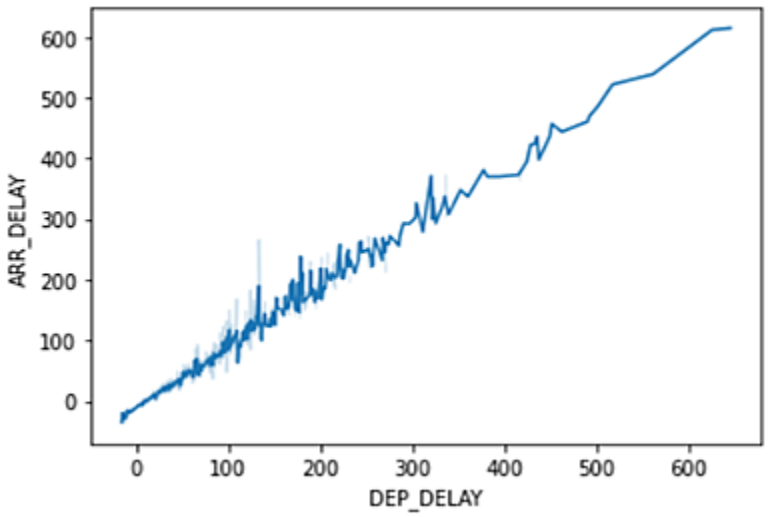
```
In [19]: data1.describe()
```

Out[19]:

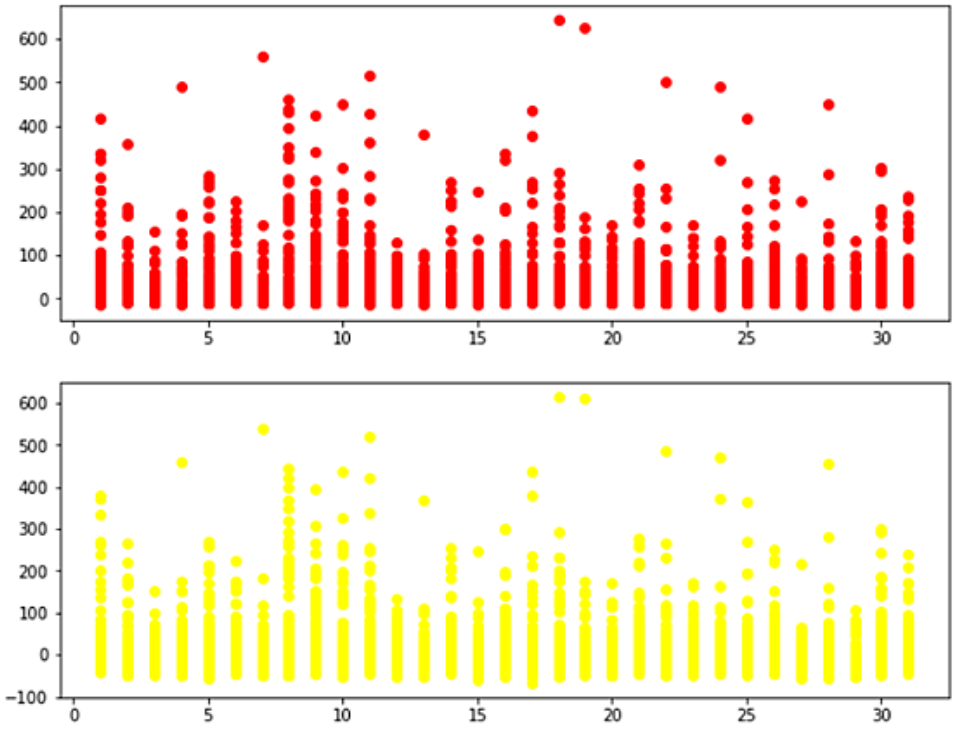
M	CRS_DEP_TIME.1	DEP_DELAY	DEP_DEL15	CRS_ARR_TIME.1	ARR_DELAY	ARR_DEL15	CANCELLED	DIVERTED	CRS_ELAPSED_TIME	DISTANCE
30	11231.000000	11124.000000	11124.000000	11231.000000	11043.000000	11043.000000	11231.000000	11231.000000	11231.000000	11231.000000
17	1320.798326	8.460266	0.142844	1537.312795	-2.573123	0.124513	0.010150	0.006589	190.652124	1161.031965
27	490.737845	36.762989	0.349930	502.512494	39.232521	0.330181	0.100241	0.080908	78.386317	643.683379
30	10.000000	-16.000000	0.000000	2.000000	-67.000000	0.000000	0.000000	0.000000	93.000000	509.000000
30	905.000000	-3.000000	0.000000	1130.000000	-19.000000	0.000000	0.000000	0.000000	127.000000	594.000000
30	1320.000000	-1.000000	0.000000	1559.000000	-10.000000	0.000000	0.000000	0.000000	159.000000	907.000000
30	1735.000000	4.000000	0.000000	1952.000000	1.000000	0.000000	0.000000	0.000000	256.000000	1927.000000
30	2359.000000	645.000000	1.000000	2359.000000	615.000000	1.000000	1.000000	1.000000	397.000000	2422.000000

Data Analysis And Visualization:

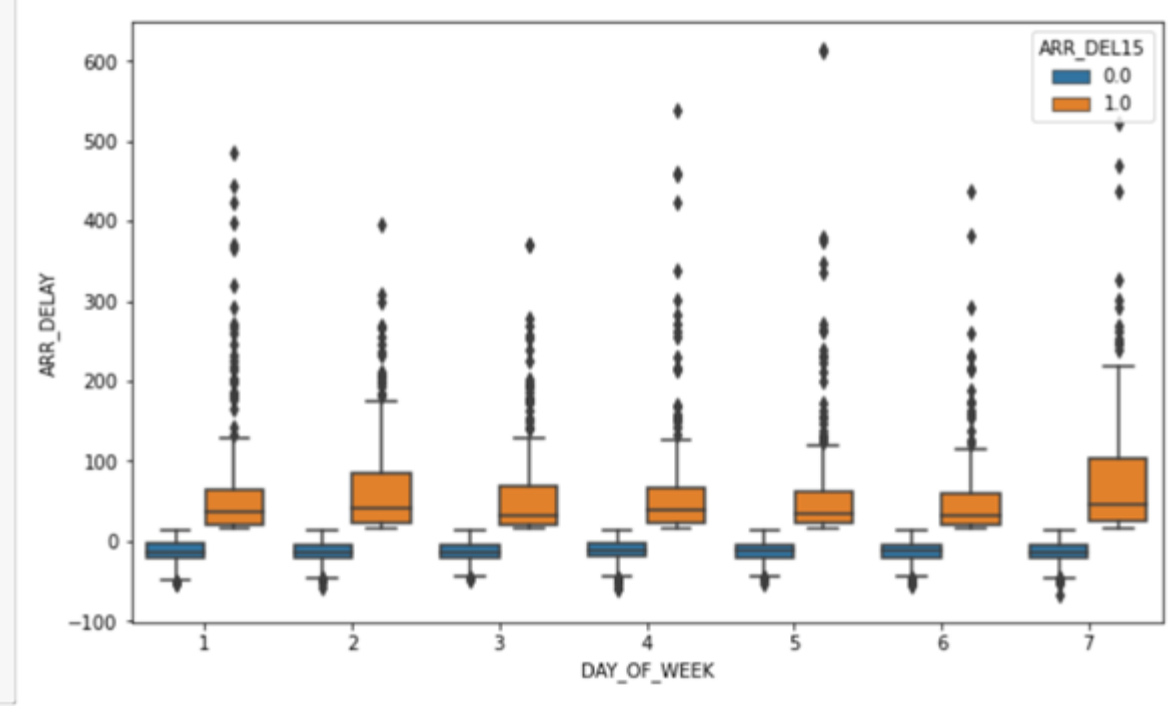
This graph shows the positive trend and strong binding between arrival and departure delay.



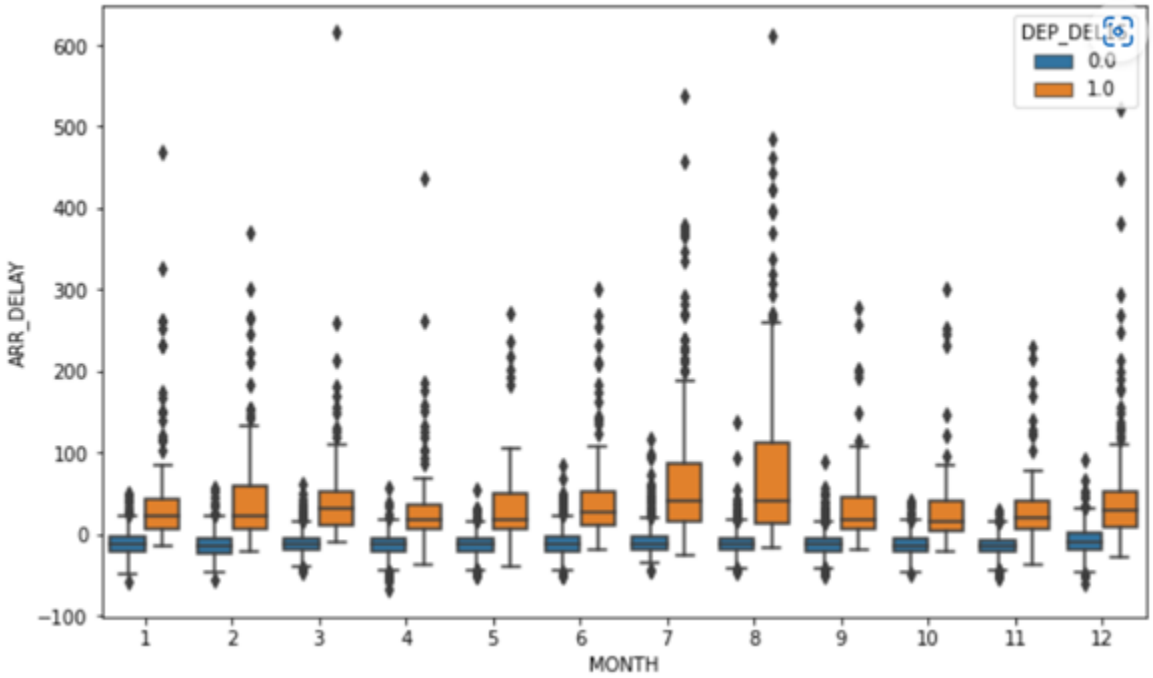
```
plt.scatter(data1["DAY_OF_MONTH"],data1["DEP_DELAY"],color="red")
plt.subplot(2,1,2)
plt.scatter(data1["DAY_OF_MONTH"],data1["ARR_DELAY"],color="yellow")
plt.show()
```



