

# **PROJECT REPORT**

## **Developing A Flight Delay Prediction Model**

### **Using Machine Learning**

Submitted By

**PNT2022TMID04987**

KEERTHANAAANAND - 921319104097

INDHUJA B - 921319104064

INDHUMATHI S - 921319104065

JEYANTHI C - 921319104076

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# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 PROJECT OVERVIEW**

Over the last twenty years, air travel has been increasingly preferred among travelers, mainly because of its speed and in some cases comfort. This has led to phenomenal growth in air traffic and on the ground. An increase in air traffic growth has also resulted in massive levels of aircraft delays on the ground and in the air. These delays are responsible for large economic and environmental losses. The main objective of the model is to predict flight delays accurately in order to optimize flight operations and minimize delays.

Using a machine learning model, we can predict flight arrival delays. The input to our algorithm is rows of feature vectors like departure date, departure delay, distance between the two airports, scheduled arrival time etc. We then use a decision tree classifier to predict if the flight arrival will be delayed or not. A flight is considered to be delayed when the difference between scheduled and actual arrival times is greater than 15 minutes. Furthermore, we compare decision tree classifiers with logistic regression and a simple neural network for various figures of merit.

### **1.2 PURPOSE**

Prior prediction of flight arrival delays is necessary for both travelers and airlines because delays in flights not only trigger huge economic loss but also airlines end up losing their reputation that was built for several years and passengers lose their valuable time.

# **CHAPTER 2**

## **LITERATURE SURVEY**

### **2.1 EXISTING PROBLEM**

Flight scheduling, is one of the challenging issue in the Modern world, which is faced with many uncertain conditions. One of such conditions is delay, which comes from various factors and inflicts considerable cost on airlines, operators, and travelers. So, we are implemented flight delay prediction through some proposed approaches based on machine learning algorithms.

### **2.2 REFERENCES**

- [1] <https://doi.org/10.24200/sci.2017.20020> (Khaksar, H., & Sheikholeslami, A. (2017)).
- [2] <https://doi.org/10.1177/0361198120930014> (Esmaeilzadeh, E., & Mokhtarimousavi, S. (2020)).
- [3] <https://doi.org/10.5121/ijdkp.2018.8301>(M. Al-Tabbakh, S., M. Mohamed, H., & H. El, Z. (2018)).
- [4]<https://doi.org/10.3390/su12072749>(Ye, B., Liu, B., Tian, Y., & Wan, L. (2020)).
- [5]<https://doi.org/10.1016/j.tre.2019.03.013>(Yu, B., Guo, Z., Asian, S., Wang, H., & Chen, G. (2019)).
- [6]<https://doi.org/10.5772/9385> (Oladipupo, T. (2010)).
- [7] <https://doi.org/10.1186/s40537-020-00355-0>(Nibareke, T.,& Laassiri, J. (2020)).

### **2.3 PROBLEM STATEMENT DEFINITION**

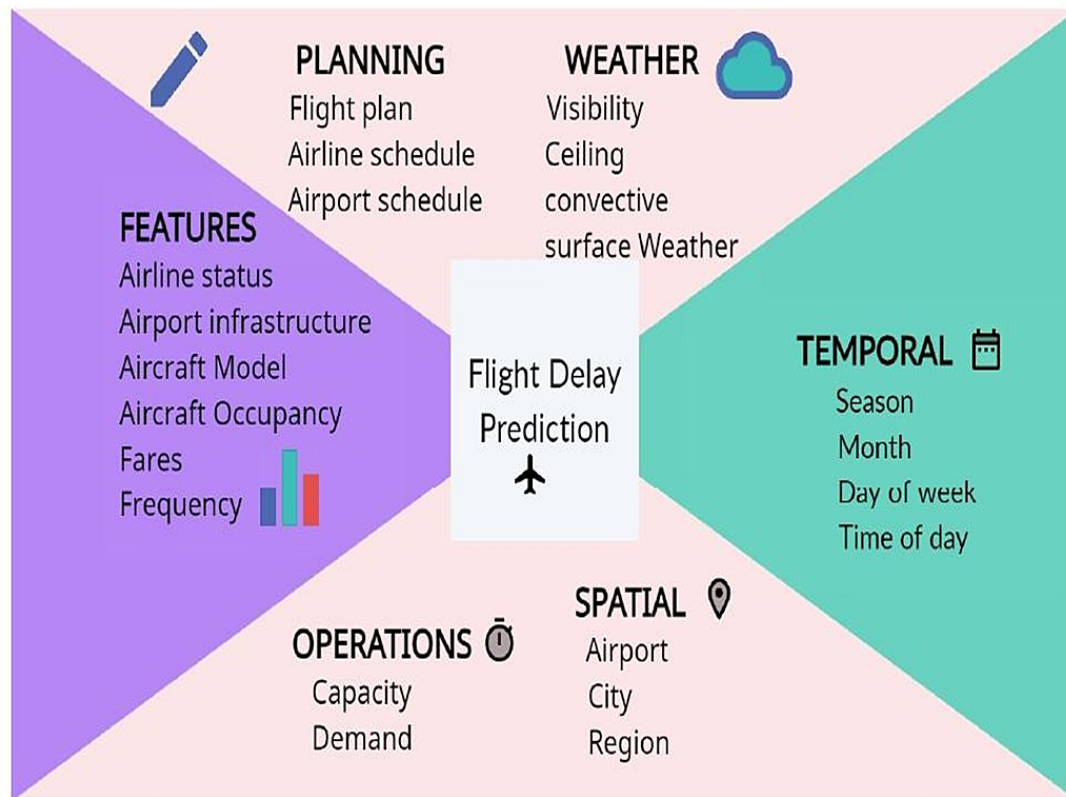
Throughout the year 2015, there has been over 5,4 million domestic flights within the US. All of their metadata are recorded and saved in the Department of Transportation's (DOT) Bureau of Transportation Statistics. Flight delays cause significant financial and other losses to airlines, airports, and passengers. Their prediction is crucial during the decision-making process for all players of American aviation industry. Therefore, predicting the likelihood of delay based on flights' features bridges an important information asymmetry between airlines and passengers.

