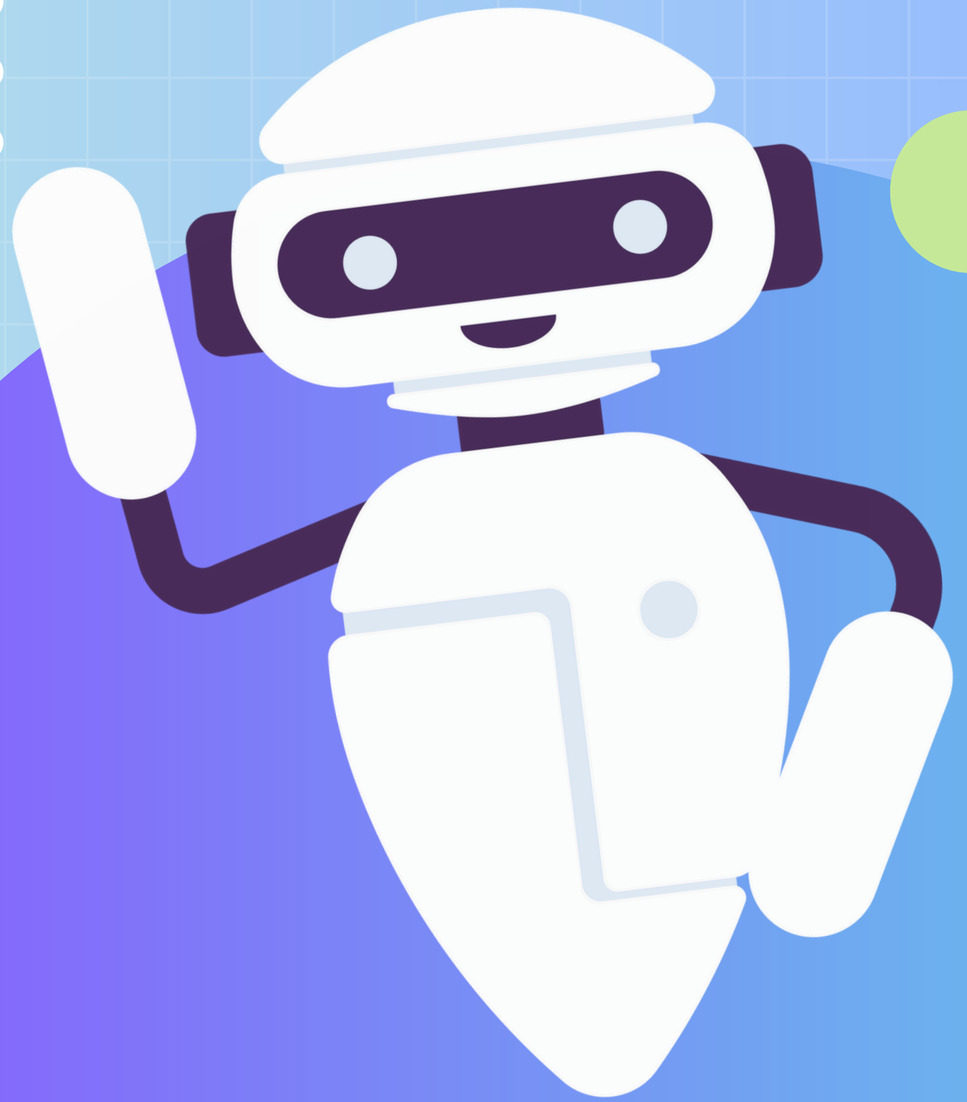
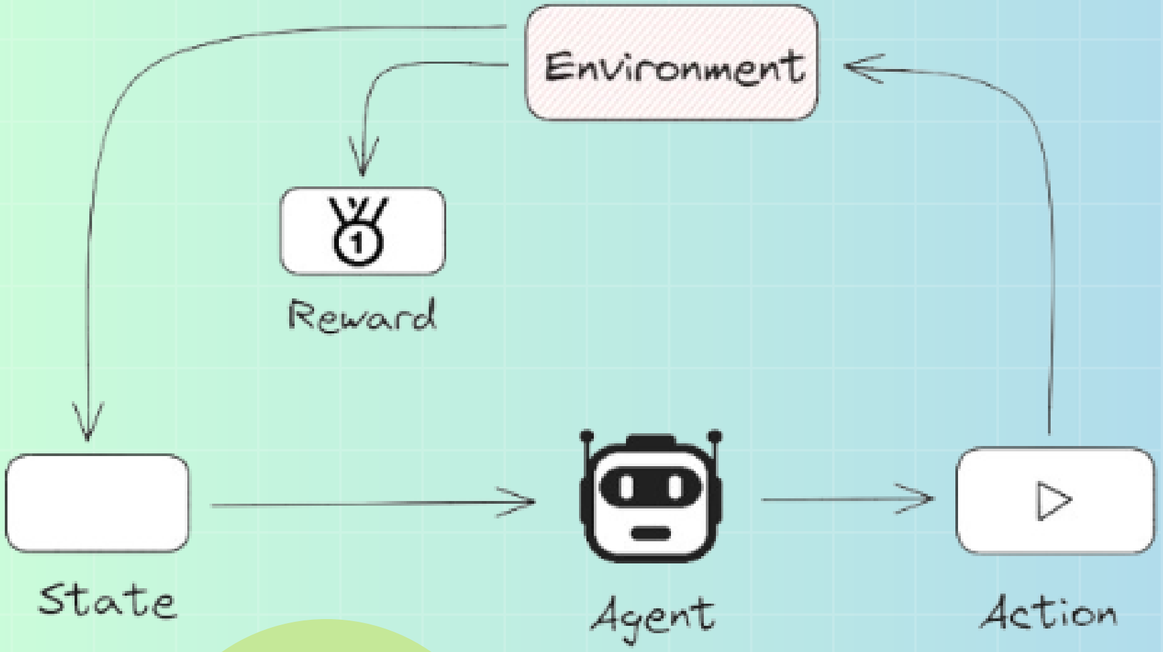
GCD
IF-A Pagi