This above picture shows the relationship between day of month and delays

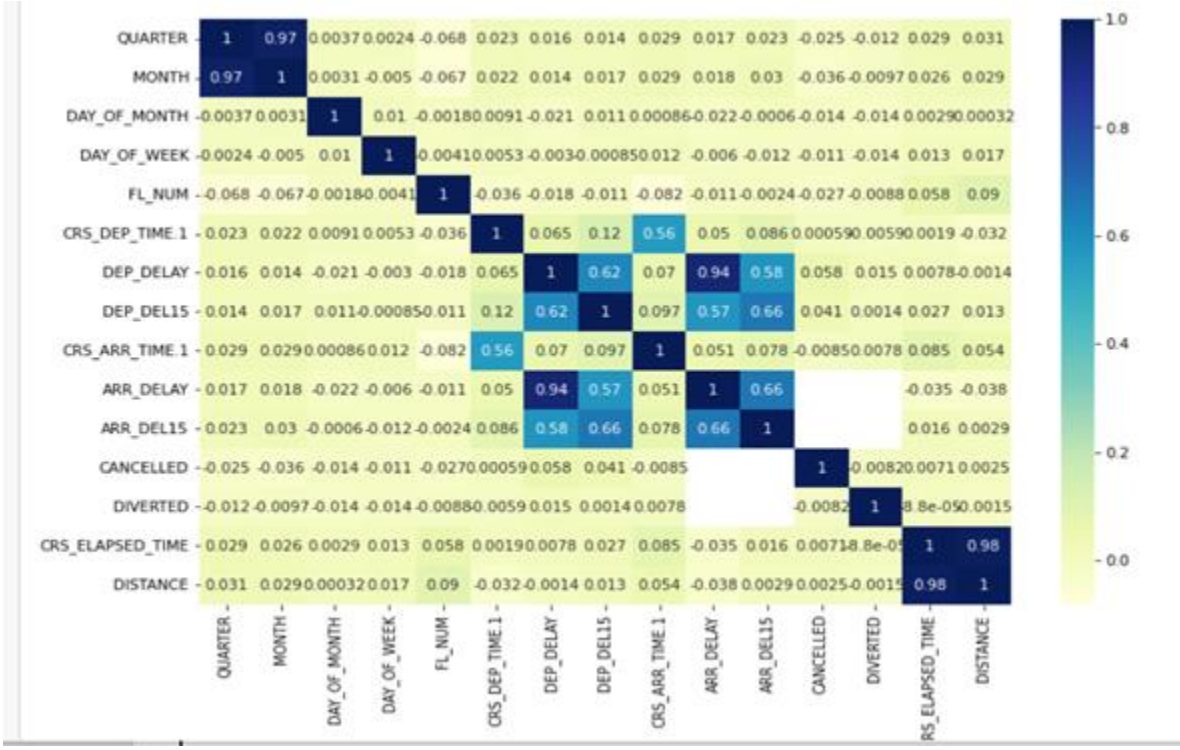


This above picture shows the relationship between day of month and delays



This above boxplot shows the trends of days of the week and delay, Monday and Saturday had high delays.

Correlation between columns:



Feature Engineering:

We engineered Season from the month according to the analysis

```
In [25]: data1.groupby(by="DAY_OF_WEEK")["DEP_DEL15"].sum()
Out[25]: DAY_OF_WEEK
         1    253.0
         2    213.0
         3    204.0
         4    245.0
         5    250.0
         6    198.0
         7    226.0
         Name: DEP_DEL15, dtype: float64

In [26]: data1.groupby(by="MONTH")["DEP_DEL15"].sum()
Out[26]: MONTH
         1     113.0
         2     115.0
         3     104.0
         4      96.0
         5      86.0
         6     168.0
         7     219.0
         8     246.0
         9      88.0
         10     86.0
         11     66.0
         12    202.0
         Name: DEP_DEL15, dtype: float64
```

Then Engineered NDELAY column from the summary of ARR_DEL15, DEP_DEL15, CANCELLED, DIVERTED columns.

Splitted NDELAY as dependenr column and others independent columns after removing unnecessary columns.

Data Balancing:

We balanced our using SMOTE technique which works based on KNN principle.

Balancing Dataset Using SMOTE Technique

```
In [48]: from imblearn.combine import SMOTETomek
         smote=SMOTETomek(sampling_strategy={1:2000,2:2000,3:400,4:700},random_state=42)
         x1,y2=smote.fit_resample(x,y)
         y2.value_counts()

Out[48]: 0.0    8316
         1.0    1537
         2.0    1493
         4.0     634
         3.0     340
         Name: NDELAY, dtype: int64
```

Encoding Categorical columns into numerical columns:

We encoded ORGIN ,DEST into numerical columns.

Model Buliding:

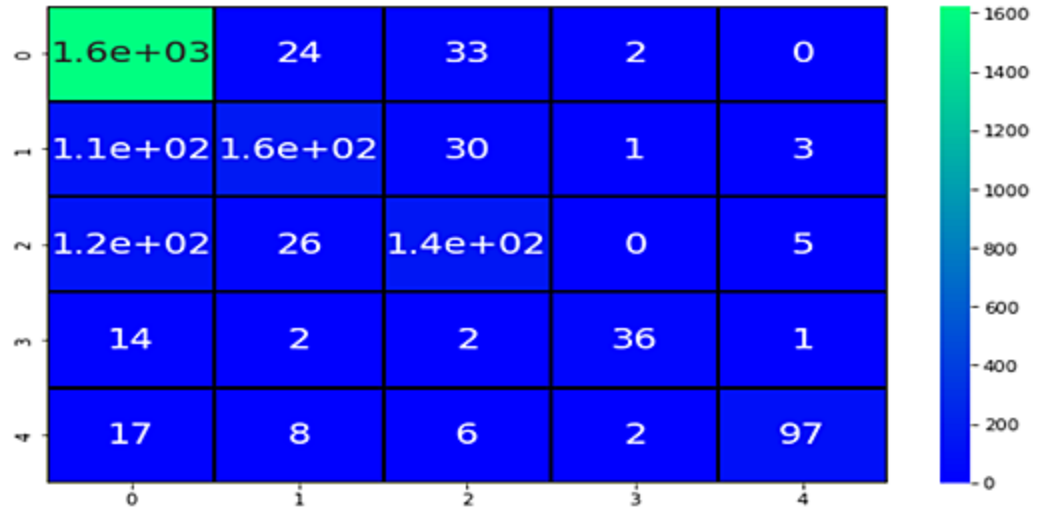
We builded

Decision Tree with 0.7536525974025974
Random Forest with 0.8368506493506493
SVM with 0.6128246753246753
KNN with 0.7280844155844156
Logistic Regession with 0.6830357142857143

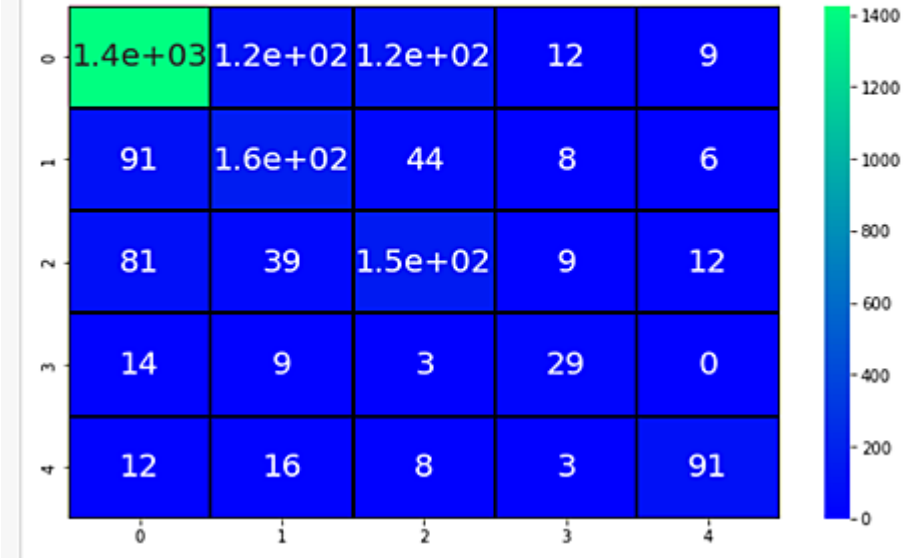
We will explore only Random Forest and Decision Tree which have high accuracy

Random Forest

```
Testing Sensitivity for Random Forest 0.9360230547550432
Testing Specificity for Random Forest 0.871657754010695 2
Testing Precision for Random Forest 0.9854368932038835
Testing accuracy for Random Forest 0.8368506493506493
```




```
Testing Accuracy for Decision Tree 0.8849804578447794
Testing Sensitivity for Decision Tree 0.9400131839156229
Testing Specificity for Decision Tree 0.5802919708029197
Testing Precision for Decision Tree 0.9253731343283582
Testing accuracy for Decision Tree 0.7516233766233766
```



Model Saving:

Random Forest gives the best accuracy then others , so we save random forest model using pickle.

```
In [71]: import pickle

In [72]: pickle.dump(rf,open("rfmodel.pkl",'wb'))
```

Conclusion:

In this sprint , we builded our model , evaluated and saved. In next sprint, we deploy our model IBM cloud using IBM Watson and building Dashboard.

SPRINT-2:

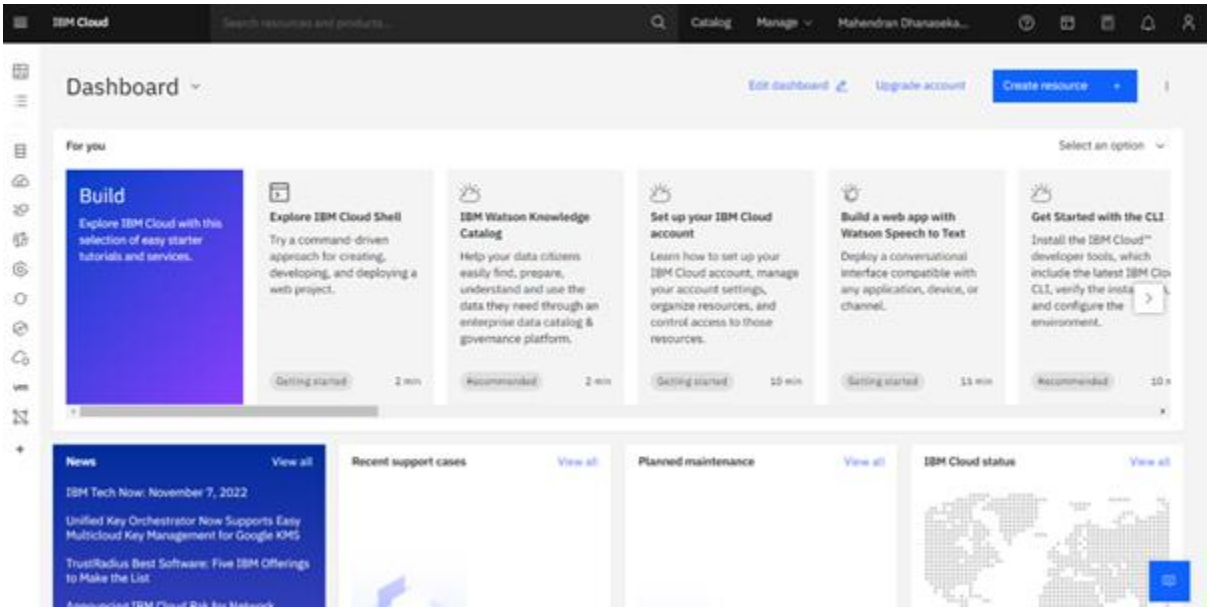
- Creating IBM cloud account & Required Resources
- Deploy our model in IBM Watson
- Creating Dashboard using HTML/CSS
- Create web app and Hosting in falsk
- Testing web app

Creating IBM cloud account & Required Resources:

Creating IBM cloud account:

Frist, need to create IBM Cloud account by using SI Mail Id and SI Password which is provided by IBM in profile.

