Optimizing Mileage Runs for Frequent Fliers

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Problem Summary

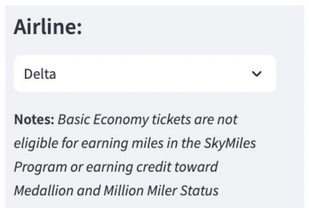
Frequent Flyer Programs (FFPs) are an effective marketing tool which incentivize customers to book higher fare flight options to optimize loyalty status. FFPs generate **~$20 billion revenue** combined across the 4 major U.S. airlines - American, Delta, Southwest & United Airlines. In fact, only **12% of the U.S. population accounts for ~60% of flights** taken in the U.S. However, **existing flight search tools**, such as Expedia or Google Flights, **focus on flight cost minimization** and **fail to optimize for frequent flyers**, a revenue-generating sub-population who purposefully purchase high-fare flights to maintain or enhance their status tier.

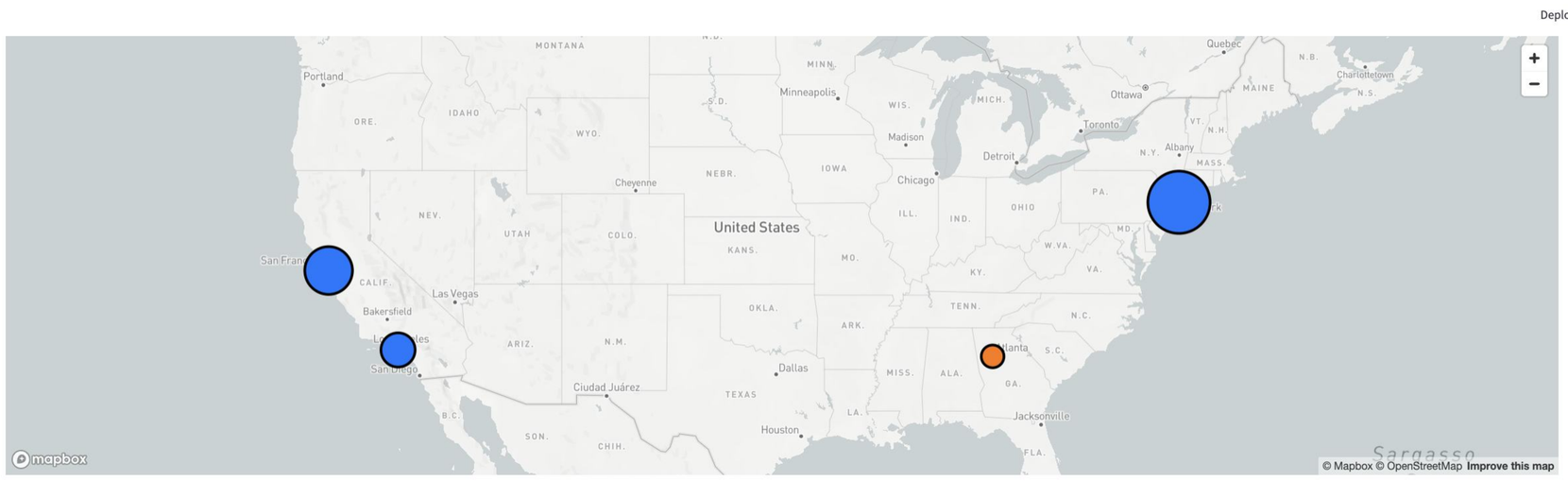
Objective: Develop a streamlined interactive tool targeted towards frequent flyers which displays flights, using multi-objective optimization, which fulfill the requirements for attaining frequent flyer status for their airline of interest based on personalized goals and preferences.

Dataset

Sources: The cached dataset was sourced from the real-time FlightLabs Flight Price API. The map visualizations were facilitated using airports' geographical information from the worldwide OpenFlights database.

Characteristics: Since the Flight Price API provides real-time data & flights are dynamically priced due to supply & demand, the cached dataset is point-in-time used to create our tool contains 1.2 million records & is 3GB in size containing departure time, arrival time, seat class & price.