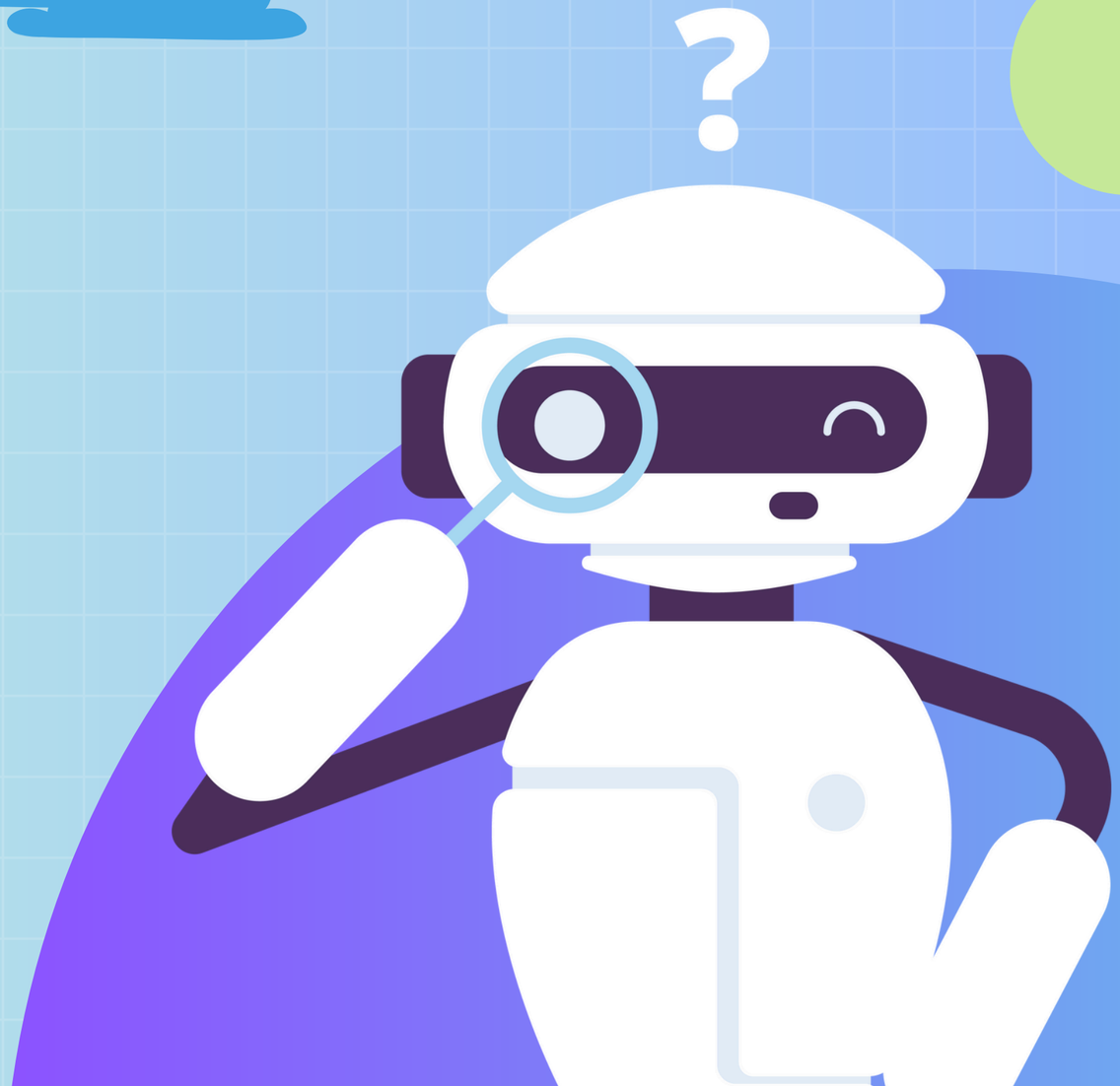
SMART NAVIGATION

Finding the Best Path with Q-Learning



WHY Q-LEARNING ON NAVIGATION?