Below dashboard of an account after created,



Creating IBM Cloud Required Resources:

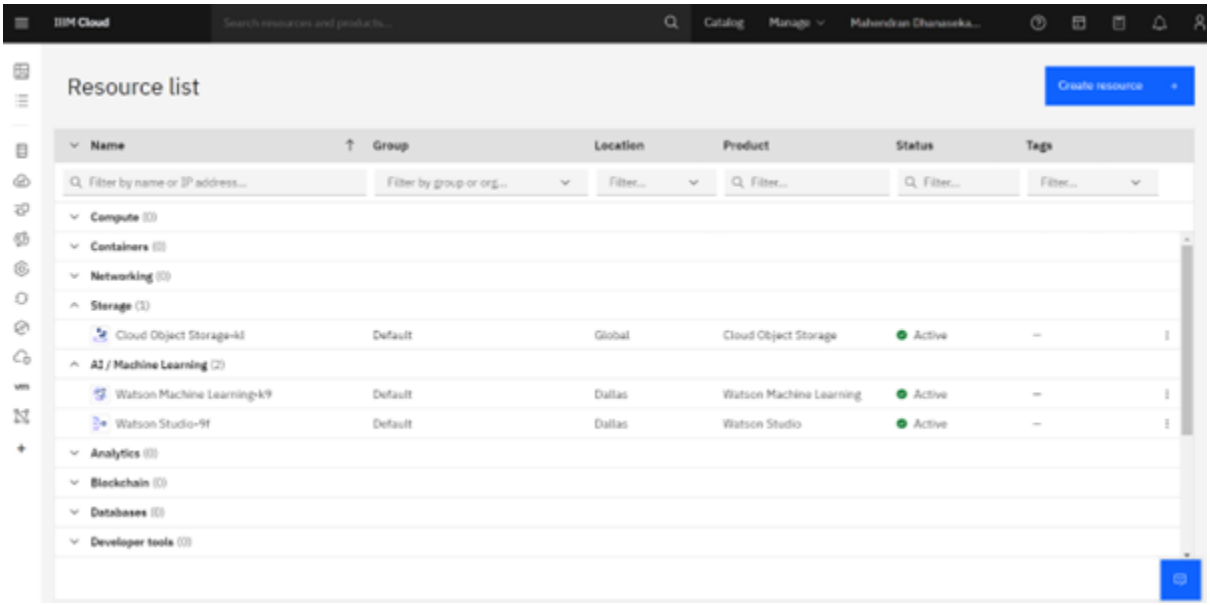
After creating IBM cloud account, to deploy ML model, need to create following resources such as,

Cloud Object Storage

Watson Machine Learning

Watson Studio

After created above resources Resource List of an account is displayed as follow,



All the resource are in active state.

All the required cloud resources are created successfully.

Deploy our model in IBM Watson:

To deploy ML model in IBM cloud, need to create project in IBM Watson. After successful creation of project import .ipynb file of sprint-1 which ML models are build in Jupyter notebook.

Upload required datasets and import it.

Deploy model using following code,

```
!pip install -U ibm-watson-machine-learning
from ibm_watson_machine_learning import APIClient
import json
import numpy as np
wml_cred={
   "apikey":"okbr7ARnOQjyplTOyvNFC2QVkCF6q7afpci065Hucby8",
   "url":"https://us-south.ml.cloud.ibm.com"
}
wml_clients=APIClient(wml_cred)
wml_clients.spaces.list()
```

```
space_id="6d7c1218-3aca-4256-be3d-d610732530b1"
wml_clients.set.default_space(space_id)
wml_clients.software_specifications.list(500)
MODEL_NAME="randomforest"
DEPLOYMENT_NAME="rf_deployment"
DEMO_MODEL=rf
soft_sepc_id=wml_clients.software_specifications.get_id_by_name("runtime-22.1-py3.9")
```

In [115]:

```
model_props={
   wml_clients.repository.ModelMetaNames.NAME:MODEL_NAME,
   wml_clients.repository.ModelMetaNames.TYPE:"scikit-learn_1.0",
   wml_clients.repository.ModelMetaNames.SOFTWARE_SPEC_UID: soft_sepc_id

}
```

In [116]:

```
model_details=wml_clients.repository.store_model(model=DEMO_MODEL,meta_props=model_props,training
_data=x_train,
                                 training_target=y_train.values.ravel())
```

In [117]:

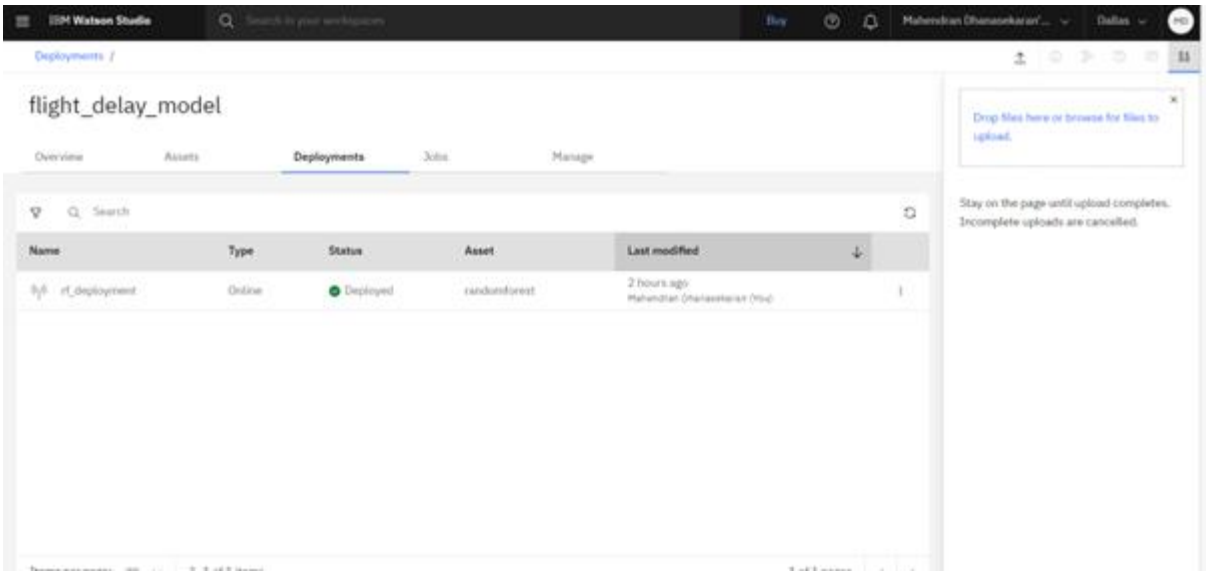
```
model_details
model_id=wml_clients.repository.get_model_id(model_details)
dep_props={
   wml_clients.deployments.ConfigurationMetaNames.NAME:DEPLOYMENT_NAME,
   wml_clients.deployments.ConfigurationMetaNames.ONLINE:{}
}
```

In [125]:

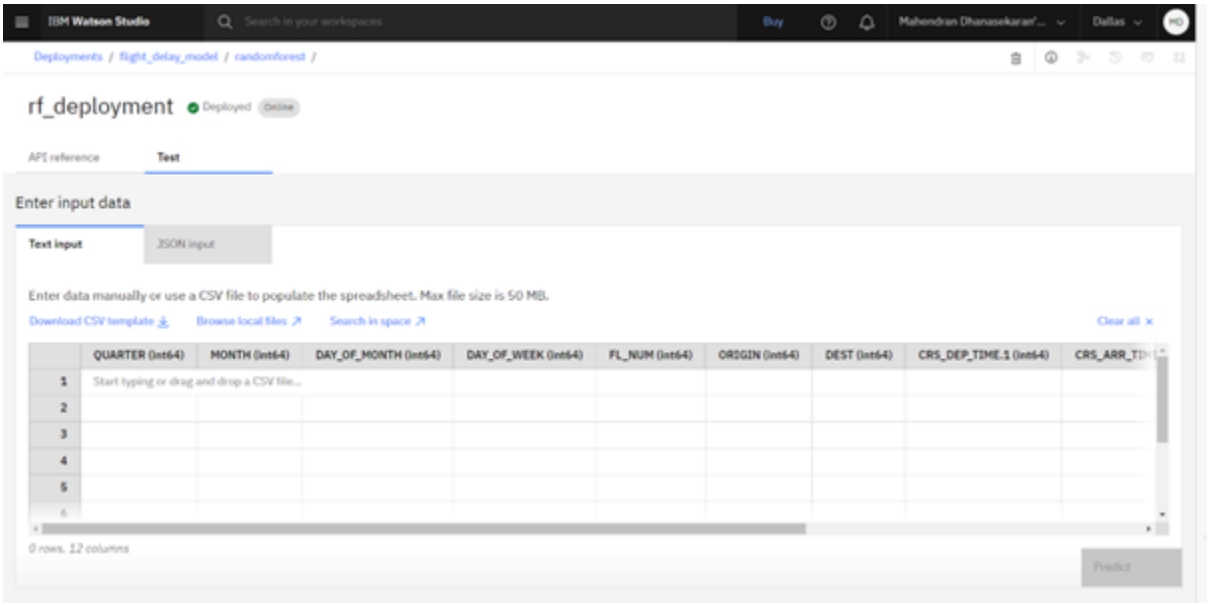
```
deployment=wml_clients.deployments.create(artifact_uid=model_id,meta_props=dep_props)
```

NOTE: APIKey must need to create to deploy and connect API

After successful of deployment, deployed is appeared in Deployment section as follow,



Testing of deployed model as follow, by giving values of all the features and it gives prediction.