# CHAPTER 3

## IDEATION AND PROPOSED SOLUTION

### 3.1 EMPATHY MAP CANVAS

#### EMPATHY MAP



### 3.2 IDEATION & BRAINSTORMING

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich amount of creative solutions.

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



### 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



#### 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 Superpowers to run a happy and productive session.

[Open article](#) →



#### Define your problem statement

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

🕒 5 minutes

PROBLEM

How might we [your  
problem statement]?



#### Key rules of brainstorming

To run a smooth and productive session



Stay in topic.



Encourage wild ideas.



Defer judgment.



Listen to others.



Go for volume.



If possible, be visual.

## 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 select a sticky note and hit the pencil [switch to sketch] icon to start drawing!

### Keerthanaa

|   |   |   |
|---|---|---|
| Communication loss due to poor connection           | Needed when there is heavy mist condition | Failures in ARTCC radars                              |
| TRACON's separation mislead                         | It affects mostly on Pilot                | Scured level of boundry                               |
| It affects mostly on passengers                     | Hospitality is greatly involved           | Sudden landing of flight in midway for emergency      |
| It occurs occasionally in emergency                 | During Takeoff and Descent                | Sometimes it may lead to time delay for co passengers |
| Business class may get affected by this             | Management is involved                    | Connecting passengers may take excess time            |
| It is usually seen during business hour or festives | In the midway of travel                   | It needs to be fixed as it takes much time            |

### Indhuja

|  |  |   |
|--|--|---|
| Increased turbulence may lead to Aircraft Damage                 | Passengers' lives are at risk  | Fog, Thunderstorm, Mist are some adverse weather conditions         |
| Results in Delayed Take-off                                      | Affects both Pilot and Passengers.   | Flights must be scheduled according to meteorological conditions.   |
| Affects the Pilot's Vision                                       | Impacts include Shattered windscreen, Jet engine ingestion, engine failure.                      | Airplane colors and jet engine spinner markings help to repel birds |
| Bird strikes occurs mostly during Landing Phase of the Flight    | Affects the aircraft parts such as engines and windscreen which may lead to unavoidable expenses | Bird strikes are minor damage but may pose threats to safety.       |
| Waiting for Crew will affect mainly the passengers' travel plans | May leads to ticket cancellation by customers  | A Backup Crew must be employed during the delay.                    |
| Crew held up in Traffic and Crew reported sick.                  | Delayed arrival of crew will affect the reputation of the Airline Company.                       | Resting periods for crew must be planned appropriately.             |

### Jeyanthi

|  |   |   |
|--|---|---|
| Delayed Catering results in unwanted expenses to airlines              | Results in Financial impact on airlines                     | Proper Schedule must be planned to avoid delays             |
| Happens because of late arrival of catering trucks                     | Best Catering firm must be employed by the airlines         | Have severe impacts on passengers' who have Health problems |
| Prolonged Security checks will results in Dissatisfaction of customers | Affects mainly the passengers                               | Does not affects the airlines in any manner                 |
| Occurs mainly due to security breach and terminal evacuation           | Occurs in airports which follows strict checking procedures | Impacts Travelers' plans                                    |
| Causes due to refueling, baggage loading etc.                          | Delays occurs mainly due to Transportation of fuel          | Proper maintenance and Cargo handling                       |
| Increased efficient of aircraft engines                                | Ideal Cleaning crew must be employed by airlines            | Will affects the trustworthiness of the airlines            |

### Indhumathi

|   |   |   |
|---|---|---|
| Cargo affects mostly on passengers  | Transportation department   | Loading and unloading of ULD                              |
| May get delayed by Customs  | Crew members are affected   | To balance the delay crew has to work on extra flights    |
| When there is need of immediate flight  | They could be over stressed due to this                           | Technical supporters are questioned                       |
| Fuel tank capacity need to be ensured   | Landing gear functions must be checked                            | Radars, safety measurements and ATC must be checked       |
| Overweight must be avoided  | Need to alarm before it crosses flight envelope                   | Should have proper power backups                          |
| Must have more ways for proper flight function when there is mechanical problem | It must recognize the problem and to work without any permissions | It must give alerts to ATC when there is any malfunctions |