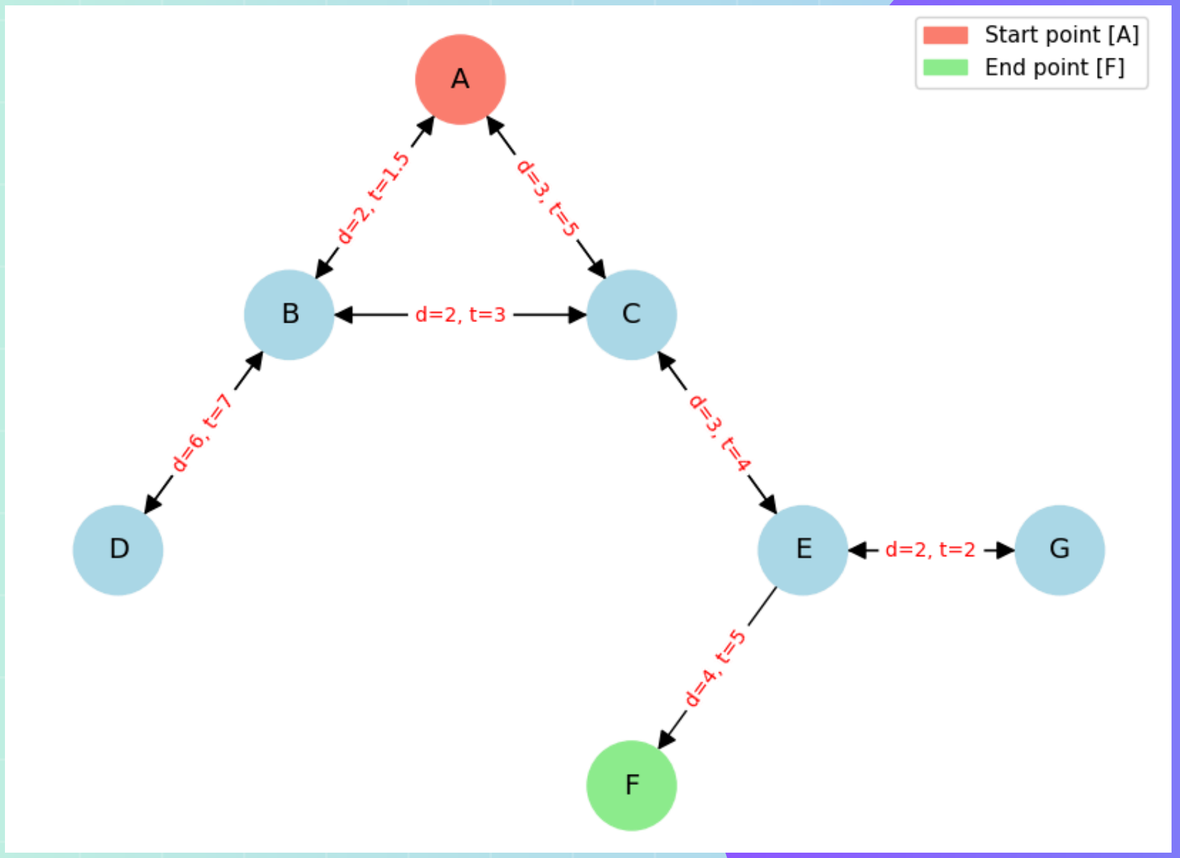




DEFINING MAP
as Graph

```
# Define the map as a graph with distances and travel times
graph = {
    'A': {'B': {'distance': 2, 'time': 1.5}, 'C': {'distance': 3, 'time': 5}},
    'B': {'A': {'distance': 2, 'time': 1.5}, 'C': {'distance': 2, 'time': 3}, 'D': {'distance': 6, 'time': 7}},
    'C': {'A': {'distance': 3, 'time': 5}, 'B': {'distance': 2, 'time': 3}, 'E': {'distance': 3, 'time': 4}},
    'D': {'B': {'distance': 6, 'time': 7}},
    'E': {'C': {'distance': 3, 'time': 4}, 'F': {'distance': 4, 'time': 5}, 'G': {'distance': 2, 'time': 2}},
    'F': {},  # Destination, no need outgoing paths
    'G': {'E': {'distance': 2, 'time': 2}},
}
```

VISUALIZE GRAPH



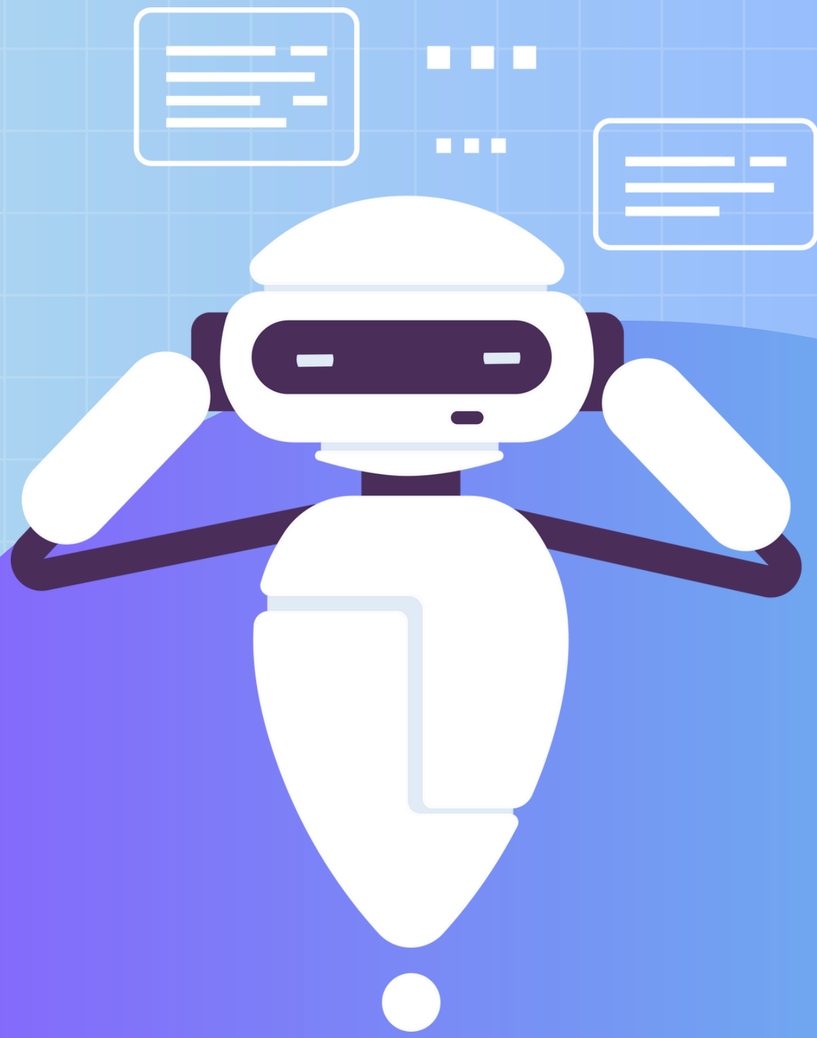
INITIALIZE PARAMETER & HYPERPARAMETERS

```
# Parameters
q_table = np.zeros((len(states), len(actions)))  # Q-table initialized with zeros

# Initialize Hyperparamaters
learning_rate = 0.3  # Alpha
discount_factor = 0.8  # Gamma
epsilon = 0.3  # Exploration rate
episodes = 100  # Number of episodes
traffic_factor = 1.5  # Simulate traffic impact (1 = normal, >1 = heavy traffic)
```

