part_1

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0.1 Artificial Intelligence Assignment 1

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Problem 1 The Following submission utilises the given city distance data in a *.csv* file.
I used LocationIQ to get `Latitude` & `Longitude` details of locations.
I used distance calculation formula provided at GeoData Source.

[1]:
```
import csv
import requests
import json
import time
from math import radians, sin, cos, acos, atan2, sqrt, pi as PI
from graphviz import Digraph
```

[70]:
```
def get_graph(graph:dict, all_cities:set, path=[]):
    dot = Digraph(comment='City Graph', strict=True, graph_attr={'size': '10,10!
 ↪'}, node_attr={'color': '#AAAAAA'})

    edges = set()
    for i in all_cities:
        if i in path:
            dot.node(i,i,color='#006992', style="filled", fontcolor="white")
    dot.node(path[0],path[0],color='#006992', style="filled",␣
 ↪fontcolor="white", shape="doublecircle")
    if path:
        for i in range(len(path)-1):
            s,d = path[i:i+2]
            dot.edge(s,d, label=str(graph[s][d]), color='green')
            edges.add((s,d))
    for x in graph.keys():
        for y in graph[x].keys():
            if (x,y) not in edges and (y,x) not in edges and x != y:
                edges.add((x,y))
                dot.edge(x,y, label=str(graph[x][y]), dir='none',␣
 ↪color='#DDDDDD')
    return dot
```

Mentioning keys required for LocationIQ API

[71]:
```
LOC_IQ_API_KEY='2e9d2aa2d46004'
LOC_IQ_URL = "https://us1.locationiq.com/v1/search.php"
```

Get latitude and longitude details from LocationIQ API

[72]:
```
def get_lat_long(location):
    data = {
        'key': LOC_IQ_API_KEY,
        'q': location,
        'format': 'json'
    }
    response = requests.get(LOC_IQ_URL, params=data)
    data = json.loads(response.text)
    if data:
        try:
            return list(map(float,(data[0]['lat'], data[0]['lon'])))
        except:
            print(data)
    return None
```

Direct Distance formula for latitude and longitude

[52]:
```
def direct_distance(s, d):
    if s is None or d is None:
        return None
    if s == d:
        return 0
    lat1,lon1 = s
    lat2,lon2 = d
    radlat1 = PI * lat1/180
    radlat2 = PI * lat2/180
    theta = lon1 - lon2
    radtheta = PI * theta/180
    dist = sin(radlat1) * sin(radlat2) + cos(radlat1) * cos(radlat2) *␣
 ↪cos(radtheta)
    if dist > 1:
        dist = 1
    dist = acos(dist)
    dist = dist * 180/PI
    dist = dist * 60 * 1.1515 * 1.609344
    return round(dist,2)
```

Load data from *.csv file* We load the data in a 2d dictionary

[53]:
```
f = open('indian_capitals.csv')
data = csv.reader(f)
```

[54]:

```
all_cities = set()
city_dist = dict()
for i in data:
    # Read Line from file
    s_city, d_city, dist = i

    # Add entry for city if not already exists
    if s_city not in city_dist:
        city_dist[s_city] = dict()
        all_cities.add(s_city)
    if d_city not in city_dist:
        city_dist[d_city] = dict()
        all_cities.add(d_city)

    # Add the city distances in the dictionary
    city_dist[s_city][d_city] = int(dist)
    city_dist[d_city][s_city] = int(dist)

# Close the file
f.close()
```

Retrieve Location details of all provided cities We did this to pervent redundant calls to API

[55]:

```
# all_city_coordinates = dict()
# tmp = set(all_cities)
# while len(tmp) > 0:
#     try:
#         i = tmp.pop()
#         all_city_coordinates[i] = get_lat_long(i)
#     except:
#         tmp.add(i)
#         time.sleep(10)
```

Cached data of previous command Since the latitude and longitudes of cities are not gonna change every minute .