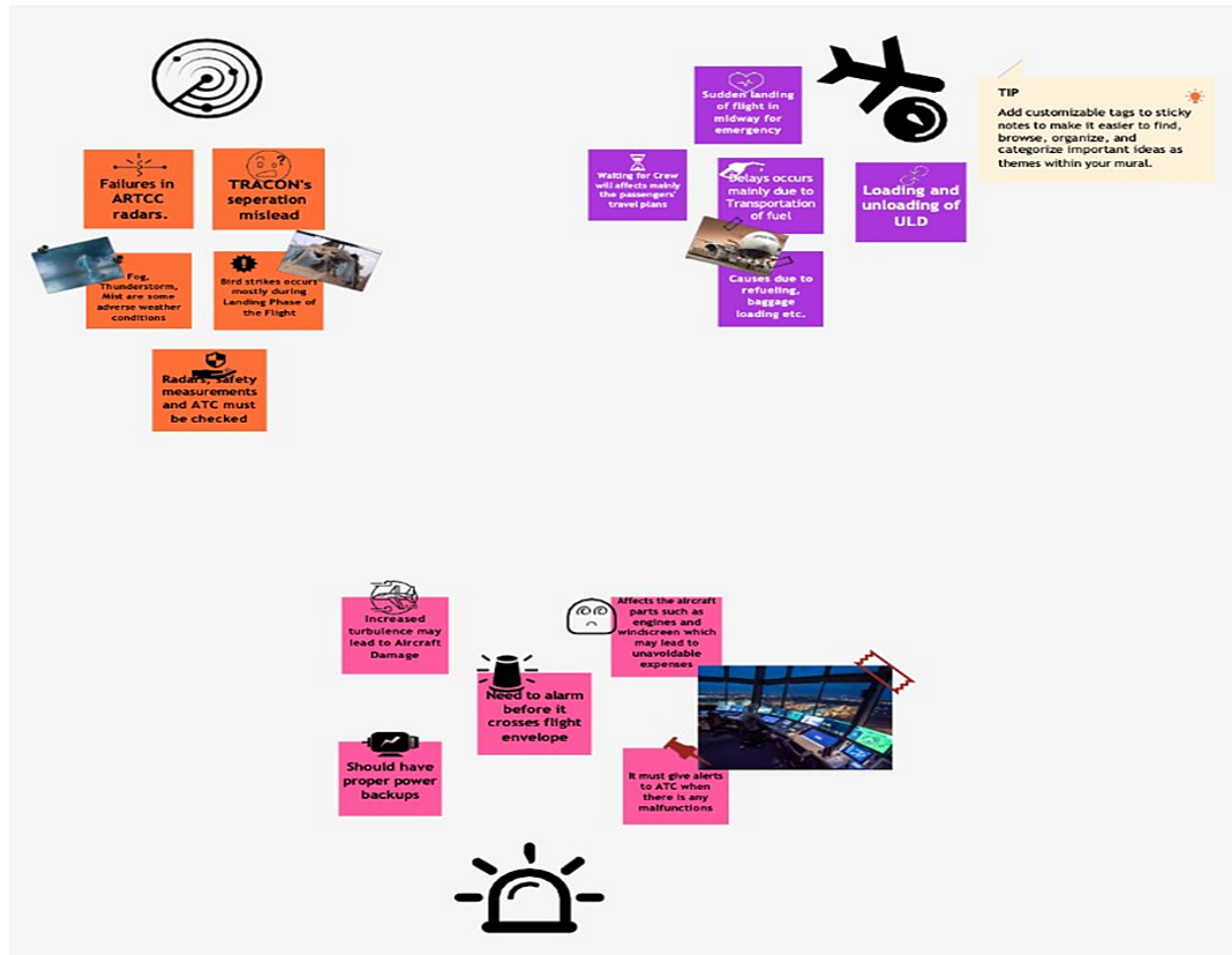
## GROUPING IDEAS:

3

### Group ideas

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

🕒 20 minutes



### 3.3 PROPOSED SOLUTION

| S.No | Parameters                               | Description  |
|------|--|--|
| 1.   | Problem Statement (Problem to be solved) | Predict the flight delay for the efficient transportation  |
| 2.   | Idea / Solution description              | To develop an ML model using deep learning to predict the delayed flight time and optimize flight operation              |
| 3.   | Novelty / Uniqueness                     | We are predicting the time varying parameters to predict the delayed flight with maximum accuracy using deep learning    |
| 4.   | Social Impact/ Customer Satisfaction     | It makes the air transportation more efficient and saves more time for the passengers                                    |
| 5.   | Business Model (Revenue Model)           | Using this model, we can create a revenue by giving appropriate solution about the delay to the people                   |
| 6.   | Scalability of the Solution              | This makes the people to take the action according to the delay and it improves time management, business value and more |