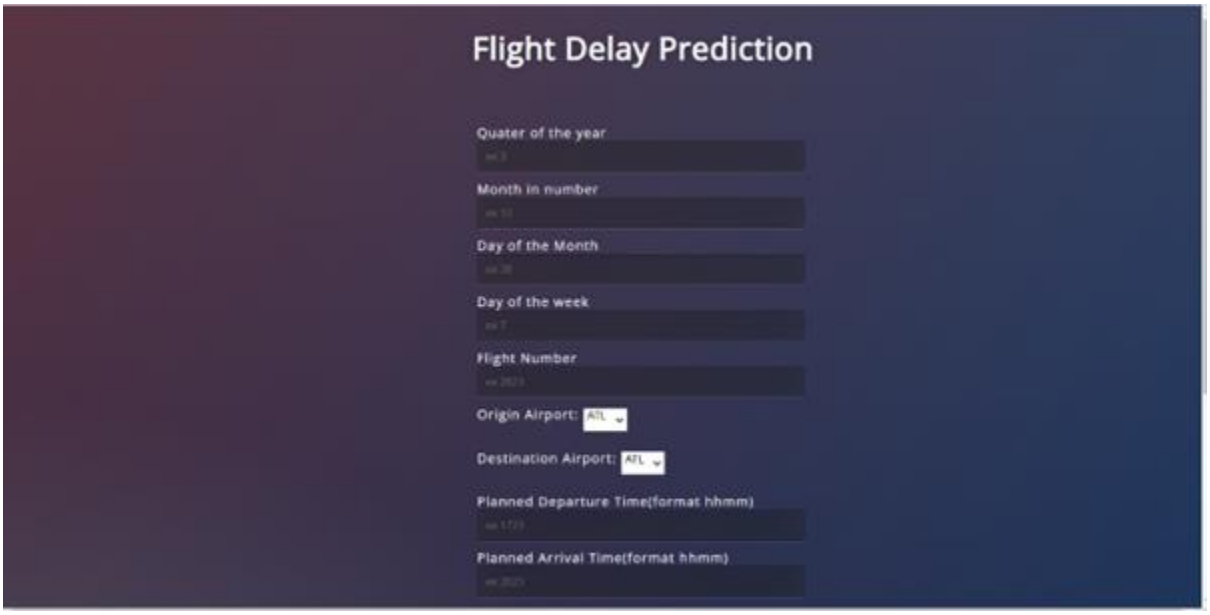


After these, need to copy API requesting codes on required language(python).

Creating Dashboard using HTML/CSS:

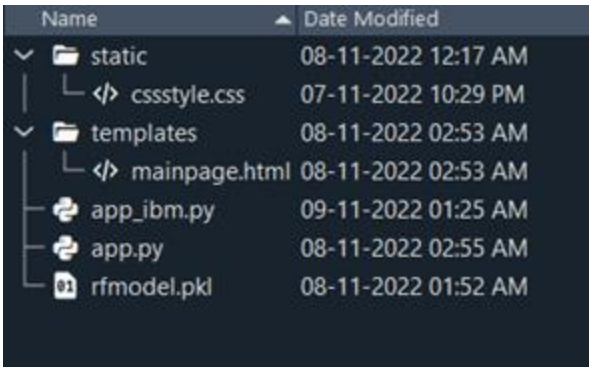
Frontend Dashboard is created using HTML/CSS,

Result as web page like,



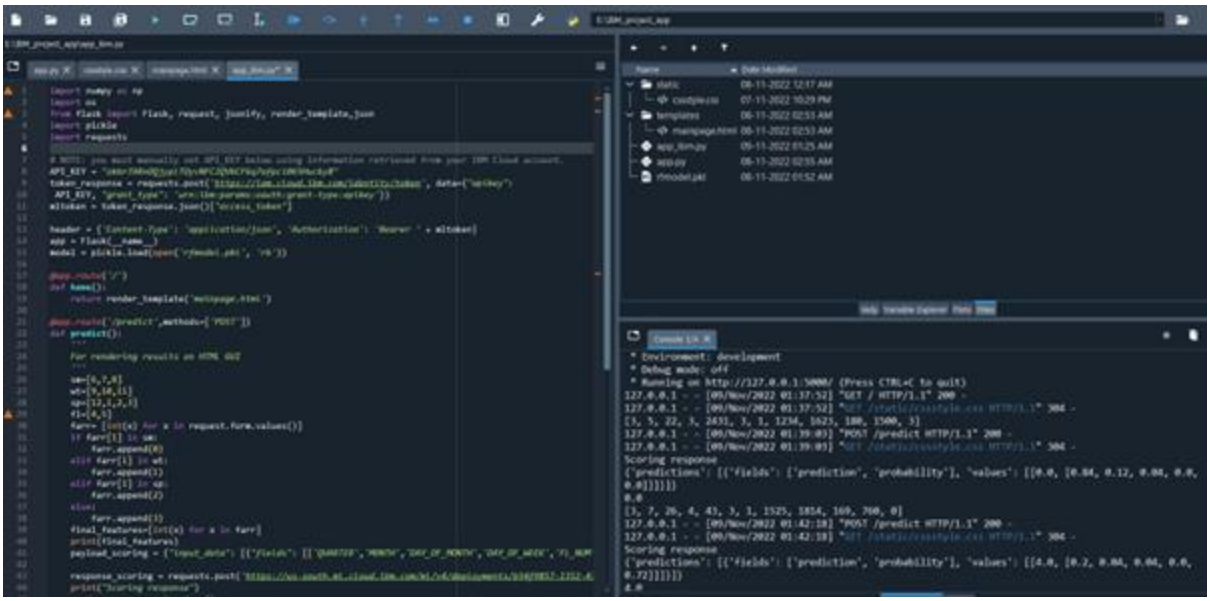
Create web app and Hosting in falsk:

First thing, need to create directory as follow,



Then, code the required logic in app.py file with API connection , request and response code.

Spyder IDE looks like,



Run the app.py file.

Localhost url is displayed in console, copy and paste in browser then search it , frond end HTML?CSS page is displayed. Successfully created and hosted web app in flask.

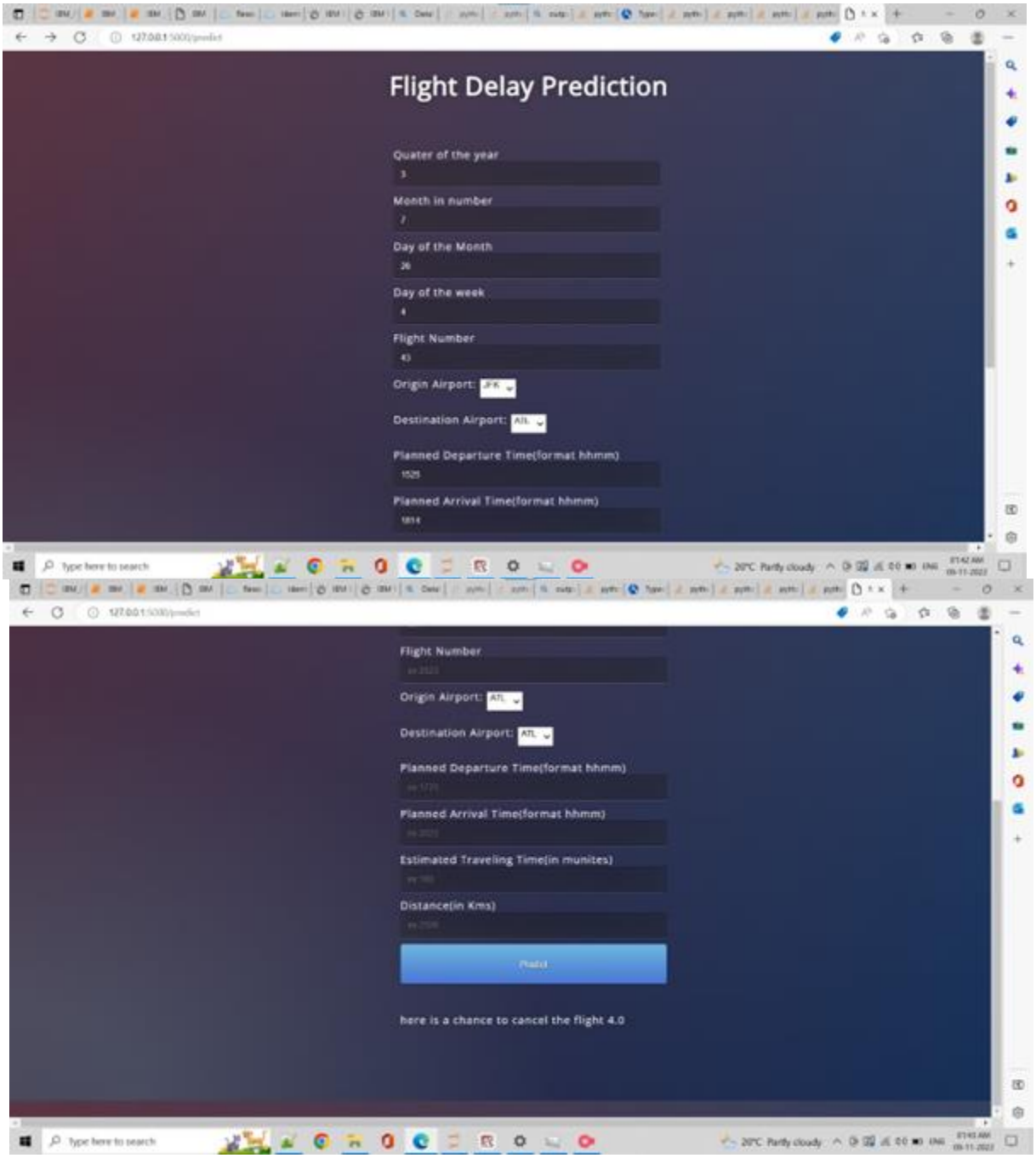
If any error caused as flask in production mode, then

Set FLASK_ENV=Development,

Then run the app

Testing web app:

Enter the data on the required fields,



Output is predicted by ML model successfully.

