

Hamiltonian Path Application

Travelling Salesman Problem

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Problem Statement

A salesman wants to visit a number of cities which are connected. The distance between any two cities is known. Which is the order in which the salesman should visit the cities so that he minimizes the total distance he walks? The problem is to find Hamiltonian path with minimum weight.

An equivalent formulation in terms of graph theory is: Given a complete weighted graph (where the vertices would represent the cities, the edges would represent the roads, and the weights would be the cost or distance of that road), find a Hamiltonian path with the least weight.

Algorithm

Insight into algorithm for finding a Hamiltonian Path:

A Hamiltonian Path in a graph having N vertices is nothing but a permutation of the vertices of the graph $[v_1, v_2, v_3, \dots, v_{N-1}, v_N]$, such that there is an edge between v_i and v_{i+1} where $1 \leq i \leq N-1$. So it can be checked for all permutations of the vertices whether any of them represents a Hamiltonian Path or not.

1. We have introduced weighted directed edges between the cities.
2. We have implemented the same in PyGame and the result of which is shown in the video in the zip file.

Basic outline of Code

The program takes a graph as an input in the form a dictionary whose keys are the vertices and the values are the corresponding neighboring vertices.

It identifies the edges in the graph, and subsequently asks for the respective weights of each.

On inputting the edges, it finds all the possible Hamiltonian paths in the code, and then chooses the smallest one of them.

Steps to run the code

1. Run the code in command prompt by writing: `python "AdvancedTSP.py"`.
It asks the user to input a dictionary in 'vertices : [all its neighbouring vertices] form'.
2. Enter the Sample input of dictionary. An example of the same is:
a. `{ "a" : ["d","e"], "b" : ["c","d"], "c" : ["b", "d", "e"], "d" : ["a","b", "c"], "e" : ["c","a"] }`
3. It identifies and display the edges in the graph, and subsequently asks for the respective weights of each. Care has to be taken to enter the weights of edges (i,j) and (j,i) as same, otherwise it will return a faulty output.
A sample input of weights (corresponding to the sample input of vertices provided above) is:
`[1,2,3,4,5,3,6,5,2,1,6,4]`
4. This displays the path which shall take the minimum amount to travel all the cities in term of edges and in the term of vertices separately.

RESULTS

1. Identification of edges from the graph

```
Command Prompt - python "AdvancedTSP (2).py" the weights of each edge in the same order in list format.
C:\Users\Anmol Gupta\Desktop\TSP>python "AdvancedTSP (2).py"
Input a dictionary in 'vertex : [all its neighbouring vertices]' form
{ "a" : ["d","e"],"b" : ["c","d"],"c" : ["b", "d", "e"],"d" : ["a","b", "c"],"e" : ["c","a"],"f" : []}
These are the edges that have been identified in the graph:
[('a', 'd'), ('a', 'e'), ('c', 'b'), ('c', 'd'), ('c', 'e'), ('b', 'c'), ('b', 'd'), ('e', 'c'), ('e', 'a'),
 ('d', 'a'), ('d', 'b'), ('d', 'c')]
Please enter the weights of each edge in the same order in list format:
for i in weights:
    weighted_edges[temp_edges[j]] = i
    j+=1

print ("These are the assigned weights to the edges:")
print (weighted_edges)
all_ham_paths_in_tupleformat=gobj.edgeslist_from_path() #finding the shortest path in terms of
minsum=sum(weights)
shortest_way_edges=List()
for i in all_ham_paths_in_tupleformat:
    tempsum=0
    for j in i:
        tempsum=tempsum+weighted_edges[j]
    if (tempsum<minsum):
        minsum=tempsum
        shortest_way_edges=i
```

3. Assignment of weights to edges

```
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Input a dictionary in 'vertex : [all its neighbouring vertices]' form
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These are the edges that have been identified in the graph:
[('a', 'd'), ('a', 'e'), ('c', 'b'), ('c', 'd'), ('c', 'e'), ('b', 'c'), ('b', 'd'), ('e', 'c'), ('e', 'a'),
 ('d', 'a'), ('d', 'b'), ('d', 'c')]
Please enter the weights of each edge in the same order in list format:
[1,2,3,4,5,3,6,5,2,1,6,4]
These are the assigned weights to the edges:
{('b', 'c'): 3, ('d', 'c'): 4, ('d', 'b'): 6, ('c', 'b'): 3, ('d', 'a'): 1, ('a', 'e'): 2, ('a', 'd'): 1, ('c', 'd'): 4, ('e', 'a'): 2, ('e', 'c'): 5, ('c', 'e'): 5, ('b', 'd'): 6}

minsum=tempsum
shortest_way_edges=i
nt ('The path which shall take the minimum amount of time to travel to all cities (in terms of
nt (shortest_way_edges)
test_way_vertices=[]
i in shortest_way_edges:
    from shortest_way_edges to shortest_way in the for
    for j in i:
        if j not in shortest_way_vertices:
            shortest_way_vertices.append(j)
nt ('The path which shall take the minimum amount of time to travel to all cities (in terms of
nt (shortest_way_vertices)

one code starts-
```


2. Assignment of weights to edges

```
Command Prompt - python "AdvancedTSP (2).py"

C:\Users\Anmol Gupta\Desktop\TSP>python "AdvancedTSP (2).py"
Input a dictionary in 'vertex : [all its neighbouring vertices]' form
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These are the edges that have been identified in the graph:
[('a', 'd'), ('a', 'e'), ('c', 'b'), ('c', 'd'), ('c', 'e'), ('b', 'c'), ('b', 'd'), ('e', 'c'), ('e', 'a'),
 ('d', 'a'), ('d', 'b'), ('d', 'c')]
Please enter the weights of each edge in the same order in list format:
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one code starts-
```

References

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- https://www.python-course.eu/graphs_python.php
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- <https://pythonprogramming.net/>
- <http://www.nerdparadise.com/programming/pygame/part1>
- <https://www.hackerearth.com/practice/algorithms/graphs/hamiltonian-path/tutorial/>
- http://www.csd.uoc.gr/~hy583/reviewed_notes/euler.pdf

Work Distribution

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