Public conveyance system for shortest path finding for real road network

Agam Mathur[1], Mayuresh Jakhotia[2], Anish Lavalekar[3], Nikita Magar[4]

Abstract: This article analyzes problems of determining the shortest path and optimal route amongst the given stoppages. The model of the problem is presented as a directional graph, where nodes are pickup points (termed as stoppage point in database) and crossings outside stoppage points and edges are roads among stoppage points and crossings. Each node has some information attached to it: stoppageId, stoppageName, latitude, longitude and numberOfPassengers of the stop, maintenance organizations, and mark(s) of the crossing(s). All pickup points are connected by roads. These roads are considered as the edges of the graph. Edges also have information attached to it: roadId, source, destination, distance, time etc. We have selected Floyd Warshall algorithm to find the shortest path between two stoppages. This algorithm works in two stages: in first stage, it finds the shortest path between all stoppages, and in second stage it finds optimized route to visit some of these stoppages. The solution is displayed in the form of shortest distance and time between two locations. The program is written in java language. It uses 3 tables as input from database: nodes, vehicle details and road. This paper gives implementation outcome of Floyd Warshall algorithm to solve the all pairs shortest path problem for directed road graph system. We have considered an example of a map of Pune.

Keyword: Adjacency matrix, intermediate path, optimal route, shortest path, transitive closure

I. Introduction

Now days in the current scenario companies and schools provide transportation facilities to their employees and students from their organizations to their respective houses and vice versa. The purpose of this article is to present an interface between a traveling agency and its traveler so that, the subscriber can keep a track of the service they have subscribed. A key problem in public conveyance system is the computation of shortest paths between different locations for a given region. Sometimes this computation has to be done in real time. During the literature survey we found how difficult it is to find the shortest path covering all pickup points and how to allocate available transport vehicles to these specific routes manually. There is always a need to find optimal path for their operational viability. So, just the idea that our system will help in efficient allocation of vehicles and shortest route creation to save time and fuel consumption. The system scope is to design such system for a small area of the city.

II. Algorithms To Find Shortest Path

There are various algorithms[9] present in literature to find shortest path between two points from source location to destination location such as Dijkstra’s, Bellman ford, A*, Johnson’s and Floyd-Warshall algorithm. After conducting extensive research on the existing shortest path algorithms, it was observed that Floyd - Warshall shortest path algorithm is the most appropriate for calculating short -est paths in real -road networks since it involves calculation of shortest path between all pair vertices. Also, this is the fastest and simplest algorithm.

III. Methods

1. The Floyd Warshall algorithm

The Floyd - Warshall algorithm[2][4][5][7][9] (also known as Floyd’s algorithm, Roy - Warshall algorithm, Roy - Floyd algorithm, or the WFI algorithm). This algorithm is a graph analysis algorithm, which is used for finding transitive closure of a relation R and also for finding shortest paths in a weighted graph. Weighted graph may be with positive or negative edge weights (but with no negative cycles).

It is a all pair shortest path algorithm, so single execution of the Floyd Warshall algorithm finds lengths of all the shortest paths between each and every pair of vertices present in the graph, thus it does not returns details of the path themselves. To nd all pair of vertices in a graph Floyd Warshall algorithm will be used. This algorithm is competitive for dense graphs and uses adjacency matrices as opposed to adjacency lists.

Consider an instance for TSP is given by W as, Represent the directed, edge weighted graph in adjacency matrix form.
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W= matrix of weights =

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: $w_{ij}$ is the weight of edge $(i, j)$, or infinity if there is no such edge.

: Return a matrix $D$, where each entry $d_{ij}$ is $d(i,j)$. Could also return a predecessor matrix, $P$, where each entry $p_{ij}$ is the predecessor of $j$ on the shortest path from $i$. Adjacency may consist of two types of values any number for weighted edge value, zero value for self loop of a node and some in infinity value which shows there is no path present between two nodes in the graph. Consider intermediate vertices of a path:

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\text{Figure 1: Intermediate vertices of path.}
\]

Consider we know the length of the shortest path between nodes $i$ and $j$ whose intermediate vertices are only those with numbers 1, 2, ..., $k-1$. Now to extend this from $k-1$ to $k$. Here we need to find path which will be the shortest path between vertices $i$ and $j$. We can use following two possible ways:

Two possibilities:
1. Going through the vertex $k$ does not help the path through vertices 1...$k-1$ is still the shortest.
2. There is a shorter path consisting of two sub paths, one from $i$ to $k$ and one from $k$ to $j$. Each sub path passes only through vertices numbered 1 to $k$-1. Thus, $d_{ij}^{(k)} = \min(d_{ij}^{(k-1)}, d_{ik}^{(k-1)} + d_{kj}^{(k-1)})$

Also, $d_{ij}$ (since there are no intermediate vertices.) When $k = |V|$, we are done. Let $n$ be $|V|$, the number of vertices. To find all $n^2$ of shortestPath($i,j,k$) (for all $i$ and $j$) from those of shortestPath($i,j,k-1$) requires $2n^2$ operations. Since we begin with shortestPath($i,j,0$) = edgeCost($i,j$) and compute the sequence of $n$ matrices shortestPath($i,j,1$), shortestPath($i,j,2$),..., shortestPath($i,j,n$), the total number of operations used is $n : 2n^2 = 2n^2$. Therefore, the complexity of the algorithm is $(n^3)$.[5],[6]

Here Floyd Warshall algorithm consider all nodes as the index of matrix and take adjacency matrix as a input considering elements in the matrix as the values of edges of directed graph. Then it

\[
\text{Figure 2: Alternative Intermediate vertices of path using Floyd Warshall algorithm.}
\]

will find transitive closure for a given adjacency matrix which will consist of shortest path between each and every vertices present in the graph.

IV. Implementation And Results

The Floyd Warshall algorithm has been tested on an example map of particular region considering one common source. E.g. Pune city with consideration of DPS school as common source for all destinations. We have started the search from DPS school, covering all nodes in the map of Pune city which are present in our database.
Our database consists of three tabular entities nodes (Figure 3), road (Figure 4) and vehicle details (Figure 5). The table nodes consist of the details about the stoppages. It consists of the fields stoppage id, stoppage name, latitude, longitude and number of students. The table road consists of the information about the road which consist of fields road id, source id, destination id, distance and time in which source and destination are referred to stoppage id in nodes table. The third table vehicle details consist of the information about the vehicles. It consist of vehicle id, registration no and seating capacity.

After creating a database we find the shortest path between all stoppages using Floyd Warshall algorithm. This algorithm needs adjacency matrix as input considering all stoppages as vertices. Then we use this matrix for further requirement of Floyd Warshall. In next step Floyd Warshall create transitive closure matrix which consist of shortest distance between all stoppages as it is an all-pair shortest path algorithm. After finding the shortest path between required pair of stoppages, system is able to display the shortest path from required source for different vehicles. There may be the situation occurs that the same stoppage consist of more than one routes with same distance from common stoppage point. In such situation, instead of distance we consider the time as a factor to find the shortest path from the current stoppage point. Algorithm Floyd Warshall only gives the shortest path between two stoppages but we required the shortest intermediate path between any two vertices so we perform bubble sort on the Floyd Warshall output and stored the shortest intermediate path in the queue.
After creating shortest path we allocate vehicles according to the capacity of vehicles and number of students present at each stoppage point. If number of student at particular stop is zero then that place will not consider as stoppage. If number of stop at particular stop is greater than the capacity of bus then system will allocate two buses for same stoppages. Then system will display the total amount of distance and time required to cover shortest path for each vehicle.

Before starting search for shortest path we allocate students according to vehicle route id and vehicle capacity etc. After testing our system it is found that it is not only capable of finding multiple routes but also shortest path between any pair of stoppages by taking consideration of factors like time and distance which can affect the system.

V. Conclusion

With the help of Floyd Warshall algorithm, it is possible to conduct transportation analysis concerning given geographical region. Sometimes, this type of analysis has to be completed in real time. As a consequence, these analysis tasks demand high performance shortest path algorithms, that run fastest on real road networks.

This system provides user friendly interface. It not only gives the shortest path between the stoppages but also provides the details about the distance, time etc. required to reach from source to destination. Additionally, it provides the information about the vehicle like vehicle route, capacity of vehicle etc. according to the number of passengers it allocates to the vehicle.

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