AIFA ASSIGNMENT 1

ELECTRICAL VEHICLE OPTIMIZATION

PROBLEM STATEMENT:

Consider a city network where we need to route a set of electric vehicles which may require to be charged during its journey from some source to some destination. Let us assume that we have n cities ($v_1; v_2; : : : ; v_n$) and the distance between cities v_i and v_j be e_{ij} (if two cities are not connected directly then $e_{ij} = \infty$ and $e_{ij} = e_{ji}$): Assume that each city has a single charging station which can charge one EV at a time. Consider a set of k EVs namely $P_1; P_2; : : : ; P_k$: For each EV the following information is provided -
(a) S_r - source node
(b) D_r - destination node
(c) B_r - battery charge status initially
(d) c_r - charging rate for battery at a charging station (energy per unit time)
(e) d_r - discharging rate of battery while traveling (distance travel per unit charge)
(f) M_r - maximum battery capacity
(g) s_r - average traveling speed (distance per unit time).
Assume that all vehicles start their journey at t = 0 and P_r reaches its destination at $t = T_r$. We need to route all the vehicles from their respective sources to destinations such that max $\{T_r\}$ is minimized. You need to develop both optimal as well as heuristic algorithms.

HEURISTIC ALGORITHM:

STATE:

State of an electric vehicle:

The state of an electric vehicle is given by the following parameters:

1. **Source position**
2. **Destination position**
3. **Initial Battery charge**
4. **Charging rate**
5. **Discharging rate**
6. **Maximum battery charge**
7. **Average speed**
8. **Index:** Index serves the purpose of naming the electric vehicle

The following parameters of an electric vehicle vary:

1. **Current position:** The current position of the electric vehicle
2. **Current battery charge:** Current battery charge of the electric vehicle
3. **Charging status:** Gives the information whether the vehicle is getting charge or not
4. **Path:** Path travelled from the start position to the current position
5. **Distance travelled:** Distance travelled from the start position to the current position
6. **Time elapsed:** Total time elapsed from the initial state to the current state of the electric vehicle
7. **Mode:** Mode is ‘active’ if the electric vehicle is travelling, ‘passive’ if it is at rest, ‘Destination Reached’ if the electric vehicle reaches its destination

8. **Total charging time:** Total time taken for charging form the start state to the current state
9. **Total resting time:** Total time used for waiting to get charge from the start state to the current state
10. **Total travelling time:** Total time used in travel from the start state to the current state

DEFINITION OF STATE:

State is defined as a list of all cities where each city itself is a list containing the electric vehicle objects currently in that city.

STATE TRANSFORMATION RULES:

STATE TRANSFORMATION RULES OF AN ELECTRIC VEHICLE:

RULE 1: Travelling:

The electric vehicle can travel from one city to other which are connected directly

RULE 2: Resting with getting charged:

The electric vehicle is getting charged

RULE 3: Resting without getting charged:

The electric vehicle is waiting to get charged

RULE 4: Destination reached:

The electric vehicle mode is changed into 'Destination Reached'

VALID STATE:

A state is said to be valid if each vehicle in a city has its battery charge in range (0, maximum) and there exist a minimum of zero or a maximum of 1 vehicle in a city, getting charged at a time.

INITIAL STATE:

State in which all vehicles are at their source positions.

GOAL STATE:

State in which all vehicles are at their destination positions.

PATH COST FUNCTION:

Total time elapsed from the start state to the current state.

ESTIMATED HEURISTIC FUNCTION:

Time required in travelling the minimum path length from the current state to the goal state.

ALGORITHM USED:

BEST-FIRST SEARCH

FUNCTIONS USED:

S.No.	Function	Input	Output
1	get_map	number of cities	matrix containing the distance between each pair of cities
2	travelling	vehicle,next position	vehicle in the next position
3	resting_with_getting_charged	vehicle,percent	vehicle charged to percent of maximum battery charge
4	resting_without_getting_charged	vehicle	vehicle that waited for the charging port
5	destination_reahced	vehicle	vehicle mode changed to 'Destination Reached'
6	get_state	vehicle_list	State (as defined)
7	check_state	state	True if valdid, False otherwise
8	get_children_of_ev	vehicle	List of all possible next states of that vehicle
9	get_children_of_all_evs_in_a_specific_city	city	List of children of all vehicles in the city
10	get_children_of_all_evs	state	List of all possible next states of all vehicles
11	get_waiting_time	city	Time period vehicles in the city to rest for the charging port
12	get_states	state	List of all valid children states
13	goal_check	state	True if goal state, False otherwise
14	dijkstra_algorithm	current position, destination position	Minimum distance from the current position to destination position
15	heurisitc	state	Estimated heuristic of the state
16	path_cost	state	path cost function of the state
17	evaluation	state	value of evaluation function
18	get_min_f_n	list of states	minimum value of evaluation function
19	best_first_search	initial_state	Estimated best path to goal state
20	edge_cost	m, n	Value of edge cost between state m and state n

OPTIMAL ALGORITHM:

In case of optimal algorithm, the estimated heuristic functions of each node (state) are modified in such a way that the heuristic function is made **admissible: h(n) >= h(m) – c (m, n)**

This ensures that the evaluation function of a child is always greater than or equal to that of its parent node (**<u>f(n) >= f(m)</u>**). This makes the algorithm A* to find a solution that is optimal.