MOO Weights: {'Total Route Duration': 0.04, 'Total Price': 0.6, 'Connections': 0.36}

Top Re-ranked Routes Based on User Preferences

Reranked routes based on user preferences: Time weight=0.0, Cost weight=1.0

Departure Time:	Arrival Time:	Total Route Duration	Total Price	Weighted Score	Itinerary	See Itinerary Details
11/14/2024 07:05	11/20/2024 07:25	144.33	1,005.92	1	ATL JFK LAX SFO ATL	☐
11/14/2024 07:05	11/20/2024 07:25	144.33	1,005.92	1	ATL JFK LAX SFO ATL	☐
11/14/2024 07:05	11/20/2024 07:25	144.33	1,005.92	1	ATL JFK LAX SFO ATL	☐
11/14/2024 08:10	11/19/2024 21:29	133.32	1,006.95	0.9999	ATL SFO ATL	☐
11/14/2024 08:10	11/14/2024 19:32	11.37	1,006.95	0.9999	ATL SFO ATL	☐
11/14/2024 08:10	11/19/2024 19:32	131.37	1,006.95	0.9999	ATL SFO ATL	☐
11/14/2024 08:10	11/19/2024 13:28	125.3	1,006.95	0.9999	ATL SFO ATL	☐
11/19/2024 07:15	11/19/2024 15:54	8.65	1,009.84	0.9997	ATL JFK ATL	☐
11/14/2024 08:28	11/19/2024 12:52	124.4	1,009.84	0.9997	ATL JFK ATL	☐
11/14/2024 09:50	11/19/2024 12:52	123.03	1,009.84	0.9997	ATL JFK ATL	☐

Algorithmic & Visualization Approaches

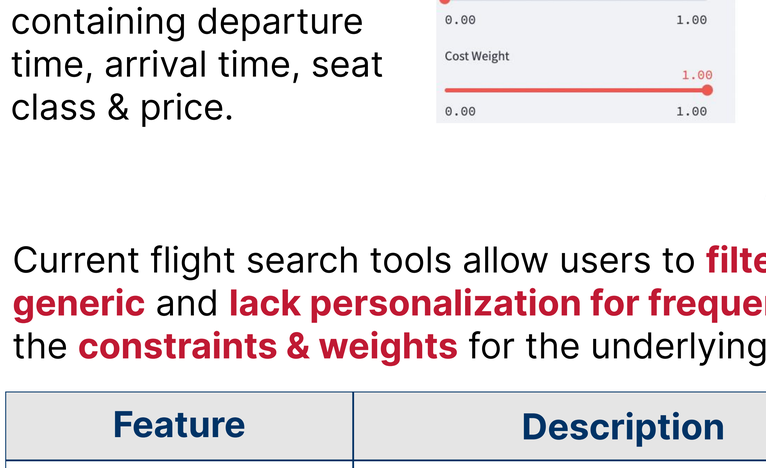
Current flight search tools allow users to **filter flight routes** based on flight attributes (i.e. seat class, layovers, etc.). However, the **outputs are generic** and **lack personalization for frequent flyers**. Our **interactive visualization tool** contains **key features** which **utilize user input** to define the **constraints & weights** for the underlying **multi-objective optimization algorithm** to **enable user personalization**.

Feature	Description	Intuition/Novelty
Customize Route Search with Time & Cost Weight	Enables frequent flyers to define the relative importance of time vs. cost when ranking the route recommendations.	Current flight search tools fail to take degree of importance of the various variables they make available for filtering. By enabling Cost & Weight scales we can use user input to provide optimal flight routes.
"Current MQD" & "Select Desired Tier" Fields	Allows frequent flyers to input their target tier & current number of miles to fine-tune route recommendation.	Current flight search tools fail to personalize to frequent flyers based on their existing & desired status level. This value serves as the constraint for the underlying optimization algorithm.