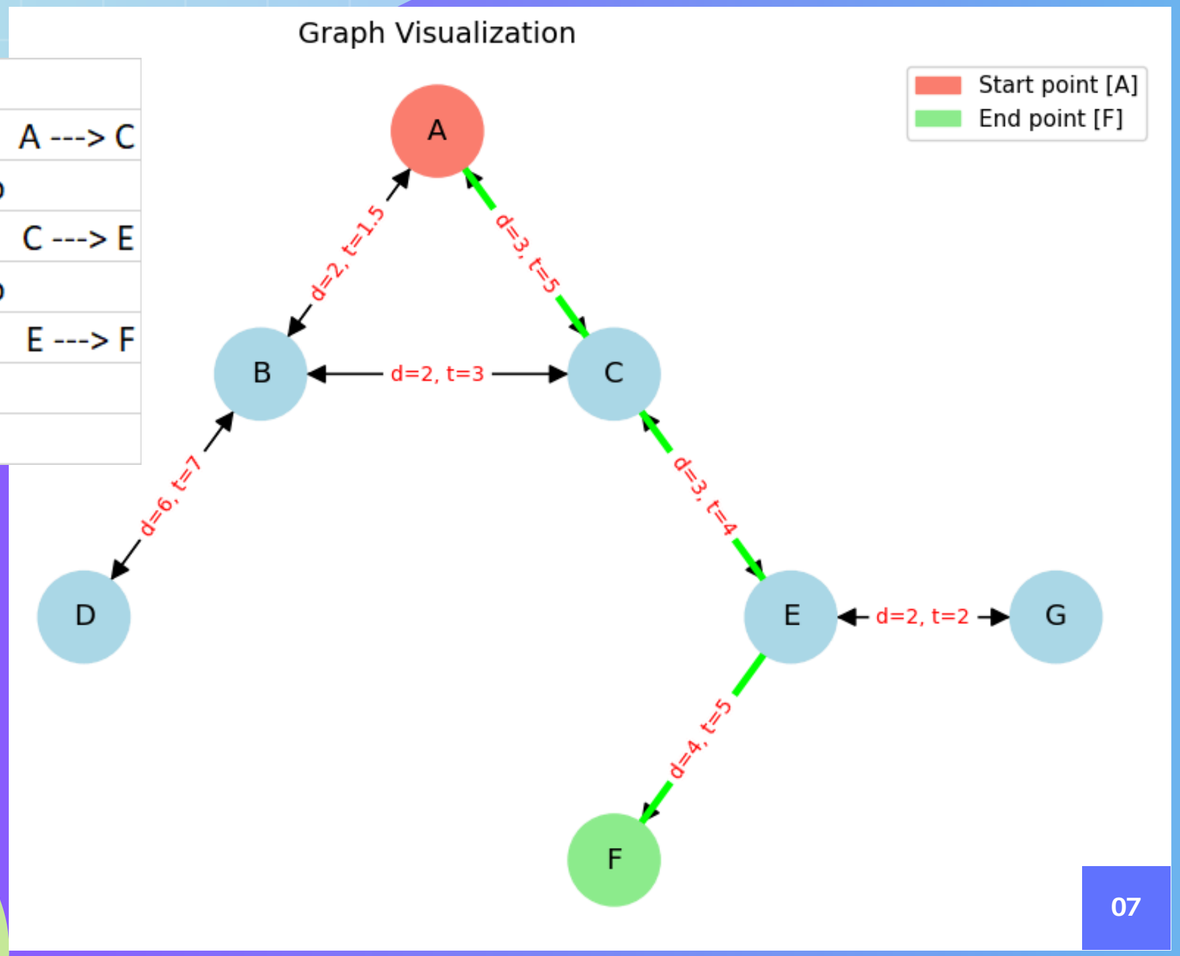
Q-TABLE

```
Learned Q-Table:
[[ 0.     -2.056   0.24    0.      0.      0.      0.    ]
 [-2.418   0.     -2.118  -1.469   0.      0.      0.    ]
 [-1.471  -2.464   0.      0.      0.181   0.      0.    ]
 [ 0.     -2.516   0.      0.      0.      0.      0.    ]
 [ 0.      0.     -1.459   0.      0.      0.087   0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.    ]]
```



VISUALIZATION

	A	B	C	D	E	F	G	
A	0	-2,056	0,240	0	0	0	0	A ---> C
B	-2,418	0	-2,118	-1,469	0	0	0	skip
C	-1,471	-2,464	0	0	0,181	0	0	C ---> E
D	0	-2,516	0	0	0	0	0	skip
E	0	0	-1,459	0	0	0,087	0	E ---> F
F	0	0	0	0	0	0	0	
G	0	0	0	0	0	0	0	

