Report

Contents

Data Interpretation

Aircraft Data

Aircraft Type	Max Range (In KM)	Cruise Speed (Kmph)	Fuel Consumption at Cruise (liters per hr)	ICAO CODES
Uniquely identifies each aircraft	Max distance possible without refueling	Speed at cruise height	Liters of fuel consumed per hour	Aircraft is available at this airport

Airport Data

ICAO Code	Latitude (In KM)	Longitude (In KM)	CIty
Uniquely identifies each airport	Latitudinal distance from airport to the city in ‘city’ column	Longitudinal distance from airport to the city in ‘city’ column	Destination city from current airport

Weather Data

Date	Wind Speed	Wind Direction	CIty
Departure date	In kmph	In degrees (0-360)	Relevant city

Preprocessing

1. In the aircraft dataset, we remove those rows where ‘fuel consumption’, ‘cruise speed’, or ‘max range’ are not given. These 3 values play a major role in the fitness function and without them the condition of the route will be in question. Therefore, by removing these rows from the aircraft dataset, we make these respective aircrafts unusable from their respective airports.
2. In the weather dataset, we perform *[wind direction mod 360]* for the values which exceed 360 degrees. However, upon further analysis we end up not using this value at all (explained further ahead).

Distance calculation

For the distance calculations, we use a simple Euclidean distance formula. This is because the latitude and longitudes are treated as x and y, respectively, distances from city A to B.

Analysis of data

When we look closely at the data we can see that for aircrafts and airports, all columns are useful and can be used in some way for fitness calculations. However, in the weather dataset, the wind direction column proved to be of no use. To understand this first we need to determine how wind direction affects flight paths. There are 3 main types of winds which are considered in aviation:

1. Crosswinds:

   Crosswinds occur when the wind blows perpendicular to the direction of the aircraft (i.e., from the side). Crosswinds can affect the aircraft's lateral control, making it challenging for pilots to maintain a straight path during takeoff or landing. During takeoff, pilots must apply corrective control inputs to prevent the aircraft from drifting off the runway. During landing, crosswinds can lead to a crabbed approach, where the aircraft is pointed into the wind to maintain the runway centerline.
2. Headwinds:

   Headwinds occur when the wind blows opposite to the direction of the aircraft's travel. Headwinds can increase the aircraft's effective airspeed, which can be beneficial during takeoff and landing. A headwind during takeoff provides additional lift, allowing the aircraft to achieve takeoff speed more quickly. During landing, a headwind reduces the groundspeed, helping to shorten the landing distance. Pilots often prefer headwinds for takeoff and landing as they improve aircraft performance.
3. Tailwinds:

   Effect on Aircraft: Tailwinds occur when the wind blows in the same direction as the aircraft's travel. Tailwinds can reduce the aircraft's effective airspeed and present challenges during takeoff and landing. During takeoff, a tailwind increases the ground speed required to achieve takeoff speed, potentially extending the distance needed for takeoff. During landing, a tailwind increases the groundspeed, requiring a longer landing distance.

Therefore, without knowing aircraft heading, runway space, aircraft net weight and ground conditions (dry, wet, snowy), we cannot utilize the wind direction effectively in our calculations. We are restricted by the data we have.

Fitness Function

Function Parameters:

- route: A list representing the sequence of airports for the flight route.
- date: The date for which the fitness is calculated.
- aircraftData: Data on available aircraft, including their types, ICAO codes, maximum range, fuel consumption at cruise, and cruise speed.
- weatherData: Data on weather conditions, including wind speed, for different cities on the given date.

Constants and Weights: (Optimization metrics)

- fuel_weightage and time_weightage: These constants determine the relative importance of fuel consumption and travel time in the overall fitness calculation.
- Wind speed categories (max_safe, max_acceptable, max_cautionary, max_unsafe): These define different levels of wind speed that impact the fitness score.
- src_weather_weight and dest_weather_weight: Weights assigned to weather conditions at the source and destination airports, respectively.

Aircraft Fitness Calculation:

- The function iterates over the provided route, calculating the distance between consecutive airports and identifying eligible aircraft for each segment based on their maximum range.
- It then selects the aircraft with the best fuel efficiency (minimum fuel consumption at cruise) for each segment.
- The fitness of the aircraft for the segment is calculated based on travel time and fuel consumption, with weights applied based on fuel_weightage and time_weightage.

Weather Fitness Calculation:

- The function retrieves wind speed data for the source and destination airports on the specified date.
- It assigns weights (src_weather_weight and dest_weather_weight) based on the wind speed categories for both source and destination airports. (see references)
- The weights are used to adjust the overall fitness based on weather conditions.

Overall Fitness Calculation:

- For each segment of the route, the local fitness is calculated by combining the aircraft fitness and weather fitness.
- The local fitness is then added to the overall fitness.

Output:

- The function returns the overall fitness score for the entire route.

Handling Special Cases:

- If no eligible aircraft are found for a segment, the function returns -1, indicating that the route is unusable.
- If weather data is missing, the function assumes cautionary weather conditions.

Initialize population Function

This function initializes a population of possible routes for the genetic algorithm. It randomly generates routes of varying lengths between src and dest, excluding them from the list of cities.

Selection Function

Selects the best routes from the current population based on their fitness values. It sorts the routes based on their fitness values in ascending order, selects the top two routes as the best-performing routes and returns them.

Crossover Function

Performs crossover between two parent routes to create two new child routes. It randomly selects a crossover point and combines segments of both parents to create two child routes. Furthermore, it ensures that the resulting routes do not contain duplicate cities and removes instances of src and dest from the children, except for the first and last indices.

Mutation Function

It randomly decides whether to remove a connection, add a new connection, or change an existing connection and implements the chosen mutation type accordingly.

Replace Function

Replaces the two least fit routes in the population with the newly generated children.

Visualization

Frontend

- Design
- Html components and naming

Flask linking

- Folder structure for flask
- Linking results from calculations to the frontend

References

What are the maximum wind limits for a commercial aircraft? (2023) *aircraft-maximum-wind-limits*. Available at: https://www.flightdeckfriend.com/ask-a-pilot/aircraft-maximum-wind-limits/

(Accessed: 22 November 2023).