[56]:

```
# The cached data from previous command
all_city_coordinates = {'Thiruvanathapuram': [8.54145, 76.9704251],
 'Ranchi': [23.3700354, 85.3250132],
 'Chennai': [13.0801721, 80.2838331],
 'Panaji': [15.4989946, 73.8282141],
 'Shimla': [31.1041526, 77.1709729],
 'Lucknow': [26.8381, 80.9346001],
 'Bhopal': [23.2530923, 77.3962718],
 'Srinagar': [34.0747444, 74.8204443],
 'Dispur': [26.1513079, 91.793380495259],
 'Shillong': [25.5760446, 91.8825282],
 'Agartala': [23.8312377, 91.2823821],
 'Itanagar': [27.0979659, 93.6237291],
 'Kohima': [25.75, 94.166667],
 'Raipur': [21.2379469, 81.6336833],
 'Aizawl': [23.7414092, 92.7209297],
 'Bhubaneswar': [20.2667774, 85.8435592],
 'Hyderabad': [25.3801017, 68.3750376],
 'Chandigarh': [30.7194022, 76.7646552],
 'Mumbai': [18.9387711, 72.8353355],
 'Gandhinagar': [23.2232877, 72.6492267],
 'Patna': [25.6093239, 85.1235252],
 'Imphal': [24.8006088, 93.9369998],
 'Dehradun': [30.3255646, 78.0436813],
 'Gangtok': [27.329046, 88.6122673],
 'Jaipur': [26.916194, 75.820349],
 'Bangalore': [12.9791198, 77.5912997],
 'Kolkata': [22.5677459, 88.3476023],
 'Amaravathi': [10.7848857, 77.5897043]}
```

Calculate distance between each pair of city

[57]:

```
city_dist_eucl = dict()
for i in all_cities:
    city_dist_eucl[i] = dict()
    for j in all_cities:
        a,b = all_city_coordinates[i], all_city_coordinates[j]
        city_dist_eucl[i][j] = direct_distance(a,b)
```

Fuction to verify equality of two values

[58]:

```
def EQUAL(node, dest):
    return node == dest
```

Function to verify if two sets intersects

[59]:

```
def INTERSECTING_SETS(set1, set2):
    return len(set1.intersection(set2)) > 0
```

Code for Breadth First Search

[60]:

```
def SEARCH_BFS(source, destination, goal_test):
    frontier = [source]
    visited = set()
    parent = dict()
    parent[source] = source

    # While there are nodes to be explored
    while frontier:
        # Pop the first element
        current = frontier.pop(0)

        # If element is already visited then skip
        if current in visited:
            continue

        # Add current node to visited nodes
        visited.add(current)

        # Check if goal state condition is reached
        if goal_test(current, destination):
            break

        # Add all the child/neigbour to frontier
        if current in city_dist:
            for i in city_dist[current].keys():
                # Do not add visited node again
                if i not in visited:
                    frontier.append(i)
                    parent[i] = current

    path = []

    # Find path to reach the goal state
    if destination in visited:
        s = destination
        while s not in path:
            path.append(s)
            s = parent[s]
        return path[::-1]
    else:
        print("Not Found!")
        return []
```

Code for Depth First Search

[61]:

```
def SEARCH_DFS(source, destination, goal_test):
    frontier = [source]
    visited = set()
    parent = dict()
    parent[source] = source

    # While there are nodes to be explored
    while frontier:
        # Pop the first element
        x = frontier.pop(-1)

        # If element is already visited then skip
        if x in visited:
            continue

        # Check if goal state condition is reached
        visited.add(x)

        # Add all the child/neigbour to frontier
        if goal_test(x, destination):
            break

        # Do not add visited node again
        if x in city_dist:
            for i in city_dist[x].keys():
                if i not in visited:
                    frontier.append(i)
                    parent[i] = x

    path = []

    # Find path to reach the goal state
    if destination in visited:
        s = destination
        while s not in path:
            path.append(s)
            s = parent[s]
        return path[::-1]
    else:
        print("Not Found!")
        return []
```

