

Data Analytics on Indigo Airlines' Business Model

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Description

Project Title: Data Analytics on Indigo Business Model

This project aims to analyse the operational strategies and performance of Indigo Airlines using real-world aviation data. By studying air traffic patterns, sector-wise demand, and market share metrics, the goal is to gain a deeper understanding of the factors contributing to Indigo's dominance in the Indian aviation industry.

Data & Problem Context

Problem Statement:

Indigo Airlines holds the largest market share in India's aviation sector. To

sustain and strengthen this position, it is crucial to understand the factors driving its success. This project addresses:

- Top-performing air travel sectors in India
- Sectors with increasing future demand
- Airlines likely to grow based on market share
- Impact of delays on operations
- Data-driven insights into Indigo's new route decisions

Purpose & Outcome:

To create an interactive, modular data analytics app capable of delivering visual insights into key aviation metrics. The goal is to support business decisions using data.

Benefits:

- Improved sector targeting
- Demand forecasting for route expansion
- Competitive benchmarking among airlines
- GUI-based visualization for enhanced user interaction

Plan

- Gather relevant datasets from DGCA & Kaggle
- Preprocess and clean the data
- Analyze traffic and market trends
- Build GUI for user interaction
- Generate outputs for each major insight
- Add delay pattern module for extended analysis

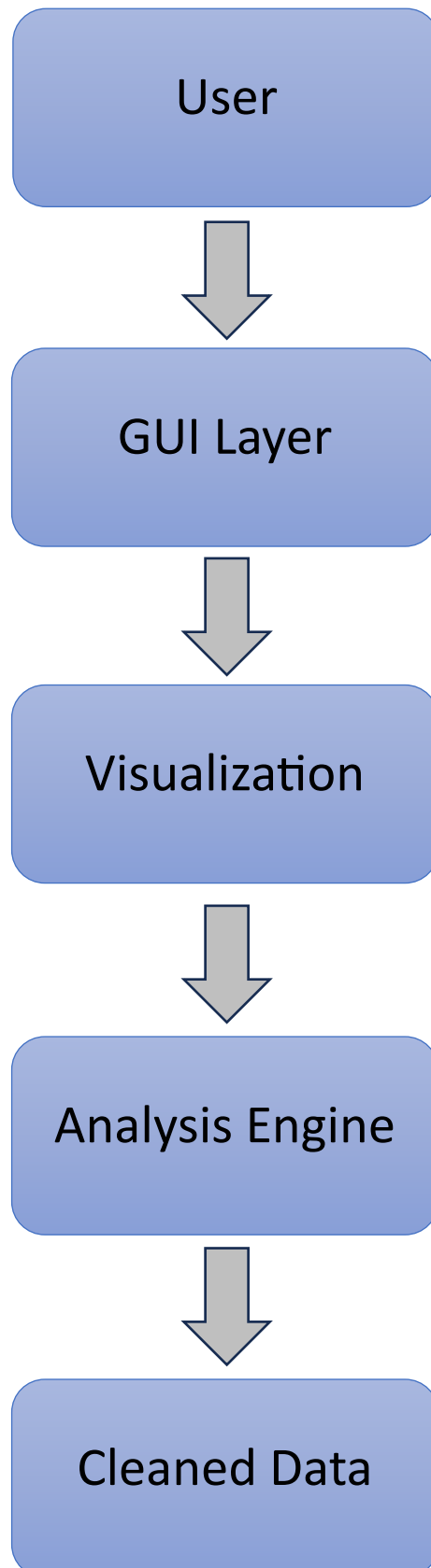
Design

Modular Structure:

- **DataLoader Module:** Reads and cleans raw data

- **Analysis Module:** Core analytics (sectors, trends, shares)
- **Visualization Module:** Plot diagrams via matplotlib
- **GUI Module:** User interface via Tkinter

Data Flow Diagram (DFD)



Implementation

Technologies Used:

- **Language:** Python
- **Libraries:** pandas, numpy, matplotlib, seaborn, tkinter
- **Paradigm:** Object-Oriented Programming
- **Data Sources:**
 - Directorate General of Civil Aviation (DGCA)
 - Kaggle (open-source datasets)

Features:

- Sector-wise traffic analysis
- Forecast model for demand growth
- Airline market share charts
- Delay analysis for punctuality insights
- Tkinter-based interactive GUI