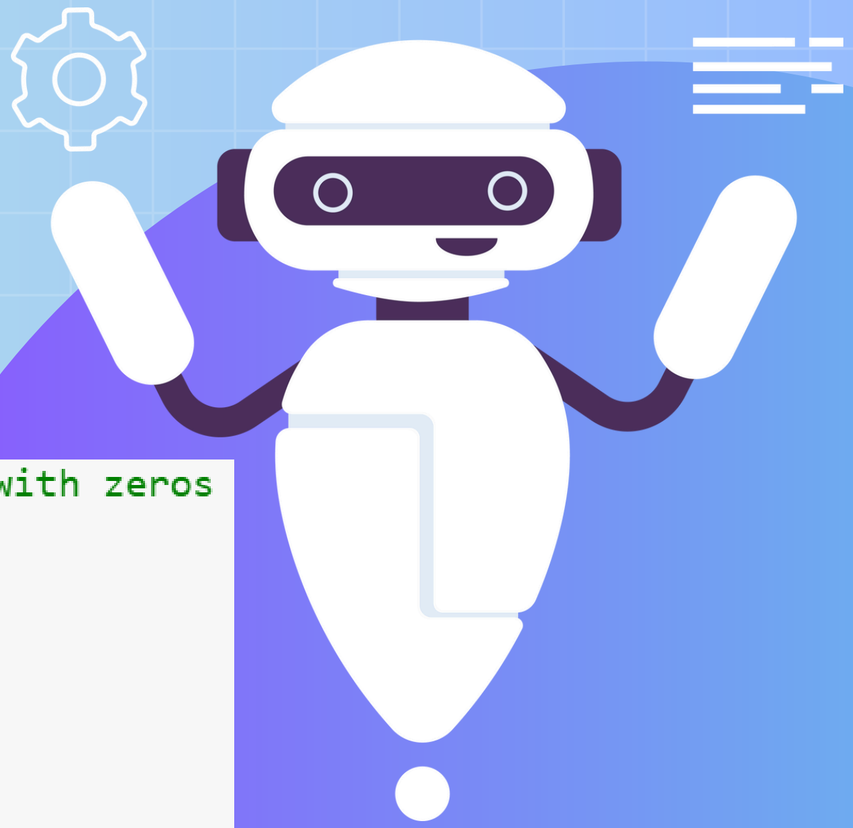


FINDING POSSIBLE PATHS

```
# Test the function
multi_paths = find_multiple_paths('A', 'F', num_trials=10)
```

```
[-] Path did not reach destination: A -> C -> E -> G
------------------------------------------------------------ (1)
[-] Path did not reach destination: A -> C -> E -> G
------------------------------------------------------------ (2)
[-] Path did not reach destination: A -> B -> D
------------------------------------------------------------ (3)
[+] New route found:
    A -> C -> E -> F
Total Distance: 10, Total Time: 21.0
------------------------------------------------------------ (4)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (5)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (6)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (7)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (8)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (9)
[-] Path did not reach destination: A -> B -> D
------------------------------------------------------------ (10)
```

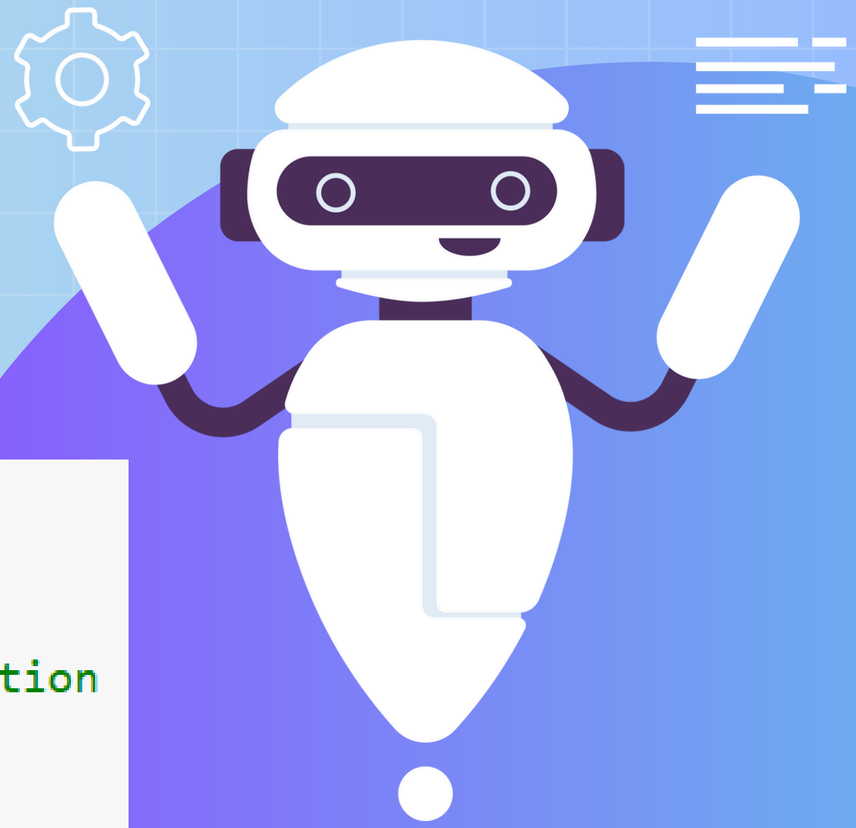
UPDATE HYPERPARAMETERS



```
q_table = np.zeros((len(states), len(actions)))  # Reset Q-table with zeros

# Updated Hyperparameters
learning_rate = 0.1  # Alpha; previous = 0.3
discount_factor = 0.9  # Gamma; previous = 0.8
epsilon = 0.3  # Exploration rate; same as previous
episodes = 100  # Number of episodes; same as previous
traffic_factor = 1.5  # Simulate traffic impact; same as previous
```