### 3.4 PROBLEM SOLUTION FIT

|   |  |  |
|---|--|--|
| <p><b>1. CUSTOMER SEGMENT(S)</b><br/>Who is your customer?</p> <p>Customers will be able to know the flight delay in prior so that they can plan accordingly.</p> | <p><b>6. CUSTOMER CONSTRAINT.</b><br/>What constraint prevents your customer from taking action or limiting their choice of solution?</p> <p>Time is precious in a every human's life.</p> | <p><b>5. AVAILABLE SOLUTION</b><br/>Which solutions are available to the customer when they face the problem.</p> <p>We gather resources from the international and domestic airlines.</p> |
|---|--|--|

|   |  |  |  |
|---|--|--|--|
| <p><b>1. TRIGGERS</b><br/>What triggers customers to act.</p> <p>a. Customers get to know the absolute recommendation and attention to their need</p> | <p><b>1. YOUR SOLUTION</b><br/>Our solution involves autonomous system which does the following:</p> <p>a. A personal Help desk which can be accessed through all the devices which are compatible with browser.</p> <p>b. Customers can post their queries in the new thread section.</p> | <p>○ For a new query they need an online connectivity to post and receive recommendation from our team.</p> <p>○ They can also use our chatbot 24/7W</p> |  |
|---|--|--|--|

|   |  |   |  |
|---|--|---|--|
| <p>d.</p> <p>b. Fast Response.</p>  | <p>c. They can also access the FAQ's Section to see if the problem is already listed</p> <p>d. They can also view their results progress through their mails.</p> <p>e. They will get support from the team until the problem gets resolved.</p> | <p>hile they are in online.</p> <p><b>OFFLINE</b></p> <ul style="list-style-type: none"> <li>○ They can Read them messages once it is received through the cloud app.</li> <li>○ They can access FAQ's while they are offline.</li> </ul> |  |
| <p><b>1. EMOTIONS: BEFORE/AFTER</b></p> <p><b>How do customers feel when they face a problem or a job and afterwards.</b></p> <p>a. Enables Customers to Trust to their agent about posting their personal informations.</p> <p>b. Feeling comfortable with the solution and the company's service.</p> |  |   |  |

# **CHAPTER 4**

## **REQUIREMENT ANALYSIS**

### **4.1 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<br>Registration through Gmail<br>Registration through LinkedIn  |
| FR-2   | User Confirmation            | Confirmation via Email Confirmation via<br>OTP  |
| FR-3   | User requirements            | Collecting informations like date of travel,<br>departing & arrival destination, flight number<br>or booking number, etc for providing the status<br>of the flight. |
| FR-4   | User friendliness            | This system is easy to learn and understand.  |

## 4.2 NON FUNCTIONAL REQUIREMENTS

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

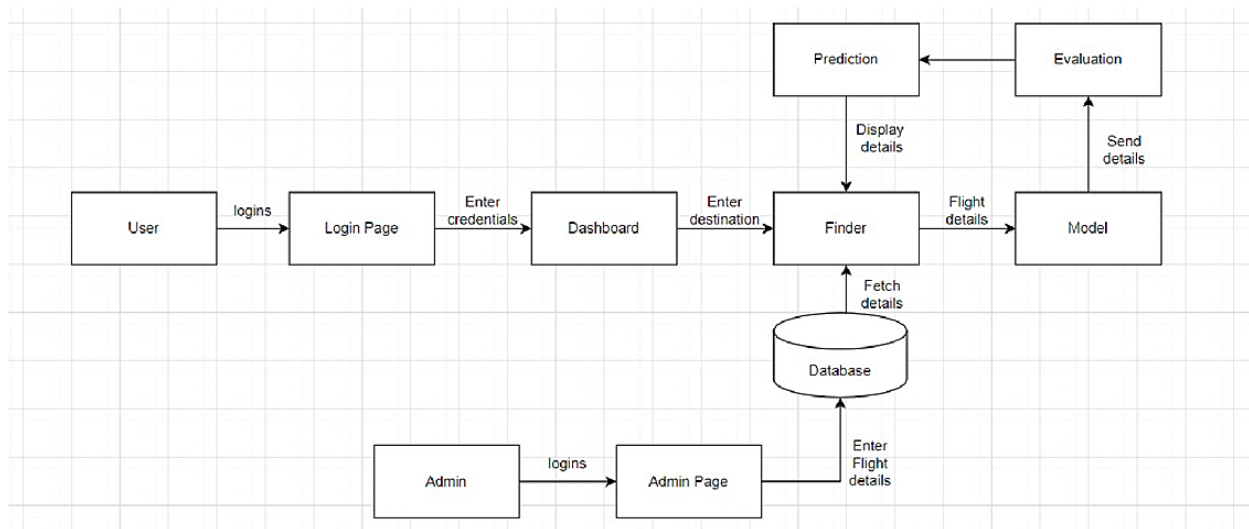
| FR No. | Non-Functional Requirement | Description   |
|--------|----------------------------|---|
| NFR-1  | <b>Usability</b>           | How easy is it for a customer to use the system?  |
| NFR-2  | <b>Security</b>            | <b>Security's</b> part will be protected against malware attacks or unauthorized access. But there's a catch. The lion's share of security non-functional requirements can be translated into concrete functional counterparts. If you want to protect the admin panel from unauthorized access, you would define the login flow and different user roles as system behavior or user actions.   |
| NFR-3  | <b>Reliability</b>         | <b>Reliability</b> specifies how likely the system or its element would run without a failure for a given period of time under predefined conditions.<br>Traditionally, this probability is expressed in percentages. For instance, if the system has 85 percent reliability for a month, this means that during this month, under normal usage conditions, there's an 85 percent chance that the system won't experience critical failure. |

|       |                    |  |
|-------|--------------------|--|
| NFR-4 | <b>Performance</b> | <b>Performance</b> defines how fast a software system or a particular piece of it responds to certain users' actions under a certain workload. In most cases, this metric explains how long a user must wait before the target operation happens (the page renders, a transaction is processed, etc.) given the overall number of users at the moment. But it's not always like that. Performance requirements may describe background processes invisible to users, e.g. backup. But let's focus on user-centric performance. |
|-------|--------------------|--|