SPRINT-3:

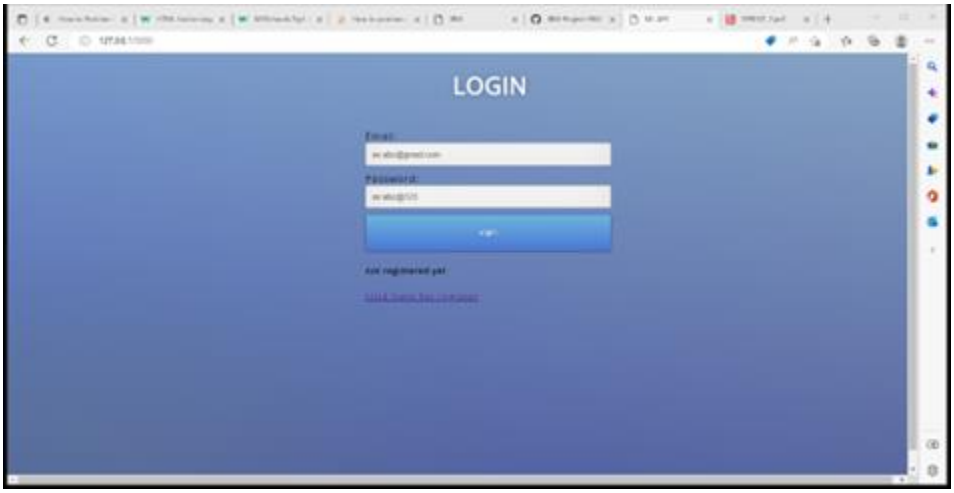
Build templates of login and register pages

Connect templates and login, register operation in flask

Test run the app

Build templates of login and register pages:

Using, HTML/CSS , Login and register templates are build.



Above picture shows the login page of this app.

Above picture is register page of web app.

Connect templates and login, register operation in flask:

There is a need to connect database for store and retrieve user details. In this project SQlite3 database is used to store and retrieve user details.

Login code as follow:

```
@app.route('/')
def main():
    return render_template('login.html')


@app.route('/login',methods=['POST','GET'])
def login():
    if request.method=='POST':
        try:
            fv=[x for x in request.form.values()]
            email=request.form["email"]
            pswd=request.form["pswd"]
            conn=sqlite3.connect("database1.db")
            cur=conn.cursor()
            cur.execute("SELECT password FROM login WHERE email=?;",(str(email),))
            result=cur.fetchone()
            cur.execute("SELECT * FROM login")
            if result:
                if result[0]==pswd:
                    flash("login successfully",'success')
                    return redirect('/home')
                else:
                    return render_template("login.html", error="please enter correct password")
```

```
            else:
                print("register")
                flash("please Register",'danger')


                return redirect('/reg')


        except Exception as e:
            return "hello error"
```

Register code as follow:

```
.route('/reg')
def reg():
    return render_template("register.html")


@app.route('/register',methods=['POST','GET'])
def register():
    if request.method=='POST':
        try:
            fv=[x for x in request.form.values()]
            email=request.form["email"]
            pswd=request.form["pswd"]
            conn=sqlite3.connect("database1.db")
            cur=conn.cursor()
            cur.execute("SELECT * FROM login WHERE email=?;",(str(email),))
            result=cur.fetchone()
            if result:
                flash("user already exist,please login",'danger')
                return redirect('/')
```

```
        else:
            cur.execute("INSERT INTO  login(email,password)values(?,?)",(str(email),str(pswd)))
            conn.commit()
            cur.execute("SELECT * FROM login")
            flash("Registered successfully",'success')
            return render_template('login.html')

    except Exception as e:
        print(e)
        #flash(e,'danger')
        return "hello error1"
```

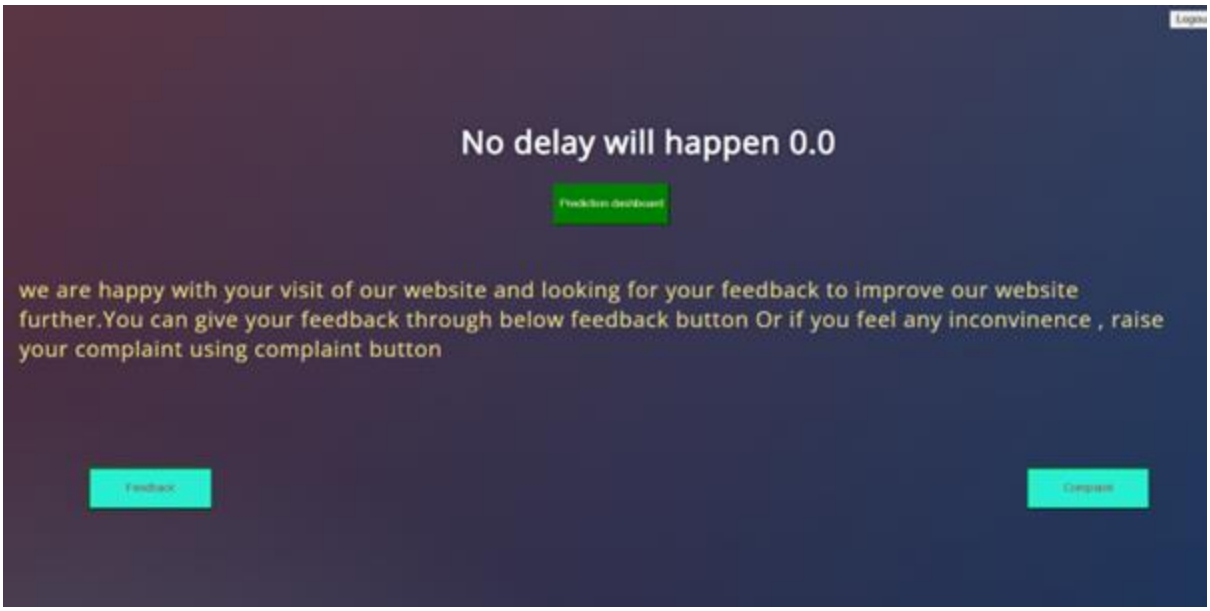
By using above code, successfully connect login and register pages to app successfully.

Test run app:

click me for demo video of app sprint 3

Sprint-4

Result page added,



8.TESTING

8.1. Test Cases

Test case ID	Feature Type	Component	Test Scenario	Pre-Requisite	Steps To Execute	Test Data	Exp Re
LoginPage_TC_OO1	Functional	Login/register Page	Verify user is able to see the Login/Signup when user register and login	any latest version browser	1.Enter URL and click go 2. click register link 3.enter your credientials 4. click register 5.Verify login/Singup	1. Email id 2. Password	1.if Lo succe redire predi page 2.Sig succe redire login with regist succe messa

LoginPage_TC_OO2	Functiona l	login page	Verify user is able to log into application with Valid credentials	any latest version browser	1.Enter URL and click go 2.Enter Valid email in Email text box 3.Enter valid password in password text box 4.Click on login button	1. Email id 2. Password	User navig predi page
LoginPage_TC_OO4	Functiona l	Login page	Verify user is able to log into application with InValid credentials	any latest version browser	1.Enter URL and click go 2.Enter Valid email in Email text box 3.Enter invalid password in password text box 4.Click on login button	1. Email id 2. invalid Password	Appli shoul show 'passv valida messa
LoginPage_TC_OO5	Functiona l	Login page	Verify user is able to log into application with InValid credentials	any latest version browser	1.Enter URL and click go 2.Enter inValid or new email in Email text box 3.Enter valid password in password text box 4.Click on login button	1. in valid or newEmail id 2. Password	Appli shoul redire regist page user exist messa

RegisterPage_TC_OO2	Functional	register page	Verify user is able to log into application with InValid credentials	any latest version browser	1.Enter URL and click go 2.go to register 3.Enter already registered email in Email text box 3.Enter valid password in password text box 4.Click on register button	1.already registered Email id 2. Password	Applic shoul redire loginp with u alread exist messa
prediction Page_TC_OO1	Functional	prediction page	Verify user is able to get prediction with valid input	any latest version browser	1.Enter URL and click go 2. login with valid user credientials 3.click login 3.in prediction page, enter valid input data 4.Click on predict button	1. valid Email id 2.paswwor d Password 3. valid input data	User navig result and g predc

prediction Page_TC_OO2	Functional	prediction page	Verify user is able warnings on try predict with InValid input data	any latest version browser	1.Enter URL and click go 2. login with valid user credientials 3.click login 3.in prediction page, enter invalid input data(like month greater than 12 or negative values, week days greater than 7, quarter greater than 4,invalid distance and time) 4.Click on predict button	1. valid Email id 2.paswword Password 3. invalid input data	user a get warni like m great 12 or negat value week great 7, qua great 4,inva distar and ti
result Page_TC_OO1	UI	result page	Verify user is able to see prediction with other UI components like prediction page button,feedback and complaint button	any latest version browser	1.Enter URL and click go 2. login with valid user credientials 3.click login 3.in prediction page, enter valid input data 4.Click on predict button	1. valid Email id 2.paswword Password 3. valid input data	User navig result and g predc able t other comp s

result Page_TC_OO2	functional	result page	Verify user is able to go back prediction page , go to feedback or complaint form with UI components like prediction page button,feedback and complaint button	any latest version browser	1.Enter URL and click go 2. login with valid user credientials 3.click login 3.in prediction page, enter valid input data 4.Click on predict button 5.click on prediction page button 6.click feedback or complaint button	1. valid Email id 2.paswwor d Password 3. valid input data	User navig result and g predc able t other comp s

8.2 User Acceptance Test

1. Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issuesof the Developing a flight delay prediction model using machine learning project at the time of the release to User Acceptance Testing (UAT).

2. Defect Analysis

This report showsthe number of resolved or closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	8	4	2	3	15
Duplicate	0	0	0	0	0
External	2	1	0	1	4
Fixed	15	10	4	5	34

Not Reproduced	0	0	0	0	0
Skipped	0	0	0	0	0
Won't Fix	0	0	0	0	0
Totals	23	15	6	9	53

3. Test Case Analysis

This report shows the number of test cases that have passed, failed,and untested

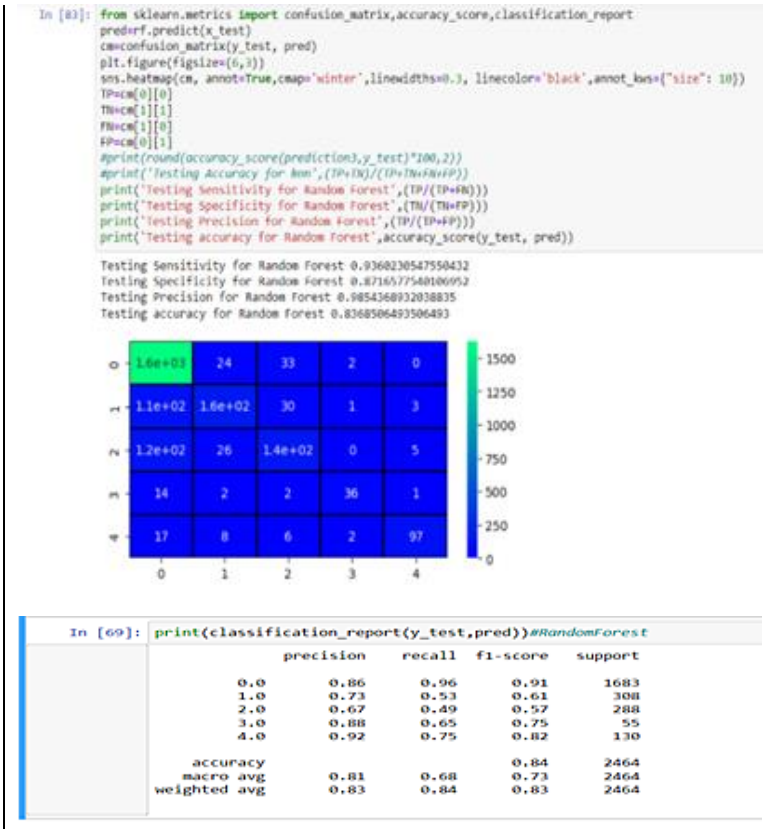
Section	Total Cases	Not Tested	Fail	Pass
Client Application	12	0	0	12
Security	2	0	0	2
Exception Reporting	6	0	0	6
Final Report Output	4	0	0	4

9.PERFORMANCE TESTING

Model Performance Testing:

Project team shall fill the following information in model performance testing template
Project team shall fill the following information in model performance testing template.

