TRAVEL SMARTER: COST-EFFECTIVE FLIGHT PLANNING USING GRAPH THEORY

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Introduction

IN THE FAST-PACED AVIATION INDUSTRY, EFFICIENT TRAVEL IS ESSENTIAL. THIS PROJECT FOCUSES ON REDUCING TRAVEL COSTS AND ENHANCING CONVENIENCE BY UTILIZING DIJKSTRA'S AND BELLMAN-FORD ALGORITHMS TO FIND THE MOST ECONOMICAL FLIGHT ROUTES. A GRAPH MODEL IS DEVELOPED, WITH AIRPORTS REPRESENTED AS NODES AND FLIGHT PRICES AS EDGES. BY ANALYZING DATA FROM THE TOP 12 MAJOR AIRPORTS GLOBALLY, THE PROJECT AIMS TO DELIVER RELIABLE AND COST-EFFECTIVE TRAVEL SOLUTIONS, ADDRESSING PRICE FLUCTUATIONS AND ENSURING A SEAMLESS BALANCE BETWEEN AFFORDABILITY AND PRACTICALITY.

AIRFARE DATA AND GRAPH CONSTRUCTION

FLIGHT COST DATA WAS MANUALLY COLLECTED FROM 12 MAJOR AIRPORTS WORLDWIDE. THESE AIRPORTS INCLUDE SINGAPORE (SIN), LOS ANGELES (LAX), MEXICO (ZLO), TOKYO (NRT), AMSTERDAM (AMS), DELHI (DEL), DUBAI (DXB), SYDNEY (SYD), NEW YORK (JFK), ISTANBUL (IST), PARIS (CDG), AND LONDON (LHR).

USING THIS DATA, A DETAILED GRAPH WAS CREATED WITH THE HELP OF NETWORKX. IN THIS MODEL, AIRPORTS ARE REPRESENTED AS NODES, WHILE DIRECT FLIGHT CONNECTIONS ARE SHOWN AS EDGES, WITH WEIGHTS ASSIGNED TO REFLECT THE RESPECTIVE FLIGHT COSTS

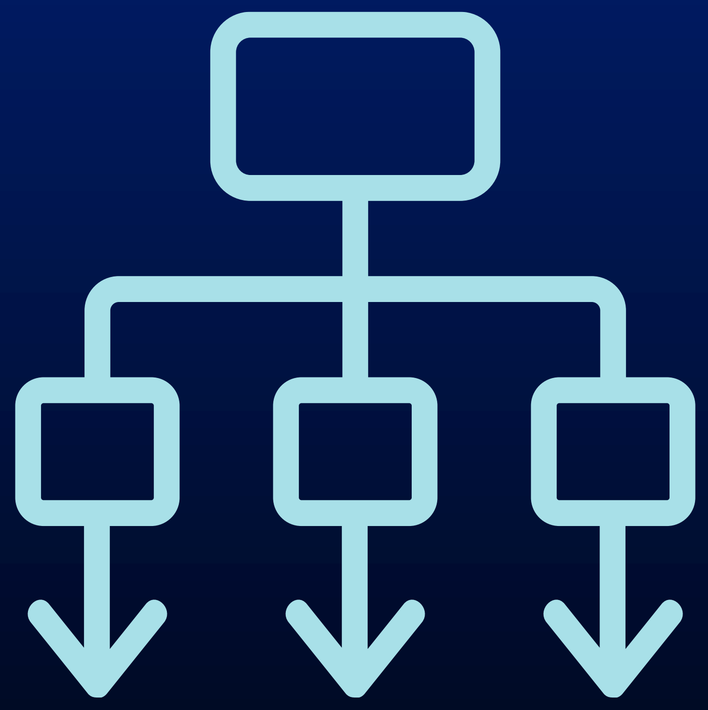
DIJKSTRA'S ALGORITHM

PURPOSE

•FINDS THE MOST COST-EFFECTIVE FLIGHT ROUTE (NOT JUST THE SHORTEST DISTANCE).