# CHAPTER 5

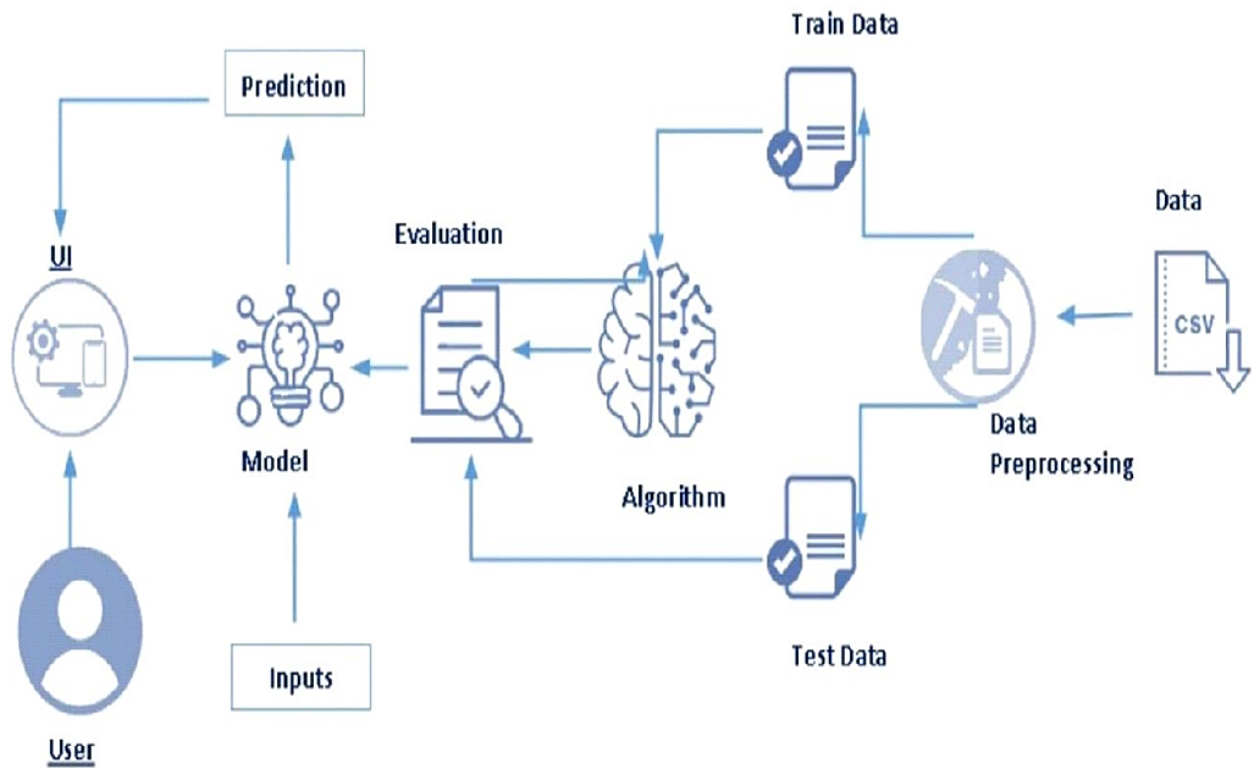
## PROJECT DESIGN

### 5.1 DATA FLOW DIAGRAM





## 5.2 SOLUTION & TECHNICAL ARCHITECTURE



# CHAPTER 6

## PROJECT PLANNING AND SCHEDULING

### 6.1 SPRINT PLANNING AND ESTIMATION

| Sprint   | Functional Requirement (Epic) | User Story Number | User Story / Task  | Story Points | Priority | Team Members   |
|----------|-------------------------------|-------------------|--|--------------|----------|--|
| Sprint 1 | Data Collection               | USN-1             | As a user, I can collect the dataset from various resources with different flight models                         | 10           | Low      | Keerthaaanand<br>Indhuja B                               |
| Sprint 1 | Data Preprocessing            | USN-2             | As a user, I can load the dataset, handling the missing data, scaling and split data into train and test.        | 10           | Medium   | Indhumathi S<br>Jeyanthi C                               |
| Sprint 2 | Model Building                | USN-3             | As a user, I will get an application with ML model which provides high accuracy of recognized handwritten digit. | 5            | High     | Keerthaaanand<br>Indhuja B<br>Indhumathi S<br>Jeyanthi C |
| Sprint 2 | Add CNN layers                | USN-4             | Creating the model and adding the input, hidden, and output layers to it.  | 5            | High     | Keerthaaanand<br>Indhuja B<br>Indhumathi S<br>Jeyanthi C |