S.No.	Parameter	Values	Screenshot

1.	Metrics	**Classification Model:** Confusion Matrix – , Accuray Score- & Classification Report -	
2.	Tune the Model	Hyperparameter Tuning - Validation Method -	

```
In [83]: from sklearn.metrics import confusion_matrix,accuracy_score,classification_report
         pred=rf.predict(x_test)
         cm=confusion_matrix(y_test, pred)
         plt.figure(figsize=(6,3))
         sns.heatmap(cm, annot=True,cmap='winter',linewidths=0.3, linecolor='black',annot_kws={"size": 10})
         TP=cm[0][0]
         TN=cm[1][1]
         FN=cm[1][0]
         FP=cm[0][1]
         #print(round(accuracy_score(prediction3,y_test)*100,2))
         #print('Testing Accuracy for knn',(TP+TN)/(TP+TN+FN+FP))
         print('Testing Sensitivity for Random Forest',(TP/(TP+FN)))
         print('Testing Specificity for Random Forest',(TN/(TN+FP)))
         print('Testing Precision for Random Forest',(TP/(TP+FP)))
         print('Testing accuracy for Random Forest',accuracy_score(y_test, pred))

Testing Sensitivity for Random Forest 0.9360230547550432
Testing Specificity for Random Forest 0.8716577540106952
Testing Precision for Random Forest 0.9854368932038835
Testing accuracy for Random Forest 0.8368506493506493
```



```
In [69]: print(classification_report(y_test,pred))#RandomForest
```

	precision	recall	f1-score	support
0.0	0.86	0.96	0.91	1683
1.0	0.73	0.53	0.61	308
2.0	0.67	0.49	0.57	288
3.0	0.88	0.65	0.75	55
4.0	0.92	0.75	0.82	130
accuracy			0.84	2464
macro avg	0.81	0.68	0.73	2464
weighted avg	0.83	0.84	0.83	2464

```
Out[77]: {'criterion': 'entropy',
          'max_depth': 7,
          'max_leaf_nodes': 9,
          'random_state': 561
```

click to scroll output; double click to hide

```
In [76]: cv_result=cross_val_score(rf,x_train,y_train,cv=kf)
         cv_result

Out[76]: array([0.81135903, 0.80974125, 0.8021309 , 0.81836631, 0.81887367])
```

```
In [74]: from sklearn.model_selection import KFold,GridSearchCV,cross_val_score
         kf= KFold(n_splits=5,shuffle=True,random_state=42)
         param={
             'max_depth':[4,5,7,9,11],
             'max_leaf_nodes':[5,6,8,9],
             'random_state':[42,56,72],
             'criterion':["gini",'entropy','log_loss']

         }

In [77]: grcv=GridSearchCV(rf,param,cv=kf)
         grcv.fit(x_train,y_train)
         grcv.best_params_
```

1

10.ADVANTAGES & DISADVANTAGES

Advantages:

- Early known of delay will reduce the tension, pressure of customer, airlines and airport authorities.
- By early known of delay, we can reduce or avoid financial loss
- We can change our plan according to the practical scenario, if we know the delay earlier
- Airlines and Airport Authorities make prevention techniques, find the source of the problem
- Airlines can inform their passengers to prepare according to that. This saves name and fame the airlines among the modern society

Disadvantage:

- Delay due to unexpected climate change , war, natural disaster.. etc can’t predict exactly.
- Need more data and analyse

11.CONCLUSION

Successfully developed the flight delay prediction model using random forest algorithm which gives best accuracy. By knowing delay earlier, many chance to avoid, so many problems and issues. This prediction gives the waring only to make prepared us.

12.FUTURE SCOPE

Add the feature to track the flight on real time and make prediction using real time data by connecting to the private API which gives real time data

13.APPENDIX

Source code

Login.html

```
1   <!DOCTYPE html>
2  <html>
3
4  <head>
5    <meta charset="UTF-8">
6    <title>ML API</title>
7    <link href='https://fonts.googleapis.com/css?family=Pacifico'
   rel='stylesheet' type='text/css'>
8  <link href='https://fonts.googleapis.com/css?family=Arimo'
   rel='stylesheet' type='text/css'>
9  <link href='https://fonts.googleapis.com/css?family=Hind:300'
   rel='stylesheet' type='text/css'>
10 <link
   href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed
   :300' rel='stylesheet' type='text/css'>
11 <link rel="stylesheet"
   href="{{url_for('static',filename='Lcssstyle.css')}}">
12
13
14 </head>
15 <body>
16  <h1 class="h1">LOGIN</h1>
17  <div class="login">
18     <form action="{{ url_for('login')}}" method="post">
19        <h4 style="color:#a60c2f"> {{alert}}<h4><h4
   style="color:green"> {{message}}<h4>
20        Email: <input type="email" name="email"
   placeholder="ex:abc@gmail.com" required="required" autocomplete
   />
21        Password: <input type="password" name="pswd" id="pswd"
   placeholder="ex:abc@123" required="required" maxlength=15/>
22    {{error}}
23     <span id="error" style="color:#F00;"> </span>
24        <button type="submit" class="btn btn-primary btn-block"
   id="lbtn">login</button>
25        <h5>not registered yet </h5><a
   href="{{url_for('reg')}}">click here for register</a>
26     </form>
27
28    <br>
29    <br>
30     </div>
```

```
</body>
</html>

```

Register.html

```
<!DOCTYPE html>
<html >

<head>
  <meta charset="UTF-8">
  <title>ML API</title>
  <link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet' type='text/css'>
<link rel="stylesheet" href='{{url_for('static',filename='Lcssstyle.css')}}'>


</head>
<script>

function confirmPass() {
    var pass = document.getElementById("pswd").value
    var confPass = document.getElementById("cpswd").value
    if(pass != confPass) {
        //alert('Wrong confirm password !');
        document.getElementById('error').innerHTML='wrong confirm password';
 document.getElementById('rbtn').disabled=true;
    }
    else
```

```
    {
        document.getElementById('error').innerHTML='';
 document.getElementById('rbtn').disabled=false;
    }
}
//function hello()
//{
// console.log("Hellow world");

</script>
<body>
 <h1 class="h1">REGISTRATION</h1>
 <div class="register">
    <h4 style="color:red"> {{alert}}<h4>
    <form action="{{ url_for('register')}}" method="post">
       Email: <input type="email" name="email"
placeholder="ex:abc@gmail.com" required="required" autocomplete
/>
       Password: <input type="password" name="pswd" id="pswd"
placeholder="ex:abc@123" required="required" maxlength=15/>
    Confirm Password:<input type="password" name="cpswd"
id="cpswd" placeholder="re-enter same password"
required="required" oninput="confirmPass()" />
    <span id="error" style="color:#F00;"> </span>
       <button type="submit" class="btn btn-primary btn-block"
id="rbtn">Register</button>
    </form>
    <br>
    <br>
<a href="{{ url_for('main')}}"><button style="color:brown;
background-color:#29eed1;
border-color:green; height:50px;width:150px;position:relative;
margin-left:100px">Back</button></a>
   <br>
   <br>
    </div>
</body>
</html>