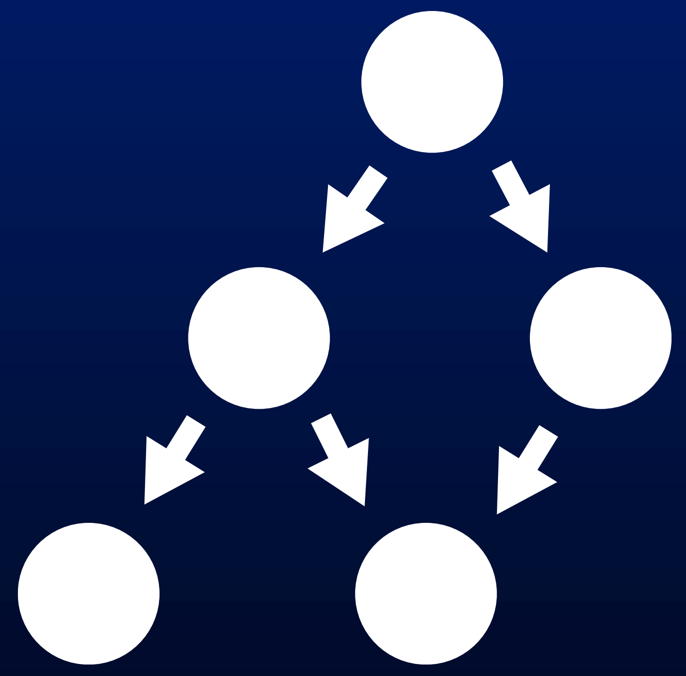
KEY FEATURES

•PROCESSES LARGE DATASETS OF FLIGHT PRICES AND CONNECTIONS EFFICIENTLY.
DELIVERS QUICK AND ACCURATE RESULTS FOR OPTIMAL ROUTES.



COMPLEXITY

TIME COMPLEXITY: O((V + E) \LOG V)
V: AIRPORTS (VERTICES)
E: FLIGHT CONNECTIONS (EDGES)
SPACE COMPLEXITY: O(V + E)



APPLICATIONS

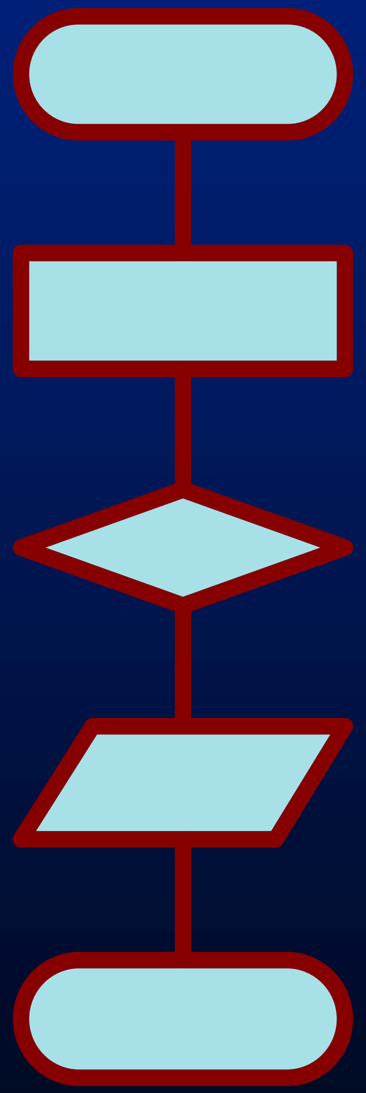
• IDEAL FOR ANALYZING AIRLINE ROUTE NETWORKS.
• USEFUL FOR MINIMIZING TRAVEL COSTS IN LARGE, COMPLEX GRAPHS.

BELLMAN-FORD ALGORITHM

PURPOSE

SERVES AS A COMPLEMENTARY TOOL TO VALIDATE ROUTE COSTS ACROSS THE NETWORK.
PROVIDES AN ADDITIONAL LAYER OF VERIFICATION FOR DIJKSTRA'S RESULTS.

KEY FEATURES



ENSURES COMPREHENSIVE EVALUATION OF ALL POSSIBLE ROUTES.
RELIABLE FOR DETECTING NEGATIVE WEIGHT CYCLES IN GRAPHS.

COMPLEXITY

TIME COMPLEXITY: O(VE)
V: NUMBER OF AIRPORTS (VERTICES)
E: NUMBER OF FLIGHT CONNECTIONS (EDGES)
SPACE COMPLEXITY: O(V), OPTIMIZED FOR LARGE DATASETS.

APPLICATIONS

EFFECTIVE FOR VALIDATING EXTENSIVE DATASETS IN AIR TRAVEL.
USEFUL FOR ENSURING THOROUGH ANALYSIS IN ROUTE OPTIMIZATION.

FORD BELLMAN VS DIJKSTRA

1. BELLMAN-FORD:

• HANDLES NEGATIVE WEIGHTS BUT CONSUMES MORE SPACE.
• USEFUL FOR EXHAUSTIVE VALIDATION OF ALL POSSIBLE ROUTES.

2. DIJKSTRA:

• FASTER IN SPARSE GRAPHS WITHOUT NEGATIVE WEIGHTS.
• IDEAL FOR COST-EFFICIENT REAL-TIME TRAVEL ROUTE OPTIMIZATION.