|          |                     |       |   |   |        |  |
|----------|---------------------|-------|---|---|--------|--|
| Sprint 2 | Compiling the model | USN-5 | With both the training data defined and model defined, it's time to configure the learning process. | 2 | Medium | Keerthaaanand<br>Indhuja B<br>Indhumathi S<br>Jeyanthi C |
|----------|---------------------|-------|---|---|--------|--|

| Functional Requirement (Epic) | User Story Number | User Story / Task  | Story Points | Priority | Team Members                               |
|-------------------------------|-------------------|--|--------------|----------|--|
| Train & test the model        | USN-6             | As a user, let us train our model with our image dataset.  | 6            | Medium   | Keerthaaanand<br>Indhuja B<br>Indhumathi S |
| Save the model                | USN-7             | As a user, the model is saved integrated with an android application or web application in order to predict something. | 2            | Low      | Jeyanthi C                                 |

|                         |        |   |    |        |  |
|-------------------------|--------|---|----|--------|--|
| Building UI Application | USN-8  | As a user, I will upload the flight model image to the application by clicking a upload button. | 5  | High   | Indhuja B<br>Indhumathi S<br>Jeyanthi C                      |
|                         | USN-9  | As a user, I can know the details of the fundamental usage of the application.                  | 5  | Low    | Keerthaaana<br>nd  |
|                         |        | er, I can see<br>ected /<br>zeddigits in<br>ication.  | 5  | Medium | Indhuja B<br>Indhumathi S                                    |
| Train the model on IBM  | USN-11 | As a user, I train the model on IBM and integrate flask with scoring end point.                 | 10 | High   | Keerthaaana<br>nd<br>Indhuja B<br>Indhumathi S<br>Jeyanthi C |

## 6.2 SPRINT DELIVERY SCHEDULE

| <b>Sprint</b> | <b>Total Story Points</b> | <b>Duration</b> | <b>Start Date</b> | <b>Sprint End Date (Planned)</b> | <b>Story Points Completed (as on Planned End Date)</b> | <b>Sprint Released Date (Actual)</b> |
|---------------|---------------------------|-----------------|-------------------|----------------------------------|--|--------------------------------------|
| Sprint1       | 20                        | 6 Days          | 29 Oct 2022       | 29 Oct 2022                      | 20   | 29 Oct 2022                          |
| Sprint2       | 20                        | 6 Days          | 05 Nov 2022       | 05 Nov 2022                      | 20   | 05 Nov 2022                          |
| Sprint3       | 20                        | 6 Days          | 07 Nov 2022       | 12 Nov 2022                      | 20   | 12 Nov 2022                          |
| Sprint4       | 20                        | 6 Days          | 14 Nov 2022       | 19 Nov 2022                      | 20   | 19 Nov 2022                          |

# CHAPTER 7

## CODING & SOLUTIONING

```
<html>
<head>
<meta name="viewport" content="width=device-width, initial-scale=1">

<style>
h2 {text-align: center;}
* {
box-sizing: border-box;
}
body{
font-family: Arial, Helvetica, sans-serif;
background-image: url('https://www.teahub.io/photos/full/17-171442_airplane-desktop-
wallpaper-data-src-airplane-wallpapers-transparent.jpg');
background-size: cover;
background-attachment: fixed;
}
input[type=text], select, textarea {
width: 100%;
padding: 12px;
border: 1px solid #ccc;
border-radius: 4px;
resize: vertical;
}
label {
padding: 12px 12px 12px 0;
```

```

display: inline-block;
}
input[type=submit] {
background-color: #04AA6D;
color:white;
padding: 12px 20px;
border: none;
border-radius: 4px;
cursor: pointer;
float: right;
}
input[type=submit]:hover {
background-color: #45a049;
}
.container {
border-radius: 5px;
background-color:transparent;
padding: 20px;
}
.col-25 {
float: left;
width: 25%;
margin-top: 6px;
}
.col-75 {
float: left;
width: 75%;
margin-top: 6px;
}
/* Clear floats after the columns */
.row:after {
content: "";

```

```

display: table;
clear: both;
}
</style>
</head>
<body>
<h2 style="color: #ebf7f3">Prediction of flight delay</h2>
<div class="container">
<form action="/action_page.php">
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Enter flight Number</label>
</div>
<div class="col-75">
<input type="text" id="fname" numbers="flight number" placeholder="flight
number..">
</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Month</label>
</div>
<div class="col-75">
<input type="text" id="" name="month" placeholder="month..">
</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Date of month</label>
</div>
<div class="col-75">

```



```

<input type="text" id="" name="Month" placeholder="Date of month..">

</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Day of week</label>
</div>
<div class="col-75">
<input type="calender" id="fname" numbers="Day of week"
placeholder="Day of week..">
</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Origin</label>
</div>
<div class="col-75">
</div>
<div class="col-25">
<select id="country" name="origin">
<option value="region">click here</option>
<option value="region">COK</option>
<option value="region">MAA</option>
<option value="region">JFK</option>

<option value="region">DXB</option>
</select>
</div>
</div>
<div class="row">
<div class="col-25">