```

Cssstyle.css

```
@import url(https://fonts.googleapis.com/css?family=Open+Sans);
.btn { display: inline-block; *display: inline; *zoom: 1;
padding: 4px 10px 4px; margin-bottom: 0; font-size: 13px; line-
height: 18px; color: #333333; text-align: center;text-shadow: 0
```

```
   1px 1px rgba(255, 255, 255, 0.75); vertical-align: middle;
   background-color: #f5f5f5; background-image: -moz-linear-
   gradient(top, #ffffff, #e6e6e6); background-image: -ms-linear-
   gradient(top, #ffffff, #e6e6e6); background-image: -webkit-
   gradient(linear, 0 0, 0 100%, from(#ffffff), to(#e6e6e6));
   background-image: -webkit-linear-gradient(top, #ffffff, #e6e6e6);
   background-image: -o-linear-gradient(top, #ffffff, #e6e6e6);
   background-image: linear-gradient(top, #ffffff, #e6e6e6);
   background-repeat: repeat-x; filter:
   progid:dximagetransform.microsoft.gradient(startColorstr=#ffffff,
   endColorstr=#e6e6e6, GradientType=0); border-color: #e6e6e6
   #e6e6e6 #e6e6e6; border-color: rgba(0, 0, 0, 0.1) rgba(0, 0, 0,
   0.1) rgba(0, 0, 0, 0.25); border: 1px solid #e6e6e6; -webkit-
   border-radius: 4px; -moz-border-radius: 4px; border-radius: 4px;
   -webkit-box-shadow: inset 0 1px 0 rgba(255, 255, 255, 0.2), 0 1px
   2px rgba(0, 0, 0, 0.05); -moz-box-shadow: inset 0 1px 0 rgba(255,
   255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.05); box-shadow: inset
   0 1px 0 rgba(255, 255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.05);
   cursor: pointer; *margin-left: .3em; }
3  .btn:hover, .btn:active, .btn.active, .btn.disabled,
   .btn[disabled] { background-color: #e6e6e6; }
4  .btn-large { padding: 9px 14px; font-size: 15px; line-height:
   normal; -webkit-border-radius: 5px; -moz-border-radius: 5px;
   border-radius: 5px; }
5  .btn:hover { color: #333333; text-decoration: none; background-
   color: #e6e6e6; background-position: 0 -15px; -webkit-transition:
   background-position 0.1s linear; -moz-transition: background-
   position 0.1s linear; -ms-transition: background-position 0.1s
   linear; -o-transition: background-position 0.1s linear;
   transition: background-position 0.1s linear; }
6  .btn-primary, .btn-primary:hover { text-shadow: 0 -1px 0 rgba(0,
   0, 0, 0.25); color: #ffffff; }
7  .btn-primary.active { color: rgba(255, 255, 255, 0.75); }
8  .btn-primary { background-color: #4a77d4; background-image: -moz-
   linear-gradient(top, #6eb6de, #4a77d4); background-image: -ms-
   linear-gradient(top, #6eb6de, #4a77d4); background-image: -
   webkit-gradient(linear, 0 0, 0 100%, from(#6eb6de), to(#4a77d4));
   background-image: -webkit-linear-gradient(top, #6eb6de, #4a77d4);
   background-image: -o-linear-gradient(top, #6eb6de, #4a77d4);
   background-image: linear-gradient(top, #6eb6de, #4a77d4);
   background-repeat: repeat-x; filter:
   progid:dximagetransform.microsoft.gradient(startColorstr=#6eb6de,
   endColorstr=#4a77d4, GradientType=0);  border: 1px solid #3762bc;
   text-shadow: 1px 1px 1px rgba(0,0,0,0.4); box-shadow: inset 0 1px
   0 rgba(255, 255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.5); }
```

```
.btn-primary:hover, .btn-primary:active, .btn-primary.active, .btn-primary.disabled, .btn-primary[disabled] { filter: none; background-color: #4a77d4; }
.btn-block { width: 100%; display:block; }

* { -webkit-box-sizing:border-box; -moz-box-sizing:border-box; -ms-box-sizing:border-box; -o-box-sizing:border-box; box-sizing:border-box;}

html { width: 100%; height:150%;}

body {
    width: 100%;
    height:100%;
    font-family: 'Open Sans', sans-serif;
    background: #092756;
    color: #fff;
    font-size: 16px;
    text-align:center-left;
    letter-spacing:1.2px;
    background: -moz-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%),-moz-linear-gradient(top,  rgba(57,173,219,.25) 0%, rgba(42,60,87,.4) 100%), -moz-linear-gradient(-45deg,  #670d10 0%, #092756 100%);
    background: -webkit-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -webkit-linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -webkit-linear-gradient(-45deg,  #670d10 0%,#092756 100%);
    background: -o-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -o-linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -o-linear-gradient(-45deg,  #670d10 0%,#092756 100%);
    background: -ms-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -ms-linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -ms-linear-gradient(-45deg,  #670d10 0%,#092756 100%);
    background: -webkit-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), linear-gradient(to bottom,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), linear-gradient(135deg,  #670d10 0%,#092756 100%);
    filter: progid:DXImageTransform.Microsoft.gradient( startColorstr='#3E1D6D', endColorstr='#092756',GradientType=1 );

}
.login {
    position: absolute;
```

```
    top: 40%;
    left: 50%;
    margin: -150px 0 0 -150px;
    width:400px;
    height:400px;
}
body .logout {text-align:right;  color:#ffff;}
.h1 {font-size: 38px;color: #fff; text-shadow: 0 0 10px
rgba(0,0,0,0.3); letter-spacing:1px; text-align:center;margin-
left: 90px; }
body .origin{padding-bottom:10px}
body .dest{padding-bottom:10px}
body .btn{padding:20px}
input {
    width: 100%;
    margin-bottom: 10px;
    background: rgba(0,0,0,0.3);
    border: none;
    outline: none;
    padding: 10px;
    font-size: 13px;
    color: #fff;
    text-shadow: 1px 1px 1px rgba(0,0,0,0.3);
    border: 1px solid rgba(0,0,0,0.3);
    border-radius: 4px;
    box-shadow: inset 0 -5px 45px rgba(100,100,100,0.2), 0 1px
1px rgba(255,255,255,0.2);
    -webkit-transition: box-shadow .5s ease;
    -moz-transition: box-shadow .5s ease;
    -o-transition: box-shadow .5s ease;
    -ms-transition: box-shadow .5s ease;
    transition: box-shadow .5s ease;
}
input:focus { box-shadow: inset 0 -5px 45px
rgba(100,100,100,0.4), 0 1px 1px rgba(255,255,255,0.2); }

```

Lcssstyle.css

```
@import url(https://fonts.googleapis.com/css?family=Open+Sans);
.btn { display: inline-block; *display: inline; *zoom: 1;
padding: 4px 10px 4px; margin-bottom: 0; font-size: 13px; line-
height: 18px; color: #333333; text-align: center;text-shadow: 0
1px 1px rgba(255, 255, 255, 0.75); vertical-align: middle;
background-color: #f5f5f5; background-image: -moz-linear-
gradient(top, #ffffff, #e6e6e6); background-image: -ms-linear-
```

```
   gradient(top, #ffffff, #e6e6e6); background-image: -webkit-
   gradient(linear, 0 0, 0 100%, from(#ffffff), to(#e6e6e6));
   background-image: -webkit-linear-gradient(top, #ffffff, #e6e6e6);
   background-image: -o-linear-gradient(top, #ffffff, #e6e6e6);
   background-image: linear-gradient(top, #ffffff, #e6e6e6);
   background-repeat: repeat-x; filter:
   progid:dximagetransform.microsoft.gradient(startColorstr=#ffffff,
   endColorstr=#e6e6e6, GradientType=0); border-color: #e6e6e6
   #e6e6e6 #e6e6e6; border-color: rgba(0, 0, 0, 0.1) rgba(0, 0, 0,
   0.1) rgba(0, 0, 0, 0.25); border: 1px solid #e6e6e6; -webkit-
   border-radius: 4px; -moz-border-radius: 4px; border-radius: 4px;
   -webkit-box-shadow: inset 0 1px 0 rgba(255, 255, 255, 0.2), 0 1px
   2px rgba(0, 0, 0, 0.05); -moz-box-shadow: inset 0 1px 0 rgba(255,
   255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.05); box-shadow: inset
   0 1px 0 rgba(255, 255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.05);
   cursor: pointer; *margin-left: .3em; }
3  .btn:hover, .btn:active, .btn.active, .btn.disabled,
   .btn[disabled] { background-color: #e6e6e6; }
4  .btn-large { padding: 9px 14px; font-size: 15px; line-height:
   normal; -webkit-border-radius: 5px; -moz-border-radius: 5px;
   border-radius: 5px; }
5  .btn:hover { color: #333333; text-decoration: none; background-
   color: #e6e6e6; background-position: 0 -15px; -webkit-transition:
   background-position 0.1s linear; -moz-transition: background-
   position 0.1s linear; -ms-transition: background-position 0.1s
   linear; -o-transition: background-position 0.1s linear;
   transition: background-position 0.1s linear; }
6  .btn-primary, .btn-primary:hover { text-shadow: 0 -1px 0 rgba(0,
   0, 0, 0.25); color: #ffffff; }
7  .btn-primary.active { color: rgba(255, 255, 255, 0.75); }
8  .btn-primary { background-color: #4a77d4; background-image: -moz-
   linear-gradient(top, #6eb6de, #4a77d4); background-image: -ms-
   linear-gradient(top, #6eb6de, #4a77d4); background-image: -
   webkit-gradient(linear, 0 0, 0 100%, from(#6eb6de), to(#4a77d4));
   background-image: -webkit-linear-gradient(top, #6eb6de, #4a77d4);
   background-image: -o-linear-gradient(top, #6eb6de, #4a77d4);
   background-image: linear-gradient(top, #6eb6de, #4a77d4);
   background-repeat: repeat-x; filter:
   progid:dximagetransform.microsoft.gradient(startColorstr=#6eb6de,
   endColorstr=#4a77d4, GradientType=0);  border: 1px solid #3762bc;
   text-shadow: 1px 1px 1px rgba(0,0,0,0.4); box-shadow: inset 0 1px
   0 rgba(255, 255, 255, 0.2), 0 1px 2px rgba(0, 0, 0, 0.5); }
9  .btn-primary:hover, .btn-primary:active, .btn-primary.active,
   .btn-primary.disabled, .btn-primary[disabled] { filter: none;
   background-color: #4a77d4; }
10 .btn-block { width: 100%; display:block; }
```

```
11
12 * { -webkit-box-sizing:border-box; -moz-box-sizing:border-box; -
   ms-box-sizing:border-box; -o-box-sizing:border-box; box-
   sizing:border-box;}
13
14 html { width: 100%; height:100%;}
15
16 body {
17  width: 100%;
18  height:100%;
19  font-family: 'Open Sans', sans-serif;
20  background: #092756;
21  color: #fffff;
22  font-size: 16px;
23  text-align:center-left;
24  letter-spacing:1.2px;
25  background: -moz-radial-gradient(0% 100%, ellipse cover,
   rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%),-moz-linear-
   gradient(top,  rgba(57,173,219,.25) 0%, rgba(42,60,87,.4) 100%),
   -moz-linear-gradient(-45deg,  #670d10 0%, #092756 100%);
26  background: -webkit-radial-gradient(0% 100%, ellipse cover,
   rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -webkit-linear-
   gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -
   webkit-linear-gradient(-45deg,  #670d10 0%,#0756 100%);
27  background: -o-radial-gradient(0% 100%, ellipse cover,
   rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -o-linear-
   gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -
   o-linear-gradient(-45deg,  #670d10 0%,#092756 100%);
28  background: -ms-radial-gradient(0% 100%, ellipse cover,
   rgba(104,128,138,.4) 10%,rgba(138,114,76,0) 40%), -ms-linear-
   gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -
   ms-linear-gradient(-45deg,  #670d10 0%,#092756 100%);
29  background: -webkit-radial-gradient(0% 100%, ellipse cover,
   rgba(104,128,138,.4) 10%,rgba(192,192,192,0) 40%), linear-
   gradient(to bottom,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4)
   100%), linear-gradient(13deg,  #67d 0%,#1156 100%);
30  filter: progid:DXImageTransform.Microsoft.gradient(
   startColorstr='#c0c0c0', endColorstr='#092756',GradientType=1 );
31
32 }
33 .register {
34  position: absolute;
35  top: 40%;
36  left: 50%;
37  margin: -150px 0 0 -150px;
38  width:400px;
```

```
 height:400px;
}
.login {
 position: absolute;
 top: 40%;
 left: 50%;
 margin: -150px 0 0 -150px;
 width:400px;
 height:400px;
}
.h1 {font-size: 38px;color: #fff; text-shadow: 0 0 10px
rgba(0,0,0,0.3); letter-spacing:1px; text-align:center;margin-
left: 90px; }
body .origin{padding-bottom:10px}
body .dest{padding-bottom:10px}
body .btn{padding:20px}
input {
 width: 100%;
 margin-bottom: 10px;
 background: #ffff;
 border: none;
 outline: none;
 padding: 10px;
 font-size: 13px;
 color: #fffff;
 text-shadow: 1px 1px 1px rgba(0,0,0,0.3);
 border: 1px solid rgba(0,0,0,0.3);
 border-radius: 4px;
 box-shadow: inset 0 -5px 45px rgba(100,100,100,0.2), 0 1px 1px
rgba(255,255,255,0.2);
 -webkit-transition: box-shadow .5s ease;
 -moz-transition: box-shadow .5s ease;
 -o-transition: box-shadow .5s ease;
 -ms-transition: box-shadow .5s ease;
 transition: box-shadow .5s ease;
}
input:focus { box-shadow: inset 0 -5px 45px
rgba(100,100,100,0.4), 0 1px 1px rgba(255,255,255,0.2); }