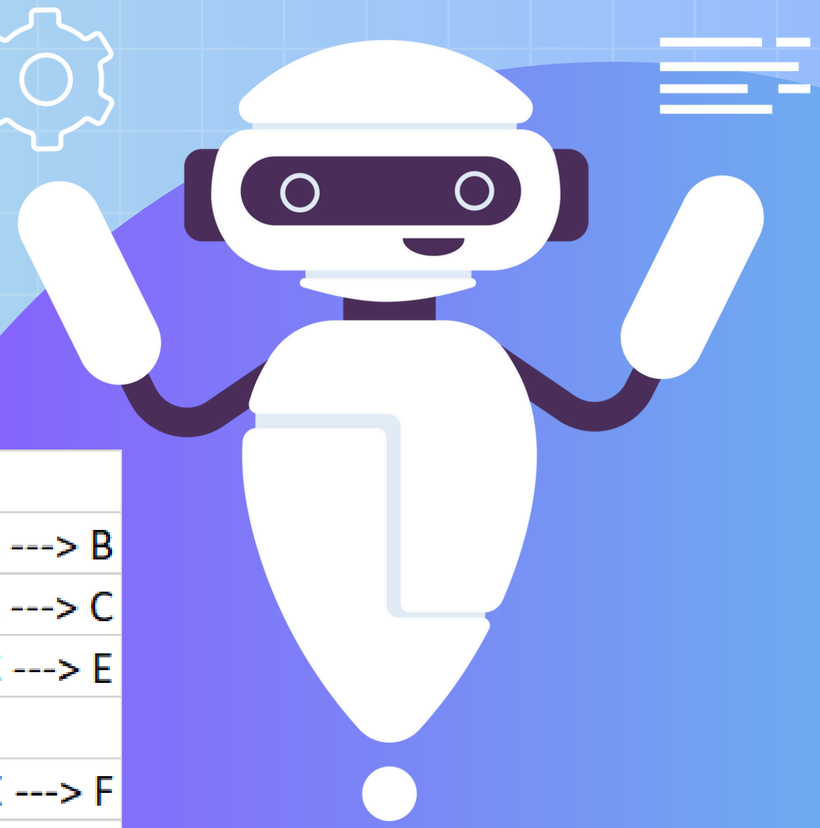
UPDATE RULES & REWARDS



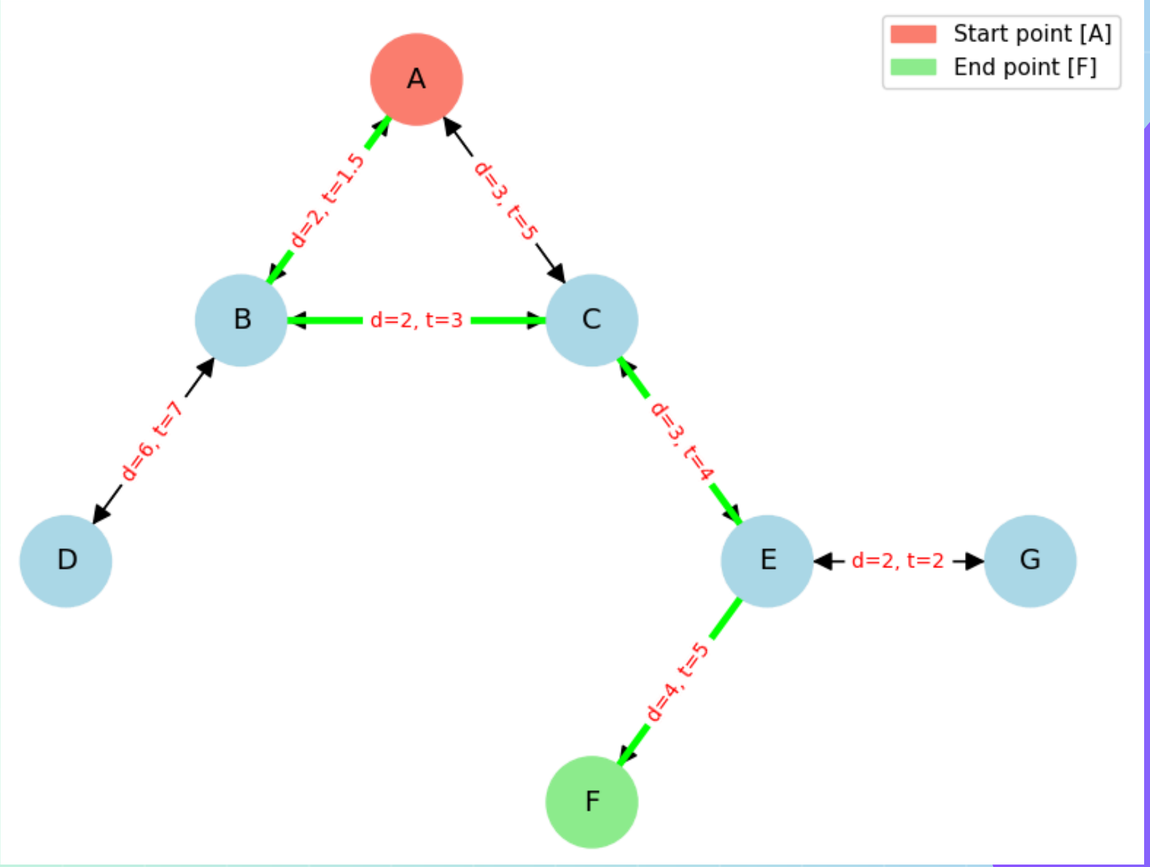
```
# Reward: Positive rewards with penalties for revisits
reward = 1 / (distance + time + 1e-7)  # Inverse of cost
if next_state == 'F':
    reward += 15  # Bonus reward for reaching the destination
elif next_state in visited_states:
    reward -= 5  # Additional penalty for revisiting
else:
    reward -= 1  # Penalty for not reaching the destination
```

UPDATED Q-TABLE

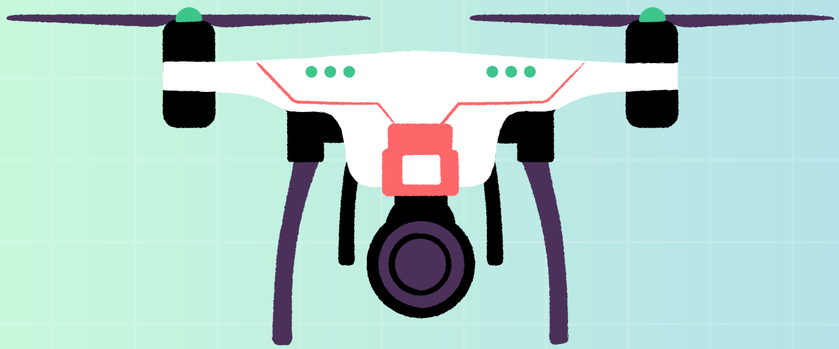
	A	B	C	D	E	F	G	
A	0	8,667	-1,005	0	0	0	0	A ---> B
B	-1,291	0	10,551	-1,047	0	0	0	B ---> C
C	-0,932	-0,921	0	0	12,685	0	0	C ---> E
D	0	-1,699	0	0	0	0	0	skip
E	0	0	-0,489	0	0	15,087	0	E ---> F
F	0	0	0	0	0	0	0	
G	0	0	0	0	0	0	0	



PATH VISUALIZATION



FINDING POSSIBLE PATHS



```
# Test the function
multi_paths = find_multiple_paths('A', 'F', num_trials=10)
```

```
[+] New route found:
    A -> B -> C -> E -> F
Total Distance: 11, Total Time: 20.25
------------------------------------------------------------ (1)
[-] Path did not reach destination: A -> B -> C -> E -> G
------------------------------------------------------------ (2)
[+] New route found:
    A -> C -> E -> F
Total Distance: 10, Total Time: 21.0
------------------------------------------------------------ (3)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (4)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (5)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (6)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (7)
[-] Path did not reach destination: A -> B -> C -> A
------------------------------------------------------------ (8)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (9)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (10)
```