EXPERIMENT SETUP

• START NODE: SIN (SINGAPORE)
• END NODE: ZLO (MEXICO)

Metric	Bellman-Ford	Dijkstra
Execution Time	0.00099 seconds	0.00099 seconds
Space Used	165,492 KB	161,924 KB
Time Complexity	$O(V \cdot E)$	$O((V+E) \log V)$
Space Complexity	$O(V)$	$O(V+E)$

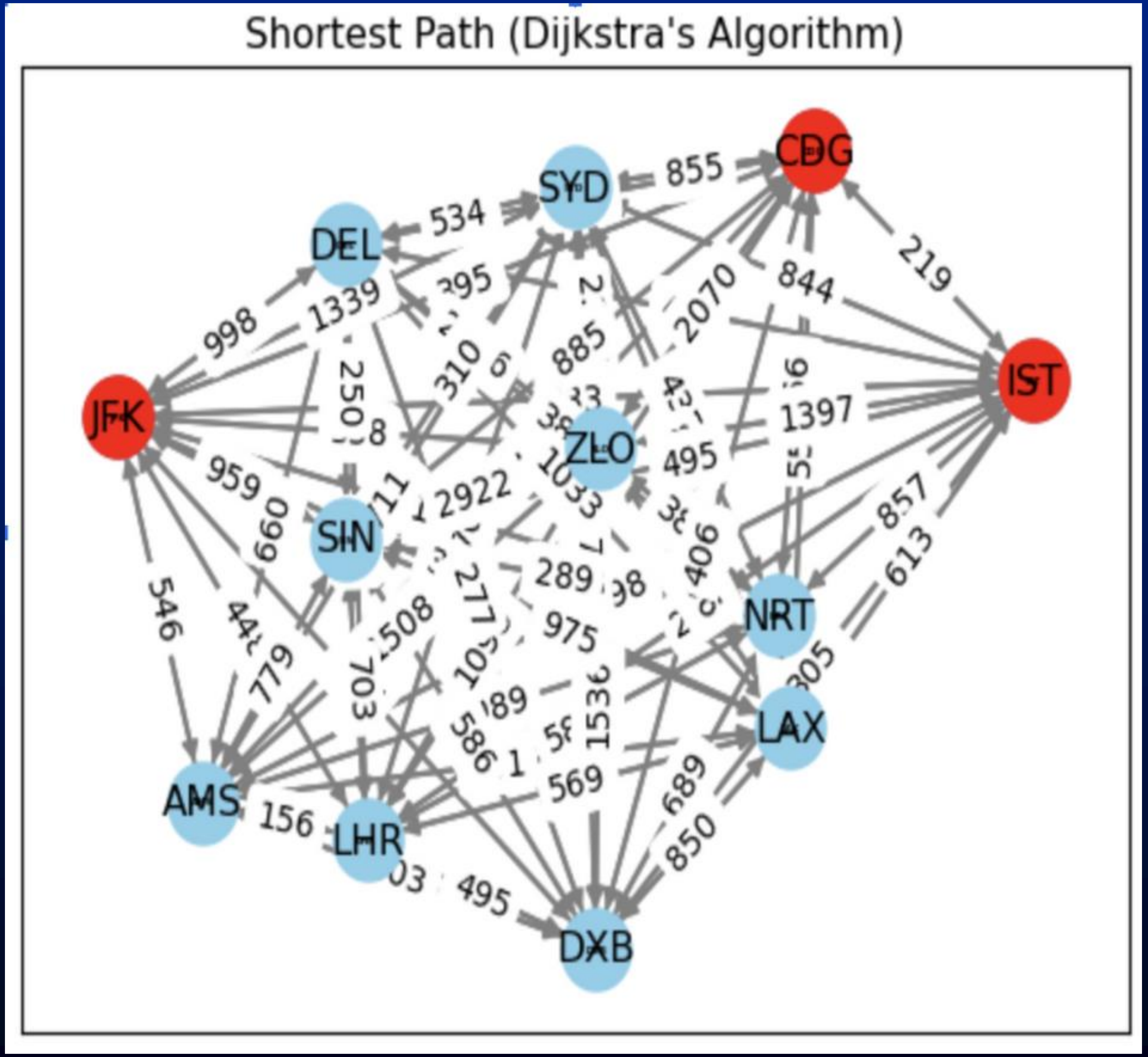
VISUALIZATIONS

- USED NETWORKX TO MODEL THE FLIGHT NETWORK OF MAJOR AIRPORTS.

- AIRPORTS ARE REPRESENTED AS NODES, AND FLIGHT COSTS AS EDGES.