```

mainpage.html

```
  <!DOCTYPE html>
<html >

```

```
<head>
  <meta charset="UTF-8">
  <title>ML API</title>
  <link href='https://fonts.googleapis.com/css?family=Pacifico' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Arimo' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Hind:300' rel='stylesheet' type='text/css'>
<link href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed:300' rel='stylesheet' type='text/css'>
<link rel="stylesheet" href="{{url_for('static',filename='cssstyle.css')}}">

</head>

<body>
<div class="logout" style="display : flex;
flex-direction: row-reverse";
>
<a href="{{ url_for('main')}}"><button>Logout</button></a>
</div>
 <h1 class="h1">Flight Delay Prediction</h1>

 <div class="login">
<!-- Main Input For Receiving Query to our ML -->
    <form action="{{ url_for('predict')}}" method="post">
       Quater of the year <input type="number" name="quater" placeholder="ex:3" required="required" min='1' max='4' />
       Month in number<input type="number" name="month" placeholder="ex:12" required="required" min='1' max='12'/>
   Day of the Month<input type="number" name="daym" placeholder="ex:28" required="required" min='1' max='31'/>
   Day of the week<input type="number" name="dayw" placeholder="ex:7" required="required" min='1' max='7'/>
       Flight Number<input type="number" name="fnum" placeholder="ex:2823" required="required" max="9999"/>

   Origin Airport: <select name="airport" class="origin">
      <option value='1'>ATL</option>
      <option value='2'>DWT</option>
      <option value='3'>JFK</option>
      <option value='4'>MSP</option>
      <option value='5'>SEA</option>
  </select><br><br>
```

```
39   Destination Airport: <select name="airportd" class="dest">
40       <option value='1'>ATL</option>
41       <option value='2'>DWT</option>
42       <option value='3'>JFK</option>
43       <option value='4'>MSP</option>
44       <option value='5'>SEA</option>
45   </select><br><br>
46   Planned Departure Time(format hhmm)<input type="number"
   name="dtime" placeholder="ex:1723" required="required"
   max="9999"/>
47   Planned Arrival Time(format hhmm)<input type="number"
   name="atime" placeholder="ex:2023" required="required"
   max="9999"/>
48   Estimated Traveling Time(in munites)<input type="number"
   name="ttime" placeholder="ex:180" required="required"
   max="9999"/>
49   Distance(in Kms)<input type="number" name="distance"
   placeholder="ex:2500" required="required"min='140' max="99999"/>
50         <button type="submit" class="btn btn-primary btn-
   block">Predict</button>
51     </form>
52  <br>
53    <br>
54    <br>
55 </div></body>
56 </html>
57
```

result.html

```
1  <html >
2  <head>
3    <meta charset="UTF-8">
4    <title>ML API</title>
5    <link href='https://fonts.googleapis.com/css?family=Pacifico'
   rel='stylesheet' type='text/css'>
6  <link href='https://fonts.googleapis.com/css?family=Arimo'
   rel='stylesheet' type='text/css'>
7  <link href='https://fonts.googleapis.com/css?family=Hind:300'
   rel='stylesheet' type='text/css'>
8  <link
   href='https://fonts.googleapis.com/css?family=Open+Sans+Condensed
   :300' rel='stylesheet' type='text/css'>
9  <link rel="stylesheet"
   href="{{url_for('static',filename='cssstyle.css')}}">
10
```

```
</head>

<body>
<div class="logout" style="display : flex;
flex-direction: row-reverse";
>
<a href="{{ url_for('main')}}"><button>Logout</button></a>
</div>
<br>
   <br>
   <br>
   <br>
   <h1 class="h1" style="text-align:center-left">{{
prediction_text }}</h1>

 <div class='prediction' style="display: flex; justify-
content:center; height:70px;">

   <a href="{{ url_for('home')}}"><button style="color:#f5f5dc;
background-color:green;border-color:green;
height:50px">Prediction dashboard</button></a>
    </div>
  <p style="color:#f7e98e; padding:15px;font-size:26px">we are
happy with your visit of our website and looking for your
feedback to improve our website  further.You can give your
feedback through below
       feedback button Or if you feel any inconvinence , raise
your complaint using complaint button  </p>
   <br>
   <br>
   <br>
   <br>
   <a href="https://forms.gle/U4yJaN9J9KmCDpQp9"><button
style="color:brown; background-color:#29eed1;
   border-color:green; height:50px;width:150px;position:relative;
   margin-left:100px">Feedback</button></a>
   <a href="https://forms.gle/6oy2KQn4VwQ1xjuAA"><button
style="color:brown; background-color:#29eed1;
   border-color:green; height:50px;width:150px;
   position:relative;
   left:67%">Complaint</button></a>
</body>
</html>

```

app_ibm.py

```
import numpy as np
import os
from flask import Flask, request, jsonify,
render_template,json,redirect,url_for,flash
import pickle
import requests
import sqlite3

# NOTE: you must manually set API_KEY below using information
retrieved from your IBM Cloud account.
API_KEY = "okbr7ARnOQjyplTOyvNFC2QVkCF6q7afpci065Hucby8"
token_response =
requests.post('https://iam.cloud.ibm.com/identity/token',
data={"apikey":
 API_KEY, "grant_type": 'urn:ibm:params:oauth:grant-
type:apikey'})
mltoken = token_response.json()["access_token"]

header = {'Content-Type': 'application/json', 'Authorization':
'Bearer ' + mltoken}
app = Flask(__name__)
app.secret_key="21433253"
model = pickle.load(open('rfmodel.pkl', 'rb'))
conn=sqlite3.connect("database1.db")
conn.execute("CREATE TABLE IF NOT EXISTS login(email TEXT PRIMARY
KEY,password TEXT)")
conn.close()

@app.route('/')
def main():
    return render_template('login.html')

@app.route('/login',methods=['POST','GET'])
def login():
    if request.method=='POST':
        try:
            fv=[x for x in request.form.values()]
            email=request.form["email"]
            pswd=request.form["pswd"]
            conn=sqlite3.connect("database1.db")
            cur=conn.cursor()
            cur.execute("SELECT password FROM login WHERE
email=?;",(str(email),))
            result=cur.fetchone()
            cur.execute("SELECT * FROM login")
            if result:
```

```
                if result[0]==pswd:
                    flash("login successfully",'success')
                    return redirect('/home')
                else:
                    return render_template("login.html",
  error="please enter correct password")

            else:
                print("register")
                flash("please Register",'danger')

                return
  render_template('register.html',alert="user not found,please
  register")

        except Exception as e:
            return "hello error"

@app.route('/reg')
def reg():
    return render_template("register.html")

@app.route('/register',methods=['POST','GET'])
def register():
    if request.method=='POST':
        try:
            fv=[x for x in request.form.values()]
            email=request.form["email"]
            pswd=request.form["pswd"]
            conn=sqlite3.connect("database1.db")
            cur=conn.cursor()
            cur.execute("SELECT * FROM login WHERE
  email=?;",(str(email),))
            result=cur.fetchone()
            if result:
                flash("user already exist,please login",'danger')
                return render_template('login.html',alert="user
  already exist,please login")
            else:
                cur.execute("INSERT INTO
  login(email,password)values(?,?)",(str(email),str(pswd)))
                conn.commit()
                cur.execute("SELECT * FROM login")
                flash("Registered successfully",'success')
```

```
                return render_template('login.html',message="Registered successfully,please login")

        except Exception as e:
            print(e)
            #flash(e,'danger')
            return "hello error1"


                #return redirect('/')
   # return render_template('login.html')
@app.route('/home')
def home():
    return render_template('mainpage.html')

@app.route('/predict',methods=['POST'])
def predict():
    '''
    For rendering results on HTML GUI
    '''
    sm=[6,7,8]
    wt=[9,10,11]
    sp=[12,1,2,3]
    fl=[4,5]
     farr= [int(x) for x in request.form.values()]
     if farr[1] in sm:
         farr.append(0)
     elif farr[1] in wt:
         farr.append(1)
     elif farr[1] in sp:
         farr.append(2)
     else:
         farr.append(3)
     final_features=[int(x) for x in farr]
     print(final_features)
     payload_scoring = {"input_data": [{"fields": [['QUARTER','MONTH','DAY_OF_MONTH','DAY_OF_WEEK','FL_NUM','ORIGIN','DEST','CRS_DEP_TIME.1','CRS_ARR_TIME.1','CRS_ELAPSED_TIME','DISTANCE','SEASON']], "values": [final_features]}]}

     response_scoring = requests.post('https://us-south.ml.cloud.ibm.com/ml/v4/deployments/b54f9857-1352-432a-8ab1-144ebda20501/predictions?version=2022-11-08', json=payload_scoring,headers={'Authorization': 'Bearer ' + mltoken})
```

```
    print("Scoring response")
    pred=response_scoring.json()
    print(pred)
    prediction=pred['predictions'][0]['values'][0][0]
    #prediction = model.predict([final_features])
    print(prediction)

    output =prediction

    if output==0:
        return render_template('result.html',
  prediction_text='No delay will happen {}'.format(output))
    elif output==1:
        return render_template('result.html',
  prediction_text='There is a chance to departure delay will happen
  {}'.format(output))
    elif output==2:
        return render_template('result.html',
  prediction_text='here is a chance to both departure and arrival
  delay will happen {}'.format(output))
    elif output==3:
        return render_template('result.html',
  prediction_text='here is a chance to flight  will diverted
  {}'.format(output))
    elif output==4:
        return render_template('result.html',
  prediction_text='here is a chance to cancel the flight
  {}'.format(output))
    else:
        return render_template('result.html',
  prediction_text='output {}'.format(output))
'''@app.route('/predict_api',methods=['POST'])
def predict_api():

    For direct API calls trought request

    data = request.get_json(force=True)
    prediction = model.predict([np.array(list(data.values()))])

    output = prediction[0]
    return jsonify(output)'''

if __name__ == "__main__":
    os.environ.setdefault('FLASK_ENV', 'development')
    app.run(debug=False)

```

GITHUB LINK

IBM-EPBL/IBM-Project-9686-1659068084: Developing a Flight Delay Prediction Model using Machine Learning (github.com)

click here for github repository

DEMO VIDEO LINK: click here for demo video link