Code with Explanation

DataLoader Code:

```
data_loader.py 1 • analysis_engine.py visualization.py 5 menu.py test.py
data_loader.py > DataLoader > load_data
1  """
2  Loads, cleans, and prepares three datasets:
3  - city.csv (route and passenger data)
4  - carrier.csv (airline performance data)
5  - delay.csv (flight delay statistics, optional)
6
7  """
8
9
10 import pandas as pd
11
12 class DataLoader:
13     def __init__(self, city_path, carrier_path, delay_path = None): # Initialize paths and DataFrame placeholders
14         self.city_path = city_path
15         self.carrier_path = carrier_path
16         self.delay_path = delay_path
17         self.city_df = None
18         self.carrier_df = None
19         self.delay_df = None
20
21     def load_data(self): # Load city, delay and carrier datasets from CSV
22         self.city_df = pd.read_csv("D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/city.csv")
23         self.carrier_df = pd.read_csv("D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/carrier.csv")
24         print("City data loaded successfully")
25         print(self.city_df.head())
26         print("Carrier data loaded successfully")
27         print(self.carrier_df.head())
28
29         if self.delay_path:
30             self.delay_df = pd.read_csv(self.delay_path)
31             print("Delay data loaded successfully")
32             print(self.delay_df.head())
```

```
data_loader.py 1 • analysis_engine.py visualization.py 5 menu.py test.py
data_loader.py > DataLoader > load_data
12 class DataLoader:
34
35     def clean_data(self): # Clean .csv files: handle missing values, drop irrelevant columns, rename headers
36
37         # Cleaning of city.csv
38
39         print("Missing values in city data")
40         print(self.city_df.isnull().sum())
41
42         # Drop unnecessary freight/mail-related columns
43
44         self.city_df.dropna(inplace=True)
45         print("Cleaned city data, missing rows are dropped")
46
47         self.city_df.drop(columns = ["FreightToCity2", "FreightFromCity2",
48                                     "MailToCity2", "MailFromCity2"], inplace=True)
49
50         print(self.city_df.columns)
51         # Rename columns for clarity and consistency
52
53         self.city_df.rename(columns={"City1": "Origin",
54                                     "City2": "Destination",
55                                     "Passengers": "Passenger_Count"}, inplace=True)
56
57         # Cleaning of carrier.csv
58
59         print("Missing values in carrier data")
60         print(self.carrier_df.isnull().sum())
61
62         self.carrier_df.dropna(inplace=True)
63
64         # Drop aircraft/freight/cargo columns that aren't used in analysis
65
66
```

```
data_loader.py 1 • analysis_engine.py visualization.py 5 menu.py test.py
data_loader.py > DataLoader > load_data
12 class DataLoader:
35     def clean_data(self): # Clean .csv files: handle missing values, drop irrelevant columns, rename headers
66
67         self.carrier_df.drop(columns = ["Aircraft Hours", "Aircraft Kilometres", "Seat Kilometers",
68                                         "Freight", "Mail", "Total Cargo",
69                                         "Passenger Tonne Kilometer", "Mail Tonne Kilometer", "Freight Tonne Kilometer",
70                                         "Total Tonne Kilometer", "Available Tonne Kilometer", "Weight Load Factor"], inplace=True)
71
72         # Rename columns for consistency and better readability
73         (variable) carrier_df: DataFrame | None
74         self.carrier_df.rename(columns={"Passenger Number": "Passengers",
75                                         "Passenger Load Factor": "LoadFactor",
76                                         "Passenger Kilometers": "PassengerKM"}, inplace=True)
77
78
79
80
81 if __name__ == "__main__":
82     loader = DataLoader("D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/city.csv",
83                         "D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/carrier.csv",
84                         "D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/indian_flight_delays.csv")
85     loader.load_data()
86     loader.clean_data()
```