```

```

<label style="color: #ebf7f3">Destination</label>
</div>
<div class="col-75">
</div>
<div class="col-25">
<select id="region" name="origin">
<option value="region">click here</option>
<option value="region">COK</option>
<option value="region">MAA</option>
<option value="region">JFK</option>

<option value="region">DXB</option>
</select>
</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Scheduled Departure Time</label>
</div>
<div class="col-75">
<input type="time" id="fname" numbers="predict" placeholder="scheduled
Departure Time..">
</div>

<div class="row">
<div class="col-25">
<label style="color: #ebf7f3"> Scheduled Arrival Time</label>
</div>
<div class="col-75">
<input type="time" id="fname" numbers="predict" placeholder="Arrival
Departure Time..">

```

```
</div>
</div>
<div class="row">
<div class="col-25">
<label style="color: #ebf7f3">Actual Departure Time</label>
</div>
<div class="col-75">
<input type="time" id="fname" numbers="predict" placeholder="..">
</div>
</div>
</div>
<div class="row">
<a href ="exe.html"><h4>SUBMIT</h4></a>
</div>
</form>
</div>
</body>
</html>
```

# CHAPTER 8

## TESTING

### 8.1 TEST CASES

| Test case ID | Feature    | Component   | Scenario                                     | Expected Result                            | Actual Result       | Status |
|--------------|------------|-------------|--|--|---------------------|--------|
| HP_TC_001    | UI         | Home Page   | Elements in the Home Page                    | The Home page must be displayed properly   | Working as expected | PASS   |
| BE_TC_001    | Functional | Backend     | Check if all the routes are working properly | All the routes should properly work        | Working as expected | PASS   |
| RP_TC_001    | UI         | Result Page | Verify UI elements in the Result Page        | The Result page must be displayed properly | Working as expected | PASS   |

## 8.2 USER ACCEPTANCE TESTING

### 8.2.1 DEFECT ANALYSIS

| Resolution     | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Total |
|----------------|------------|------------|------------|------------|-------|
| By Design      | 1          | 0          | 1          | 0          | 2     |
| Duplicate      | 0          | 0          | 0          | 0          | 0     |
| External       | 0          | 0          | 2          | 0          | 2     |
| Fixed          | 4          | 1          | 0          | 1          | 6     |
| Not Reproduced | 0          | 0          | 0          | 1          | 1     |
| Skipped        | 0          | 0          | 0          | 1          | 1     |
| Total          | 5          | 1          | 3          | 3          | 12    |

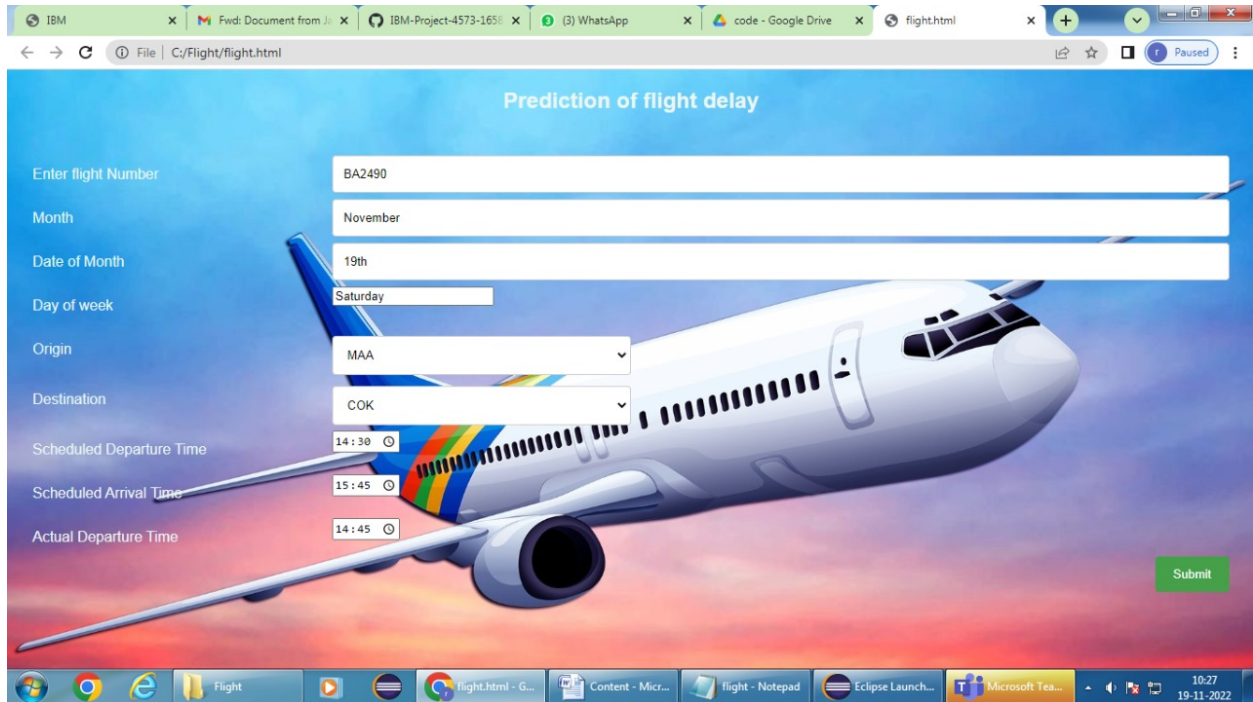
### 8.2.2 TEST CASE ANALYSIS

| Section             | Total Cases | Not Tested | Fail | Pass |
|---------------------|-------------|------------|------|------|
| Client Application  | 10          | 0          | 3    | 7    |
| Security            | 2           | 0          | 1    | 1    |
| Performance         | 3           | 0          | 1    | 2    |
| Exception Reporting | 2           | 0          | 0    | 2    |

