

## Capstone Project

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## Flight Delay Prediction

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### Abstract:

The project proposal is designed for creating a machine learning model for predicting flight delay. So that ground staff and network team can plan for aircraft scheduling and ground handling staff and even passenger also can plan their journey accordingly. It will help flight operation and ground staff for ground handling and network operation. For achieving this goal, we are going to use Supervised Machine Learning.

Data for the flight delay and cancellation problem was collected and published by the DOT's Bureau of Transportation Statistics. This project will be implemented with the help of Scikit-learn, Tensorflow and Python.

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## Domain Background:

# Machine Learning Engineer Nanodegree



This project has been inherited from Airline Domain. In Airline, if you want travel or anyone who want to travel, he has to book the flight from one place to another.

There are number of factor, which can impact the flight journey like Weather, flight departure time, boarding gate time and actually departure time etc. Keeping these factor in mind, we can decide that particular aircraft can be landed or arrive on time or not or how much it will be delay.

Every airline has their flight history past journey, which can help them in predicting future flight delay. We can implement a machine learning model, which will help us in prediction of flight delay.

Motivation behind this project is to optimization of network operation, ground staff management and passenger.

## Problem Statement:

This problem is related to flight operation department of Airline Industry. Flight is flying from source to destination, sometimes it's reaching on time, sometime it reaching with some delay. This Delay in journey can impact many things like it can block airline's resource and in Respect to passenger, they can miss their meetings etc.

Flight delay prediction mean, how much time was estimated for journey and how much time actually aircraft took to reach from Origin to Destination.

It's a binary classification problem. We will classify that the upcoming flight will reach on time or will it be delay to reach at destination airport. For overcome this problem, we will drive a Supervised Classification Machine Learning.

## Dataset and Inputs:

Data for this ML problem provided by DOT's Bureau of Transportation Statistics. It's in CSV format. These CSV contains all the information related to airport, flight and airline, which is necessary to for it.

This corpus has 3 csv files.

- flights.csv
- airports.csv
- airline.csv

<https://www.kaggle.com/fabiendaniel/predicting-flight-delays-tutorial/data>

For model prediction we will use flights.csv. But for data insight we will use other two also.

## Flights.csv

This has all the data related to flight schedule from source to destination. It's containing 31 features with 5819079 sample. We will use **arrival\_delay** to drive final target feature like **flight\_delay**.

Feature Name	Data Type	Description
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YEAR	Integer	Year of travel
MONTH	Integer	Month of journey
DAY	Integer	Day of Journey
DAY OF WEEK	Integer	Day of week for given journey
AIRLINE	String	Name of Airline
FLIGHT NUMBER	String	Unique identifier of Flight
TAIL NUMBER	String	It Aircraft registration number.
ORIGIN AIRPORT	String	Source airport of journey
DESTINATION AIRPORT	String	Destination airport of journey
SCHEDULED_DEPARTURE	Float	Schedule departure time of aircraft
DEPARTURE TIME	Float	Actual departure time of aircraft
DEPARTURE_DELAY	Float	Actual Delay in departure of aircraft.
TAXI OUT	Float	Time to leave the gate
WHEELS OFF	Float	Wheels take off from runway.
SCHEDULED TIME	Float	Schedule take of time of wheels
ELAPSED TIME	Float	
AIR TIME	Float	Arrival time on airport
DISTANCE	Integer	Distance between ORIGIN AIRPORT and DESTINATION AIRPORT
WHEELS ON	Float	Landing time on runway
TAXI IN	Float	Reached on gate
SCHEDULED ARRIVAL	Float	Schedule time to reach on gate
ARRIVAL TIME	Float	Actual arrival time
<b>ARRIVAL_DELAY</b>	<b>Float</b>	<b>Arrival Delay of flight to reach the destination.</b>
DIVERTED	Boolean	Flight diverted in between journey to any other airport.
CANCELLED	Boolean	Particular flight got cancelled or not.
CANCELLATION_REASON	String	What was the reason of cancellation of flight?
AIR_SYSTEM_DELAY	Boolean	Air system issue.
SECURITY_DELAY	Boolean	Security issue
AIRLINE_DELAY	Boolean	Airline started delay
LATE_AIRCRAFT_DELAY	Boolean	Connecting flight delay
WEATHER_DELAY	Boolean	Weather issue

## Airline.csv

This csv contains information related to airline. It has 2 feature with 15 sample.

Feature Name	Data Type	Description
IATA_CODE	string	IATA Code for airline. It's unique identifier of airline
Airline	string	Airline Name

## Airport.csv

This csv contains information related to airport. It has 7 feature with 322 sample.

Feature Name	Data Type	Description
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IATA_CODE	String	IATA code for airport
AIRPORT	String	Airport name
CITY	String	Airport city
STATE	String	Airport belongs to which state.
COUNTRY	String	Country of airport
LATITUDE	Float	Geographical location of airport
LONGITUDE	Float	Geographical location of airport

## Solution Statement:

It's a binary classification problem. So for solving it, we will use Supervised Classification algorithms. But before applying algorithms we have to do the data pre-Processing.

1. Visualization (for getting data insight )
2. Missing value handling
3. Feature selection
4. Categorical and continues feature processing
5. Driving new features
6. Normalization

After Data Pre-Processing, as per thumb rule we need to divide data into train and test for ML Model training and validation. There are several algorithms for classification, we will apply some of them for predicting aircraft delay.