DEFINE NEW MAP

```
# Example usage:
graph = {
    'A': {'B': {'distance': 2, 'time': 1.5}, 'C': {'distance': 3, 'time': 5}},
    'B': {'A': {'distance': 2, 'time': 1.5}, 'C': {'distance': 2, 'time': 3}, 'D': {'distance': 6, 'time': 7}},
    'C': {'A': {'distance': 3, 'time': 5}, 'B': {'distance': 2, 'time': 3}, 'E': {'distance': 3, 'time': 4}},
    'D': {'B': {'distance': 6, 'time': 7}},
    'E': {'C': {'distance': 3, 'time': 4}, 'F': {'distance': 4, 'time': 5}, 'G': {'distance': 2, 'time': 2}},
    'F': {'E': {'distance': 4, 'time': 5}},
    'G': {'E': {'distance': 2, 'time': 2}},
}
```

CREATE OBJECT FROM CLASS

```
# Initialize PathFinder with custom start and end points
path_finder = PathFinder(graph=graph, start_point='D', end_point='F')
```

CREATE OBJECT FROM CLASS

```
# Initialize PathFinder with custom start and end points
path_finder = PathFinder(graph=graph, start_point='D', end_point='F')
```

TRAIN THE AGENT

```
# Train the agent
path_finder.train()
```

```
Agent training Done!
```

SHOW THE Q-TABLE

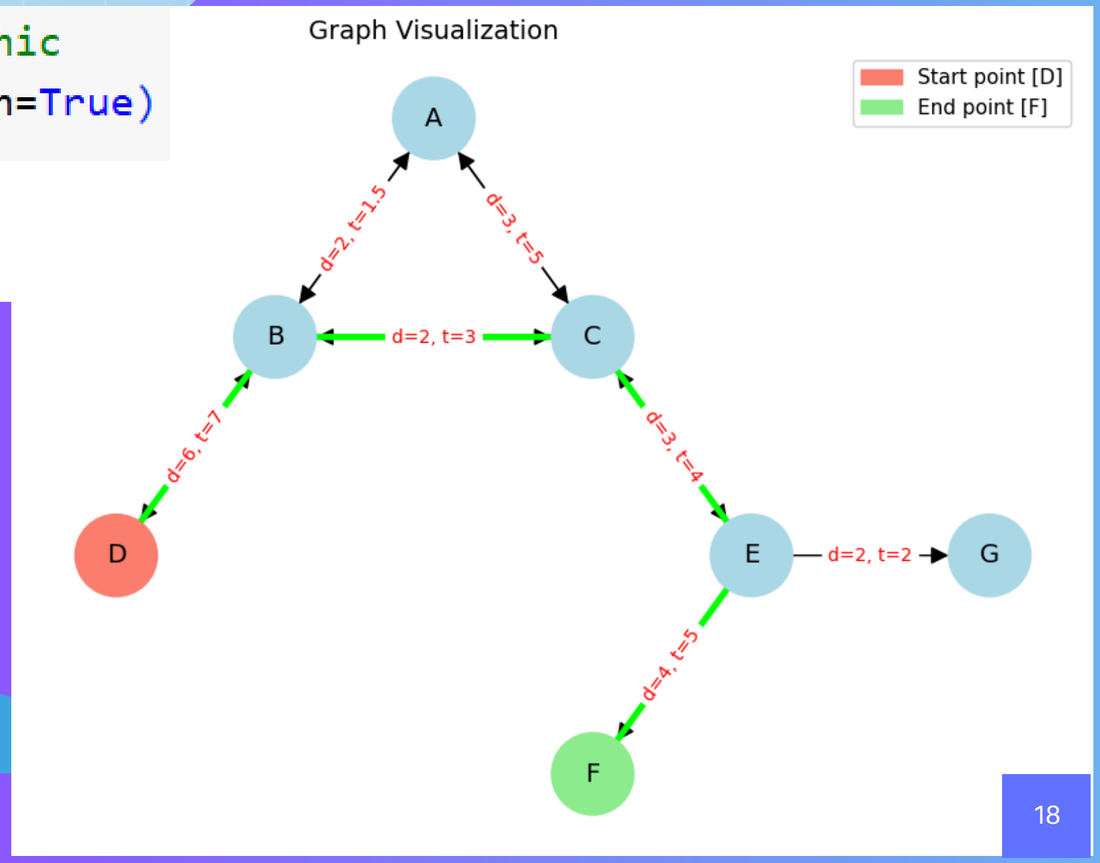
```
# Access the Q-table (after training)
q_table = path_finder.get_q_table()
```

```
Q-table:
[[ 0.      8.667 -1.005  0.      0.      0.      0.    ]
 [-1.291   0.    10.551 -1.047  0.      0.      0.    ]
 [-0.932 -0.921  0.      0.    12.685  0.      0.    ]
 [ 0.    -1.699  0.      0.      0.      0.      0.    ]
 [ 0.      0.    -0.489  0.      0.     15.087  0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.    ]
 [ 0.      0.      0.      0.      0.      0.      0.    ]]
```

SHOW THE OPTIMAL PATH

```
# Get the optimal path and visualize the path in graphic
optimal_path = path_finder.get_optimal_path(show_graph=True)
```