Analysis Code:

```
analysis_engine.py > AnalysisEngine > forecast_demand
1 """
2 Performs the core analytics for your dashboard using the cleaned DataFrames (city_df, carrier_df, delay_df)
3 - stuff like:
4
5 Top sectors
6 Demand prediction
7 Airline market share
8 Delay pattern detection
9 Forecasting future demand using ML
10
11 """
12
13
14
15 import pandas as pd
16 from sklearn.linear_model import LinearRegression
17 import numpy as np
18
19 class AnalysisEngine:
20     def __init__(self, city_df, carrier_df, delay_df=None): # Initialize the analytics engine with preloaded DataFrames
21         self.city_df = city_df
22         self.carrier_df = carrier_df
23         self.delay_df = delay_df
24
25     def top_sectors(self): # Finds the top 3 busiest air routes based on total passenger traffic.
26         self.city_df["Passenger_count"] = self.city_df["PaxToCity2"] + self.city_df["PaxFromCity2"]
27         grouped = self.city_df.groupby(["Origin", "Destination"])
28         sector_traffic = grouped["Passenger_count"].sum().reset_index()
29         sorted_sector_traffic = sector_traffic.sort_values(by="Passenger_count", ascending = False)
30         top_3 = sorted_sector_traffic.head(3)
31
32         return top_3
33
34     def predict_demand(self, Origin, Destination, Year=None): #Returns past passenger data for a specific route (optionally filtered by year).
35         self.city_df["Passenger_count"] = self.city_df["PaxToCity2"] + self.city_df["PaxFromCity2"]
36         grouped = self.city_df.groupby(["Origin", "Destination", "Year"])
37         grouped_sum = grouped["Passenger_count"].sum().reset_index()
```

```

38     filtered_data = (grouped_sum["Origin"] == Origin) & (grouped_sum["Destination"] == Destination)
39     route_data = grouped_sum[filtered_data]
40
41     if Year:
42         route_data = route_data[route_data["Year"] == Year]
43
44     return route_data
45
46 def airline_market_share(self): # Calculates yearly market share % for each airline to spot growth trends.
47     self.carrier_df.columns = self.carrier_df.columns.str.strip()
48     grouped = self.carrier_df.groupby(["Airline", "Year"])["Passengers"].sum().reset_index()
49     airline_data = grouped
50     total_per_year = airline_data.groupby("Year")["Passengers"].sum().reset_index()
51     total_per_year.rename(columns={"Passengers": "Total Passengers"}, inplace=True)
52     merged = pd.merge(airline_data, total_per_year, on="Year")
53     merged["Market Share (%)"] = (merged["Passengers"] / merged["Total Passengers"]) * 100
54
55     result = merged.sort_values(by=["Year", "Market Share (%)"], ascending=[True, False])
56
57     return result
58
59 def flight_delay_patterns(self, top_n = 5): # Shows top delayed airlines, routes, and most common delay reasons.
60     df = self.delay_df.copy()
61     df.columns = df.columns.str.strip()
62
63     # Top Delayed Airlines
64     airline_delays = (
65         df.groupby("Airline")["Delay_Minutes"]
66         .sum()
67         .reset_index()
68         .sort_values(by="Delay_Minutes", ascending=False)
69         .head(top_n)
70     )
71
72     # Top Delayed Routes
73     route_delays = (
74         df.groupby(["Origin", "Destination"])["Delay_Minutes"]
75         .sum()
76         .reset_index()
77         .sort_values(by="Delay_Minutes", ascending=False)
78         .head(top_n)
79     )
80
81     # Top Delay Reasons (excluding 'None')
82     reason_df = (
83         df[df["Delay_Reason"] != "None"]
84         .groupby("Delay_Reason")
85         .size()
86         .reset_index(name="Delay_Count")
87         .sort_values(by="Delay_Count", ascending=False)
88     )
89
90     return airline_delays, route_delays, reason_df
91
92
93 def forecast_demand(self, origin, destination, future_years=[2025, 2026]): # Predicts future passenger demand on a route using linear regression.
94     self.city_df["Passenger_count"] = self.city_df["PaxToCity2"] + self.city_df["PaxFromCity2"]
95     grouped = self.city_df.groupby(["Origin", "Destination", "Year"])["Passenger_count"].sum().reset_index()
96     route_data = grouped[(grouped["Origin"] == origin) & (grouped["Destination"] == destination)]
97
98     if route_data.empty:
99         print("No historical data found for this route.")
100         return None, None, None
101
102     X = route_data["Year"].values.reshape(-1, 1)
103     y = route_data["Passenger_count"].values
104     model = LinearRegression()
105     model.fit(X, y)
106
107     future_X = np.array(future_years).reshape(-1, 1)
108     future_preds = model.predict(future_X)
109
110     predictions = pd.DataFrame({
111         "Year": future_years,
112         "Predicted_Passenger_count": future_preds.astype(int)
113     })
114
115     return route_data, future_years, future_preds