1. Linear Classifiers: Logistic Regression, Naive Bayes Classifier
2. Support Vector Machines
3. Decision Trees
4. Boosted Trees
5. Random Forest
6. Neural Networks
7. Nearest Neighbour

I am planning to train my model on Logistic Regression, SVM, Decision Tree and neural Networks. At the end on the bases of evaluation matrix, I will selected one model which will perform best for our problem.

## Benchmark Model:

Planning to use Logistic Regression to train and test flight delay prediction. And the output of logistic Regression, I will use as my benchmark model.

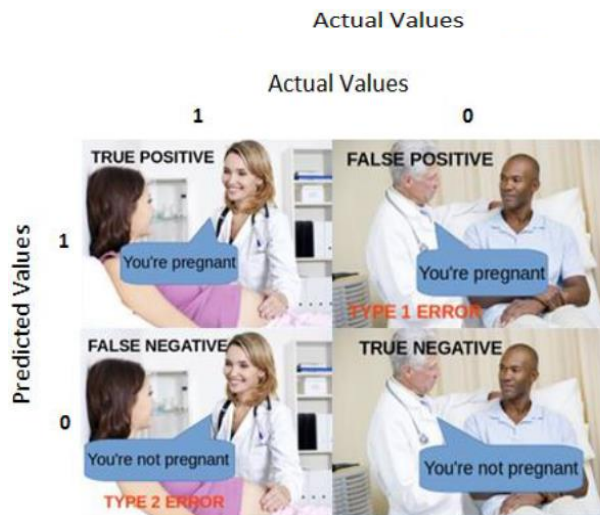
## Evaluation Metrics:

Evaluation or performance matrices, after features selection, features engineer, and model training. We need to test the performance of our model, there are couple of matrices to test the model performance or evaluation.

### Confusion Matrix

Confusion matrix is used for validating classification machine learning model. Its table representation of outcome.

		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN



## Accuracy

Accuracy is the measure of calculating that how often Machine learning Model is predicting correct

$$\text{Accuracy} = \frac{\text{Total Correctly classified}}{\text{Total Sample}}$$

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN}$$

## Precision

Precision is a measure that tells us what proportion of patients that we diagnosed as having cancer, actually had cancer.

$$\text{Precision} = \frac{TP}{TP + FP}$$

## Recall or Sensitivity

Proportion of correctly classified form the given positive sample.

$$\text{Recall} = \frac{TP}{TP + FN}$$

## Project Design:

Every Machine Learning Project have some steps to achieve the goal. Below the steps or action we need to perform for any ML project. I will follow the same for this project

## Language and Libraries

- Python 3.X
- Tensorflow
- Scikit-learn

## Data Collection

For implementing machine learning model, we need data. In this problem we will collect data in CSV format.

## Data Visualization

With the help of data visualization, we will try to get insight of data. In visualization, we can see the correlation in between features of dataset like HeatMap, Scatter plot.

## Feature Engineering

Feature engineering is a main step in ML model designing. In this we will do the feature analysis, which feature is more relevant and which are less impacting the outcome.

In feature Engineering, we will do feature normalization. So because of high magnitude one should not dominate another feature.

It very important step in machine learning model. It can drastically can impact model performance.

- [https://scikit-learn.org/stable/auto\\_examples/ensemble/plot\\_forest\\_importances.html](https://scikit-learn.org/stable/auto_examples/ensemble/plot_forest_importances.html)
- <https://machinelearningmastery.com/an-introduction-to-feature-selection/>
- <https://towardsdatascience.com/a-feature-selection-tool-for-machine-learning-in-python-b64dd23710f0>

## Train & Test Dataset

We will Split the dataset into train and test, Training set we will use for our training and testing set for model validation.

## Model Training

Training selected model on train dataset and validating on Training set.

## Model Testing

Testing is the process to test the model performance or accuracy on test data set.

(Validating overfitting and under fitting)

## Model Tuning

In tuning, we will try to tune our algorithms hyperparameter to get high accuracy and performance on test and train set with the help of GridSearch algorithm.

## Finalizing Model

Selecting best final model for production promote.

## Production Deployment

For production deployment we can use any Python framework, we will use Flask for your production deployment. We will create Rest Endpoint, So service will be available as rest API.

## References:

- <https://www.kaggle.com/c/flight-delays-spring-2018/data>
- <https://medium.com/greyatom/performance-metrics-for-classification-problems-in-machine-learning-part-i-b085d432082b>
- <https://www.dataschool.io/simple-guide-to-confusion-matrix-terminology/>
- [https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion\\_matrix.html](https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html)
- <https://www.quora.com/What-is-the-difference-between-the-project-background-problem-definition-aims-of-project-project-justification-and-scope-of-project>
- <https://towardsdatascience.com/understanding-confusion-matrix-a9ad42dcfd62>
- [https://en.wikipedia.org/wiki/Precision\\_and\\_recall](https://en.wikipedia.org/wiki/Precision_and_recall)
- <https://www.kaggle.com/c/flight-delays-fall-2018/kernels>
- <https://www.kaggle.com/c/flight-delays-prediction>
- <https://machinelearningmastery.com/data-leakage-machine-learning/>
- [https://scikit-learn.org/stable/auto\\_examples/ensemble/plot\\_forest\\_importances.html](https://scikit-learn.org/stable/auto_examples/ensemble/plot_forest_importances.html)