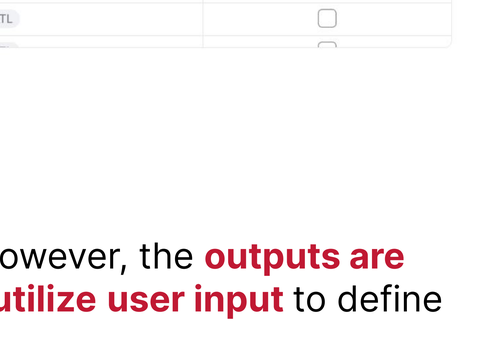
$$\min Z(x) = w_1 S(x) + w_2 C(x) + w_3 T(x)$$
$$s.t. C(x) \geq target$$

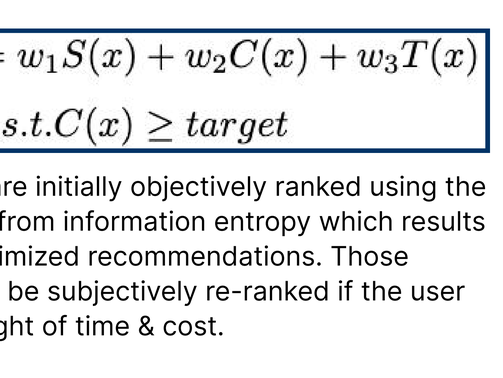
*__Note__: Routes are initially objectively ranked using the weight derived from information entropy which results in impartial, optimized recommendations. Those routes can then be subjectively re-ranked if the user adjusts the weight of time & cost.

Experiments & Evaluation



Parameters	Top 3 Best Routes
Origin: ATL **Time Weight**: 0.0 **Cost Weight:** 1.0 **Stopover Weight**: 0.0	(1) ATL → SFO → ATL | Cost: $1,006.95 | Time: 11.37 | Score: 1.0000 (2) ATL → SFO → ATL | Cost: $1,006.95 | Time: 131.37 | Score: 1.0000 (3) ATL → SFO → ATL | Cost: $1,006.95 | Time: 133.32 | Score: 1.0000
Origin: ATL **Time Weight**: 0.05 **Cost Weight:** 0.03 **Stopover Weight**: 0.92	(1) ATL → JFK → ATL | Cost: $1,009.84 | Time: 8.65 | Score: 1.0000 (2) ATL → JFK → ATL | Cost: $1,029.83 | Time: 9.73 | Score: 0.9996 (3) ATL → JFK → ATL | Cost: $1,029.84 | Time: 9.73 | Score: 0.9996
Origin: ATL **Time Weight**: 0.5 **Cost Weight:** 0.5 **Stopover Weight**: 0.0	(1) ATL → JFK → ATL | Cost: $1,009.84 | Time: 8.65 | Score: 0.9995 (2) ATL → SFO → ATL | Cost: $1,006.95 | Time: 11.37 | Score: 0.9950 (3) ATL → JFK → ATL | Cost: $1,029.83 | Time: 9.73 | Score: 0.9948





Exploratory Data Analysis: The heatmap above displays origin-destination pairs and the associated price/duration ratios. Higher intensity indicates a lower duration and higher price thus maximizing MQDs spent with minimal time sink. The chart suggests that popular routes meeting this criteria would be ATL ↔ CLT, MCO ↔ MIA & ATL ↔ MCO. Less popular routes would be LAX ↔ MIA, DEN ↔ DFW, & DEN ↔ EWR.

Numerical Experimentation (Above): With ATL as the origin & 4,000 current MQDs & attempting to obtain 5,000 - the optimal route would give stopover weight = 0.92, time weight = 0.05 & cost weight = 0.03. This combination would minimize cost & time with $1,000 MQD.
User Feedback (Right): 8 subjects were asked to perform a "Time to Task Completion" when identifying an optimal mileage run route using the Interactive Mileage Tool vs. Google Flights and record. A majority of respondents indicated the Mileage Tool took less time for task completion. Same respondents reported positive ease of use & task completion satisfaction.