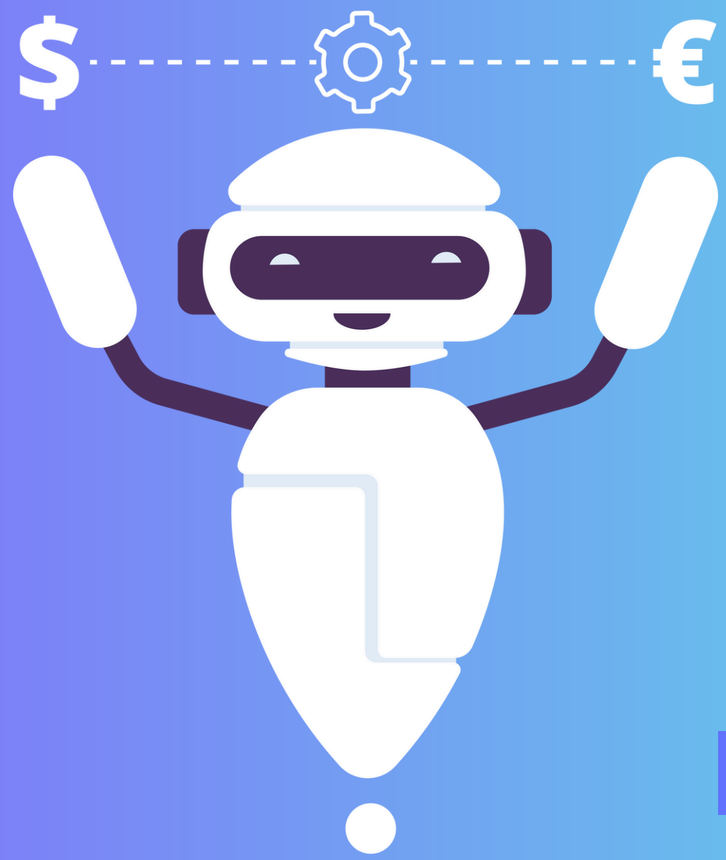
```
Optimal Path: A -> B -> C -> E -> F
Total Distance: 11, Total Time: 20.25
```

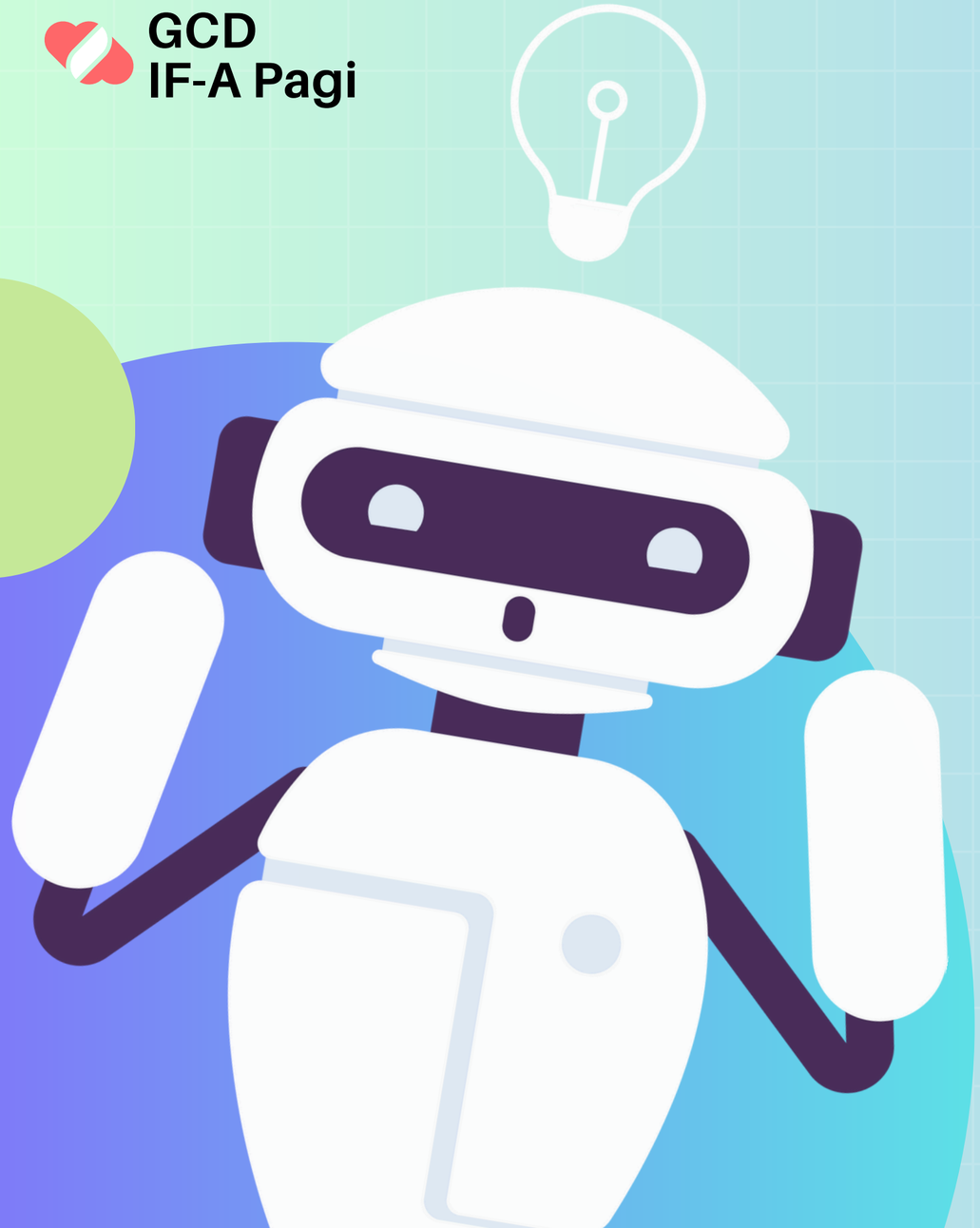


FIND MULTIPLE PATHS

```python
# Find multiple paths
multiple_paths = path_finder.find_multiple_paths(num_trials=10)
```

```
[+] New route found:
    A -> B -> C -> E -> F
Total Distance: 11, Total Time: 20.25
------------------------------------------------------------ (1)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (2)
[-] Path did not reach destination: A -> C -> E -> G
------------------------------------------------------------ (3)
[+] New route found:
    A -> C -> E -> F
Total Distance: 10, Total Time: 21.0
------------------------------------------------------------ (4)
[-] Path did not reach destination: A -> B -> C -> A
------------------------------------------------------------ (5)
[=] Route already explored.
    A -> C -> E -> F
------------------------------------------------------------ (6)
[-] Path did not reach destination: A -> B -> C -> A
------------------------------------------------------------ (7)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (8)
[=] Route already explored.
    A -> B -> C -> E -> F
------------------------------------------------------------ (9)
[+] New route found:
    A -> B -> A -> C -> E -> F
Total Distance: 14, Total Time: 25.5
------------------------------------------------------------ (10)
```





CONCLUSION & RECCOMENDATION

THANK YOU