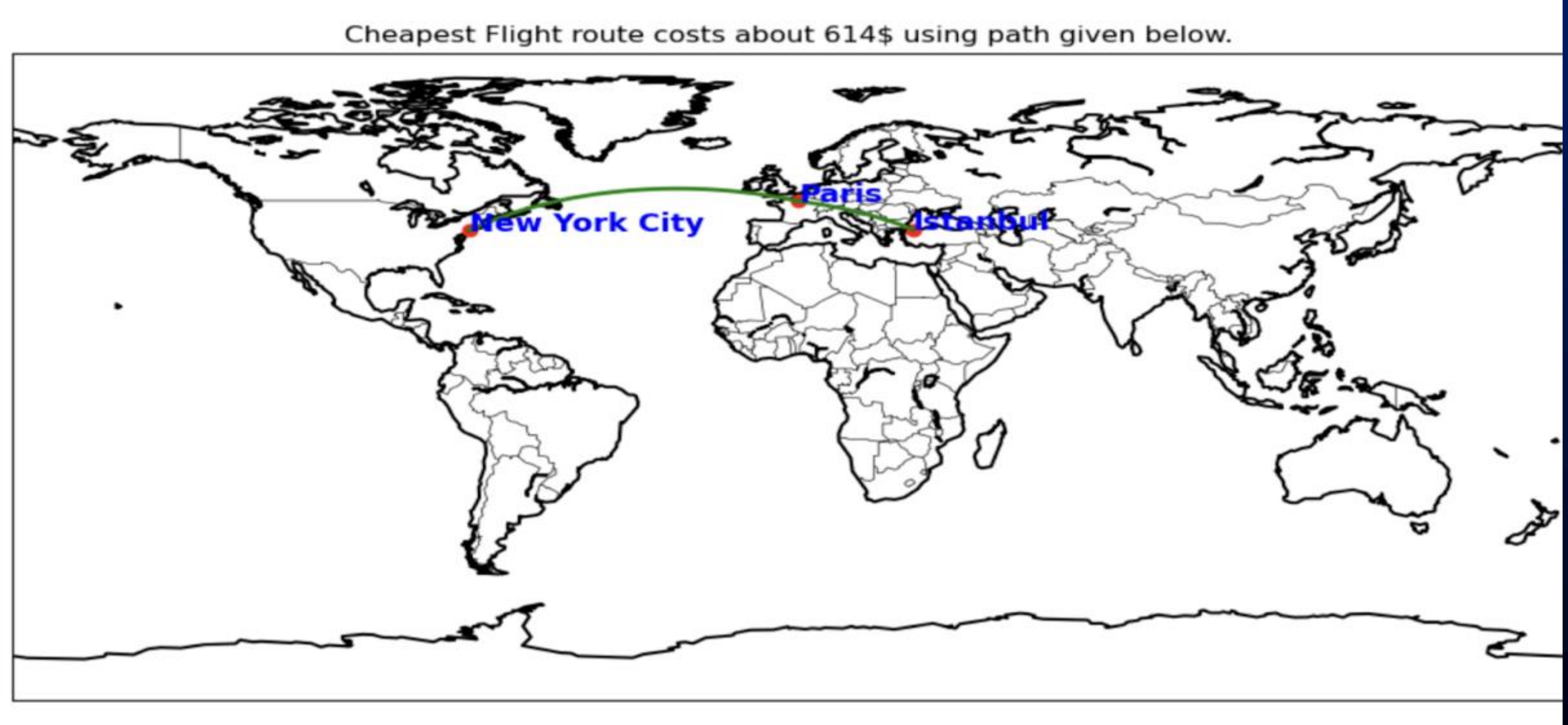
- HIGHLIGHTED KEY AIRPORTS INVOLVED IN THE SHORTEST PATH (E.G., IST, CDG, JFK) TO VISUALIZE THE OPTIMAL ROUTE.

- PROVIDES A CLEAR AND DETAILED VIEW OF THE NETWORK'S STRUCTURE AND COMPLEXITY.



GEOGRAPHIC MAPPING:

- USED BASEMAP TO CREATE DETAILED VISUAL REPRESENTATIONS OF FLIGHT ROUTES.
- DISPLAYS THE CHEAPEST ROUTES ON A GLOBAL MAP, INCLUDING TOTAL TRAVEL COSTS.
- OFFERS A COMPREHENSIVE GEOGRAPHIC CONTEXT FOR FLIGHT PATHS.
- IMPROVES TRIP PLANNING BY SHOWCASING REAL-WORLD TRAVEL PATHS.
- ENABLES USERS TO INTERACT WITH AND COMPARE MULTIPLE ROUTE OPTIONS EASILY.



INTUITIVE USER INTERFACE:

- DESIGNED A SIMPLE AND ACCESSIBLE PLATFORM FOR USERS OF ALL EXPERIENCE LEVELS.

- ENABLES SEAMLESS SELECTION OF DEPARTURE AND DESTINATION POINTS.

- PROVIDES INSTANT ACCESS TO OPTIMIZED ROUTES AND THEIR TOTAL TRAVEL COSTS.

- CONNECTS TECHNICAL BACKEND CALCULATIONS WITH PRACTICAL, USER-FRIENDLY FEATURES.

Thank you!