# CHAPTER 9

## RESULTS

### 9.1 PERFORMANCE METRICS



The screenshot displays a web browser window with the address bar showing 'File | C:/Flight/flight.html'. The browser tabs include 'IBM', 'Fwd: Document from...', 'IBM-Project-4573-165...', '(3) WhatsApp', 'code - Google Drive', and 'flight.html'. The web application has a blue header with the title 'Prediction of flight delay'. The form contains the following fields:

- Enter flight Number: BAZ490
- Month: November
- Date of Month: 19th
- Day of week: Saturday
- Origin: MAA (dropdown menu)
- Destination: COK (dropdown menu)
- Scheduled Departure Time: 14:30 (clock icon)
- Scheduled Arrival Time: 15:45 (clock icon)
- Actual Departure Time: 14:45 (clock icon)

A green 'Submit' button is located at the bottom right of the form. The background of the form features a large image of a white airplane with a rainbow-colored tail, flying against a blue sky with a sunset or sunrise gradient. The Windows taskbar at the bottom shows the following icons: Windows Start button, Google Chrome, Microsoft Edge, File Explorer (Flight), VLC media player, flight.html - Google, Content - Microsoft, flight - Notepad, Eclipse Launch..., and Microsoft Teams. The system clock in the bottom right corner shows the time as 10:27 and the date as 19-11-2022.

# **CHAPTER 10**

## **ADVANTAGES & DISADVANTAGES**

### **ADVANTAGES**

- Reduces manual work
- More accurate than average human
- Capable of handling a lot of data
- Can be used anywhere from any device

### **DISADVANTAGES**

- Cannot handle complex data
- All the data must be in digital format
- Requires a high performance server for faster predictions
- Prone to occasional errors

# **CHAPTER 11**

## **CONCLUSION**

This project demonstrated a web application that uses machine learning to recognise handwritten numbers. Flask, HTML, CSS, JavaScript, and a few other technologies were used to create this project. The model predicts the handwritten digit using a CNN network. During testing, the model achieved a 99.61% recognition rate. The proposed project is scalable and can easily handle a huge number of users. Since it is a web application, it is compatible with any device that can run a browser. This project is extremely useful in real-world scenarios such as recognizing number plates of vehicles, processing bank cheque amounts, numeric entries in forms filled up by hand (tax forms) and so on. There is so much room for improvement, which can be implemented in subsequent versions.



## **CHAPTER 12**

### **FUTURE SCOPE**

This project is far from complete and there is a lot of room for improvement. Some of the improvements that can be made to this project are as follows:

- Add support to detect from digits multiple images and save the results
- Add support to detect multiple digits
- Improve model to detect digits from complex images
- Add support to different languages to help users from all over the world

This project has endless potential and can always be enhanced to become better. Implementing this concept in the real world will benefit several industries and reduce the workload on many workers, enhancing overall work efficiency.

# APPENDIX

## SOURCE CODE

### MODEL CREATION

```
import numpy as np
import tensorflow #open source used for both ML and DL for computation
from tensorflow.keras.datasets import mnist #mnist dataset
from tensorflow.keras.models import Sequential #it is a plain stack of layers
from tensorflow.keras import layers #A Layer consists of a tensor-in tensor-out computation function
from tensorflow.keras.layers import Dense, Flatten #Dense-Dense Layer is the regular deeply connected r
#flatten -used for flattening the input or change the dimension
from tensorflow.keras.layers import Conv2D #convolutional Layer
from keras.utils import np_utils #used for one-hot encoding
import matplotlib.pyplot as plt #used for data visualization
```

```
(x_train, y_train), (x_test, y_test)=mnist.load_data () #splitting the mnist data into train and test
```

Downloading data from <https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz>  
11490434/11490434 [=====] - 0s 0us/step

```
print (x_train.shape) #shape is used for give the dimension values #60000-rows 28x28-pixels
print (x_test.shape)
```

```
(60000, 28, 28)
(10000, 28, 28)
```

```
#Reshaping to format which CNN expects (batch, height, width, channels)
x_train=x_train.reshape (60000, 28, 28, 1).astype('float32')
x_test=x_test.reshape (10000, 28, 28, 1).astype ('float32')
```

## **Project Demo Video**

[https://drive.google.com/file/d/1e3Uix6v6VNxalr5CpLPDKz-ewPfZDW7e/view?usp=share\\_link](https://drive.google.com/file/d/1e3Uix6v6VNxalr5CpLPDKz-ewPfZDW7e/view?usp=share_link)