```

Visualization Code:

```

1  visualization.py > plot_demand_prediction
2  """
3  This module handles all visualizations for the Indigo Analytics Dashboard.
4  Functions include:
5  - Delay analysis charts
6  - Forecasted passenger trends
7  - Market share trends over time
8  - Top air sector visualizations
9  - Predicted demand plotting
10 All graphs are built using matplotlib and seaborn (where needed) for clarity and insight.
11 """
12 import matplotlib.pyplot as plt
13
14 def plot_delay_analysis(airlines_df=None, routes_df=None, reasons_df=None):
15     """
16     Plots 3 delay-related visualizations:
17     1. Bar chart of top delayed airlines
18     2. Bar chart of top delayed routes
19     3. Pie chart of delay reasons
20     """
21     if airlines_df is not None:
22         plt.figure(figsize=(12, 5))
23         plt.bar(airlines_df["Airline"], airlines_df["Delay_Minutes"], color="skyblue")
24         plt.title("Top Delayed Airlines")
25         plt.xlabel("Airline")
26         plt.ylabel("Total Delay Minutes")
27         plt.xticks(rotation=45)
28         plt.tight_layout()
29         plt.show()
30
31     if routes_df is not None:
32         plt.figure(figsize=(12, 5))
33         route_labels = routes_df["Origin"] + " + " + routes_df["Destination"]
34         plt.bar(route_labels, routes_df["Delay_Minutes"], color="salmon")
35         plt.title("Top Delayed Routes")
36         plt.xlabel("Route")
37         plt.ylabel("Total Delay Minutes")
38
39         plt.xticks(rotation=45)
40         plt.tight_layout()
41         plt.show()
42
43     if reasons_df is not None:
44         plt.figure(figsize=(8, 8))
45         plt.pie(
46             reasons_df["Delay_Count"],
47             labels=reasons_df["Delay_Reason"],
48             autopct="%1.1f%%",
49             startangle=140,
50             colors=plt.cm.Pastel1.colors
51         )
52         plt.title("Common Delay Reasons")
53         plt.tight_layout()
54         plt.show()
55
56 def plot_forecast(route_data, future_years, future_preds, origin, destination):
57     """
58     # Plots actual passenger data vs forecasted predictions for a selected route.
59     """
60     plt.figure(figsize=(10, 5))
61     plt.plot(route_data["Year"], route_data["Passenger_count"], marker='o', label='Actual')
62     plt.plot(future_years, future_preds, marker='x', linestyle='--', label='Forecast')
63     plt.title(f"Passenger Forecast for {origin} → {destination}")
64     plt.xlabel("Year")
65     plt.ylabel("Passenger count")
66     plt.legend()
67     plt.tight_layout()
68     plt.show()
69
70

```



```

71 def plot_market_share(market_share_df): # Uses seaborn to show airline-wise market share % trend over years.
72     import seaborn as sns
73     plt.figure(figsize=(12, 6))
74     sns.lineplot(data=market_share_df, x="Year", y="Market Share (%)", hue="Airline", marker="o")
75     plt.title("Airline Market Share Over Years")
76     plt.ylabel("Market Share (%)")
77     plt.xlabel("Year")
78     plt.legend(bbox_to_anchor=(1.05, 1), loc="upper left")
79     plt.tight_layout()
80     plt.show()
81
82 def plot_top_sectors(top3_df): # Plots the top 3 busiest air sectors (routes) based on passenger count.
83     routes = top3_df["Origin"] + " → " + top3_df["Destination"]
84     counts = top3_df["Passenger_count"]
85     plt.figure(figsize=(8, 5))
86     plt.bar(routes, counts, color="goldenrod")
87     plt.title("Top 3 Busiest Air Sectors")
88     plt.xlabel("Route")
89     plt.ylabel("Total Passengers")
90     plt.tight_layout()
91     plt.show()
92
93 def plot_demand_prediction(result_df, origin, destination): # Plots bar graph of predicted demand per year for a given route.
94     if result_df.empty:
95         print("No data to plot.")
96         return
97     plt.figure(figsize=(6, 4))
98     plt.bar(result_df["Year"].astype(str), result_df["Passenger_count"], color="mediumseagreen")
99     plt.title(f"Predicted Demand: {origin} → {destination}")
100    plt.xlabel("Year")
101    plt.ylabel("Passenger Count")
102    plt.tight_layout()
103    plt.show()