Code for Bi-Direction Breadth First Search

[62]:

```
def SEARCH_BI_DIR_BFS(source, destination, goal_test):
    frontier1 = [source]
    frontier2 = [destination]
    visited1 = set()
    visited2 = set()
    parent1 = dict([(source, source)])
    parent2 = dict([(destination, destination)])


    # While there are nodes to be explored
    while frontier1 and frontier2:
        if frontier1:
            # Pop the first element
            s_node = frontier1.pop(0)

            # If element is already visited then skip
            if s_node in visited1:
                continue

            # Add current node to visited nodes
            visited1.add(s_node)

            # Check if goal state condition is reached
            if goal_test(visited1, visited2):
                break

            # Add all the child/neigbour to frontier
            if s_node in city_dist:
                for i in city_dist[s_node].keys():
                    # Do not add visited node again
                    if i not in visited1:
                        frontier1.append(i)
                        parent1[i] = s_node

        if frontier2:
            # Pop the first element
            d_node = frontier2.pop(0)

            # If element is already visited then skip
            if d_node in visited2:
                continue

            # Add current node to visited nodes
            visited2.add(d_node)

            # Check if goal state condition is reached
            if goal_test(visited1, visited2):
                break

            # Add all the child/neigbour to frontier
            if d_node in city_dist:
                for j in city_dist[d_node].keys():
                    # Do not add visited node again
                    if j not in visited2:
                        frontier2.append(j)
                        parent2[j] = d_node

    path1 = []
    path2 = []
    # Find path to reach the goal state
    if visited1.intersection(visited2):
        mid = visited1.intersection(visited2).pop()
        s = mid
        while destination not in path1:
            path1.append(s)
            s = parent2[s]
        s = mid
        while source not in path2:
            path2.append(s)
            s = parent1[s]
        return path2[::-1] + path1[1:]
    else:
        print("Not Found!")
        return []
```

Code for A Search

[63]:
```
def SEARCH_A_STAR(source, destination, goal_test, heuristic=lambda x,y:␣
 ↪city_dist_eucl[x][y]):
    frontier = [(source, 0)]
    visited = set()
    parent = dict()
    parent[source] = source

    # While there are nodes to be explored
    while frontier:
        # Sort Frotier according to
        frontier.sort(key=lambda x: x[1] + heuristic(x[0], destination))

        # Pop the first element
        x,c = frontier.pop(0)

        # If element is already visited then skip
        if x in visited:
            continue

        # Check if goal state condition is reached
        visited.add(x)

        # Add all the child/neigbour to frontier
        if goal_test(x, destination):
            break

        # Do not add visited node again
        if x in city_dist:
            for i in city_dist[x].keys():
                if i not in visited:
                    frontier.append((i, c + city_dist[x][i]))
                    parent[i] = x

    path = []

    # Find path to reach the goal state
    if destination in visited:
        s = destination
        while s not in path:
            path.append(s)
            s = parent[s]
        return path[::-1]
    else:
        print("Not Found!")
        return []
```

[64]:

```
SEARCH_BFS('Bangalore', 'Patna', EQUAL)
```

[64]:

```
['Bangalore',
 'Amaravathi',
 'Bhubaneswar',
 'Raipur',
 'Ranchi',
 'Lucknow',
 'Patna']
```

[65]:

```
SEARCH_DFS('Bangalore', 'Patna', EQUAL)
```

[65]:

```
['Bangalore', 'Hyderabad', 'Mumbai', 'Raipur', 'Ranchi', 'Patna']
```

[66]:

```
SEARCH_BI_DIR_BFS('Bangalore', 'Patna', INTERSECTING_SETS)
```

[66]:

```
['Bangalore', 'Amaravathi', 'Bhubaneswar', 'Ranchi', 'Lucknow', 'Patna']
```