```

Menu Code:

```

menu.py > ...
1  ...
2  This file creates a clean, user-friendly GUI dashboard for IndiGO Analytics.
3  Features:
4  - Top 3 busiest air sectors
5  - Passenger demand prediction
6  - Airline market share trends
7  - Delay pattern visualizations
8  - Forecasting future demand via ML
9  The GUI is built using Tkinter and connects to analysis & visualization modules.
10
11  ⚠ IMPORTANT: This application might take a few **seconds to load and respond** due to the
12  use of **large real-world aviation datasets**. Please be patient while the data is being processed.
13  ...
14
15  from tkinter import *
16  from tkinter import ttk
17  from data_loader import DataLoader
18  from analysis_engine import AnalysisEngine
19  import visualization as viz
20
21  # 1. Load & clean data from CSV files
22  loader = DataLoader(
23      "D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/city.csv",
24      "D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/carrier.csv",
25      "D:/learning/sic_pu_june25/Hackathon/IndiGO-Analytics_datasets/indian_flight_delays.csv"
26  )
27  loader.load_data()
28  loader.clean_data()
29
30  engine = AnalysisEngine(loader.city_df, loader.carrier_df, loader.delay_df) # 2. Initialize analysis engine with the cleaned data
31
32  def show_top_sectors(): # Display top 3 busiest sectors using passenger traffic.
33      top3 = engine.top_sectors()
34      print(top3)
35      viz.plot_top_sectors(top3)
36

```

```

37 def show_demand_prediction(): # Open a sub-window to take route & year input, then plot predicted demand.
38     def run_prediction():
39         destination = dest_entry.get().upper().strip()
40         try:
41             year = int(year_entry.get().strip())
42         except ValueError:
43             error_label.config(text="Invalid year. Use numbers only.")
44             return
45
46         result = engine.predict_demand(origin, destination, year)
47         if not result.empty():
48             viz.plot_demand_prediction(result, origin, destination)
49             error_label.config(text="")
50         else:
51             error_label.config(text="No data found for that route + year.")
52
53     # GUI
54     pred_window = Toplevel(root)
55     pred_window.title("Predict Demand")
56     Label(pred_window, text="Origin City: (example: mumbai, delhi)").pack(pady=2)
57     origin_entry = Entry(pred_window)
58     origin_entry.pack(pady=2)
59
60     Label(pred_window, text="Destination City: (example: mumbai, pune, delhi)").pack(pady=2)
61     dest_entry = Entry(pred_window)
62     dest_entry.pack(pady=2)
63
64     Label(pred_window, text="Year:").pack(pady=2)
65     year_entry = Entry(pred_window)
66     year_entry.pack(pady=2)
67
68     error_label = Label(pred_window, text="", fg="red")
69     error_label.pack(pady=5)
70
71     Button(pred_window, text="Predict", command=run_prediction).pack(pady=5)
72
73

```

```

74 def show_market_share(): # Analyze market share of airlines over years.
75     share_df = engine.airline_market_share()
76     print(share_df.head())
77     viz.plot_market_share(share_df)
78
79 def show_flight_delays(): # Open sub-window to select between delay analysis types.
80     def show_airlines():
81         airlines, _ = engine.flight_delay_patterns()
82         viz.plot_delay_analysis(airlines, None, None)
83
84     def show_routes():
85         _, routes, _ = engine.flight_delay_patterns()
86         viz.plot_delay_analysis(None, routes, None)
87
88     def show_reasons():
89         _, _, reasons = engine.flight_delay_patterns()
90         viz.plot_delay_analysis(None, None, reasons)
91
92     # Sub-window for selecting delay type
93     delay_window = Toplevel(root)
94     delay_window.title("Choose Delay Analysis")
95     Label(delay_window, text="Select Delay Category", font=("Helvetica", 14)).pack(pady=10)
96
97     Button(delay_window, text="Top Delayed Airlines", command=show_airlines).pack(pady=5)
98     Button(delay_window, text="Top Delayed Routes", command=show_routes).pack(pady=5)
99     Button(delay_window, text="Common Delay Reasons", command=show_reasons).pack(pady=5)
100
101
102 def show_forecast(): # Take future years input and forecast passenger demand on a route.
103     def run_forecast():
104         origin = origin_entry.get().upper().strip()
105         destination = dest_entry.get().upper().strip()
106         try:
107             years = [int(y.strip()) for y in years_entry.get().split(',')]
108         except ValueError:

```

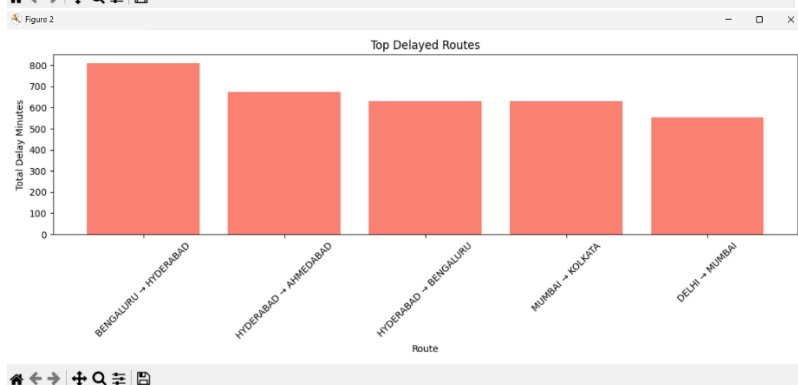
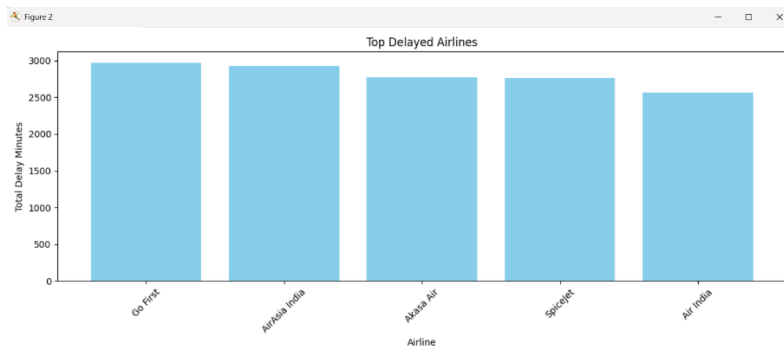
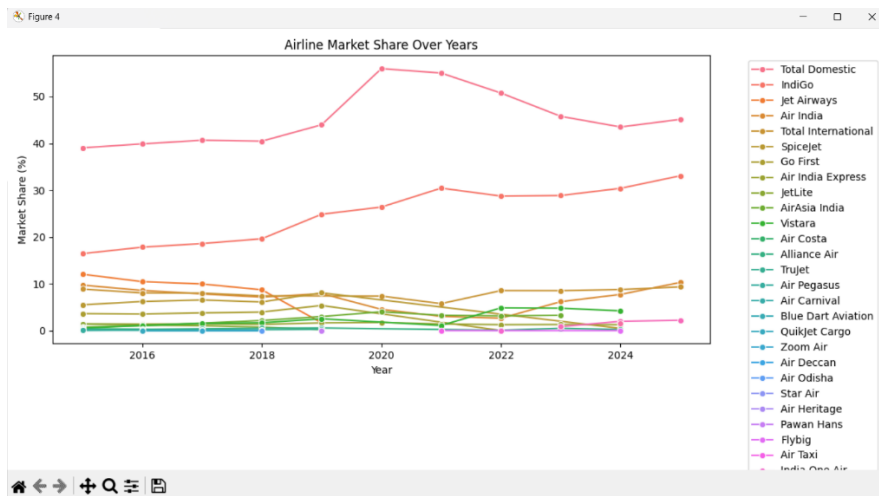
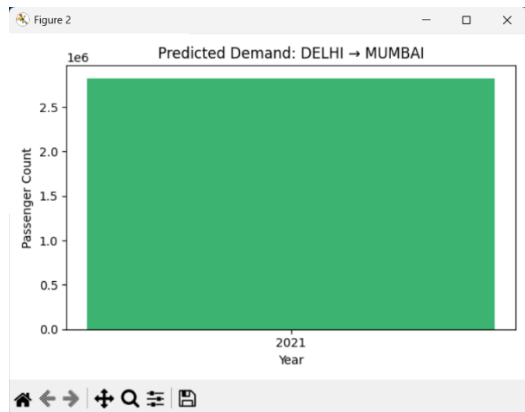
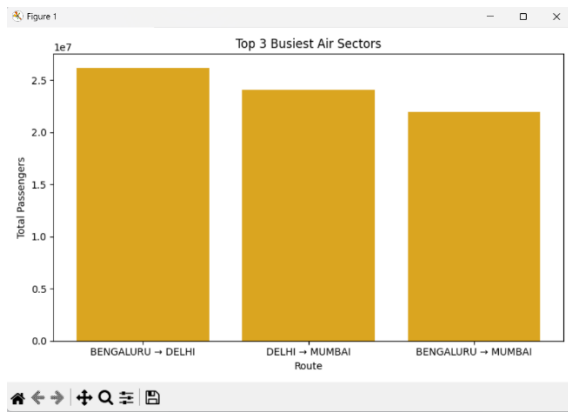
```

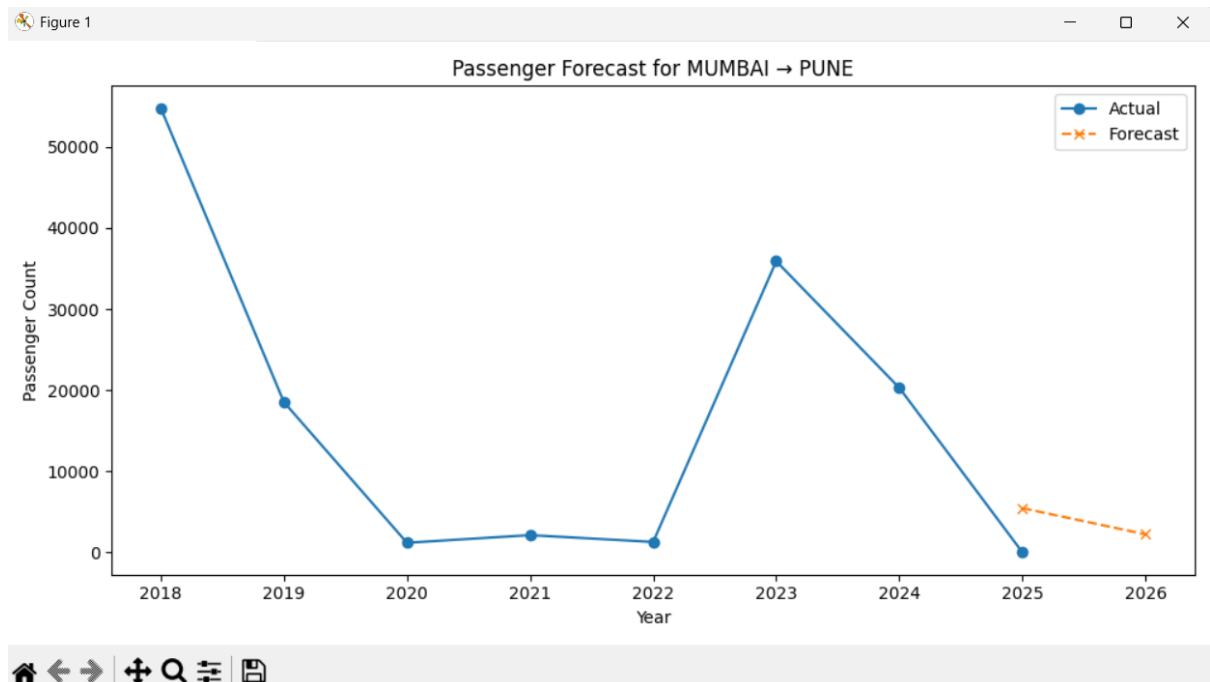
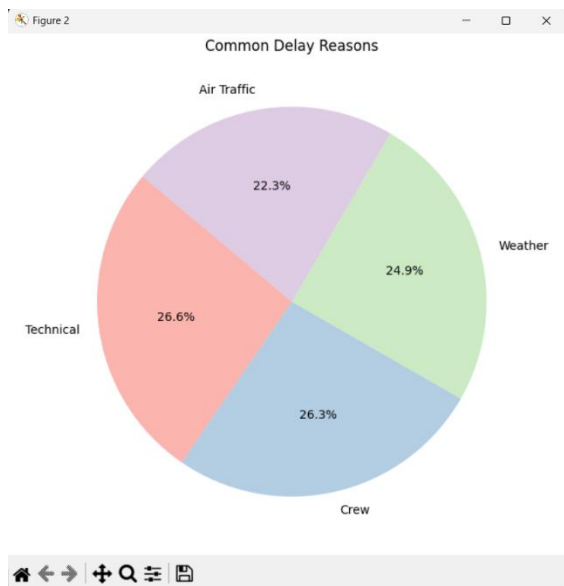
109         error_label.config(text="Invalid year format. Use commas, e.g. 2025,2026")
110         return
111
112     route_data, future_years, future_preds = engine.forecast_demand(origin, destination, years)
113     if route_data is not None:
114         viz.plot_forecast(route_data, future_years, future_preds, origin, destination)
115     else:
116         error_label.config(text="No historical data for this route.")
117
118     # Create popup
119     forecast_window = Toplevel(root)
120     forecast_window.title("Forecast Demand Input")
121     Label(forecast_window, text="Origin City: (example: mumbai, delhi)").pack(pady=2)
122     origin_entry = Entry(forecast_window)
123     origin_entry.pack(pady=2)
124
125     Label(forecast_window, text="Destination City: (example: mumbai, pune, delhi)").pack(pady=2)
126     dest_entry = Entry(forecast_window)
127     dest_entry.pack(pady=2)
128