[67]:

```
SEARCH_A_STAR('Bangalore', 'Patna', EQUAL)
```

[67]:

```
['Bangalore', 'Hyderabad', 'Raipur', 'Ranchi', 'Patna']
```

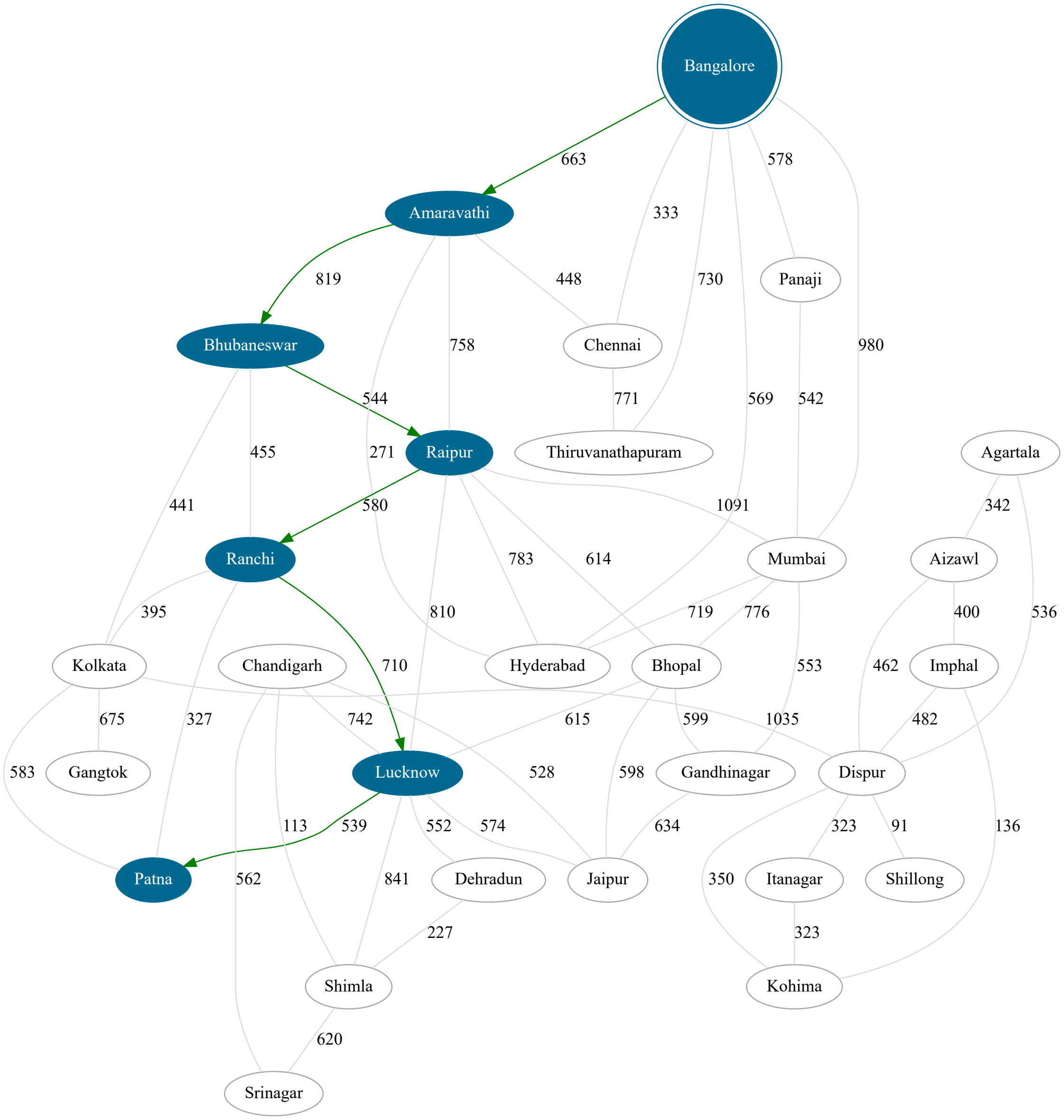
[75]:

```
def SEARCH():
    ALGO = {
        'BFS': SEARCH_BFS,
        'DFS': SEARCH_DFS,
        'BDBFS': SEARCH_BI_DIR_BFS,
        'ASTAR': SEARCH_A_STAR,
    }
    source = input("Enter Source:")
    destination = input("Enter Destination:")
    algo = input("Enter Algo:")
    if algo in ALGO:
        path = ALGO[algo](source, destination, (EQUAL if (algo != 'BDBFS') else␣
↪INTERSECTING_SETS))
        return get_graph(city_dist, all_cities, path)
```

[76]:
```
SEARCH()
```

```
Enter Source: Bangalore
Enter Destination: Patna
Enter Algo: BFS
```

[76]:



Bangalore
663
578
Amaravathi
333
819
448
730
Panaji
Bhubaneswar
758
Chennai
980
544
771
569
542
455
271
Raipur
Thiruvanathapuram
Agartala
441
580
1091
342
Ranchi
783
614
Mumbai
Aizawl
395
810
719
776
400
536
Kolkata
Chandigarh
710
Hyderabad
Bhopal
553
462
Imphal
675
327
742
615
599
1035
482
583
Gangtok
Lucknow
528
598
Gandhinagar
Dispur
113
539
552
574
634
323
91
136
Patna
562
841
Dehradun
Jaipur
350
Itanagar
Shillong
227
323
Shimla
Kohima
620
Srinagar