129     Label(forecast_window, text="Years (comma separated):").pack(pady=2)
130     years_entry = Entry(forecast_window)
131     years_entry.pack(pady=2)
132
133     error_label = Label(forecast_window, text="", fg="red")
134     error_label.pack(pady=5)
135
136     Button(forecast_window, text="Run Forecast", command=run_forecast).pack(pady=5)
137
138 # === GUI Layout ===
139
140 root = Tk()
141 root.title("IndiGO Analytics Dashboard")
142 root.geometry("600x500")
143 root.configure(bg="#f4f6fa")
144
145 style = ttk.Style()
146 style.configure("TButton", font=("Segoe UI", 11), padding=10)
147 style.map("TButton", background=[("active", "#0052cc")])
148
149 header = Frame(root, bg="#003366")
150 header.pack(fill=X)
151 Label(header, text="➔ IndiGO Analytics", font=("Helvetica", 20, "bold"), fg="white", bg="#003366", pady=10).pack()
152
153 Label(root, text="Select an analysis to begin", font=("Segoe UI", 14), bg="#f4f6fa", fg="#333").pack(pady=20)
154
155 button_frame = Frame(root, bg="#f4f6fa")
156 button_frame.pack(pady=10)
157
158 ttk.Button(button_frame, text="📊 Top 3 Sectors", command=show_top_sectors, width=25).grid(row=0, column=0, padx=10, pady=10)
159 ttk.Button(button_frame, text="🔮 Predict Demand", command=show_demand_prediction, width=25).grid(row=1, column=0, padx=10, pady=10)
160 ttk.Button(button_frame, text="📈 Market Share", command=show_market_share, width=25).grid(row=2, column=0, padx=10, pady=10)
161 ttk.Button(button_frame, text="✈️ Flight Delay Analysis", command=show_flight_delays, width=25).grid(row=3, column=0, padx=10, pady=10)
162 ttk.Button(button_frame, text="📅 Forecast Demand", command=show_forecast, width=25).grid(row=4, column=0, padx=10, pady=10)
163
164 Label(root, text="Powered by Team IndiGO Hackers 🚀", font=("Segoe UI", 9), bg="#f4f6fa", fg="#777").pack(side=BOTTOM, pady=10)
165
166 root.mainloop()
167

```

Output Screenshots







Closure

This project successfully bridges data science and aviation operations by analysing Indigo's business strategy through an analytical lens. From identifying high-performing sectors to forecasting future demand and mapping market share trends, the application delivers valuable insights. The GUI enables easy access and interaction, making the tool practical for both academic and

business use. Future enhancements include live data integration and advanced delay prediction models.

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