Constructing Transportation Network for Loilem District using Dijkstra's Shortest Path Algorithm

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Abstract

*The Dijkstra's algorithm is solved the shortest path problem (SPP) or minimum spanning tree (MSP). A transportation management system is necessary to provide the shortest path from a specified origin location to other destination location. In this paper, a transportation network from town to town in Loilem District is constructed with the shortest path routes. A numerical description of a transportation network is used to demonstrate the efficiency of the system motioned. Using Dijkstra's algorithm, analysis shows that the best route which provides the shortest distance will be from node A-B-C-E-G (location**Loilem-Pang Long- Laihka - Mong Naung- Mong Hsu).The result gives total distance of 116miles. Simillary, the result gives the shortest distance from Loilem to Kyaing Taung is 100miles. A TORA software (version 2006) was used in the analysis.*

Keywords: Dijkstra's algorithm, Shortest path, Minimum spanning tree, Network, Tree, Node

1. Introduction

Graphs are discrete structures composed of edges and vertices linking these vertices. Graph may be used to design roadmaps and the allocate jobs to an organization's workers.[1] Graph theoretical concepts are widely used in Operation Research. Here are some essential operations research problems which can be solved using graph. A network called a transporation network that uses a graph to muddle commodity transport from one location to another.[2] In road network applications like city managing and drive guiding problem, shortest path issue is unavoidable.[5] Graphs with weights assigned to their edges can be used to solve problems such as finding the shortest path between two towns in a transportation network. In this paper, a minimum spanning tree constructed as 13 towns, namely Loilem, Laihka, Kyethi, Mong Kung, Mong Naung, Mong Hsu, Kunhing, Kho Lam, Pang Long, Karli, Namsang, Mongnai, Kyaing Taung.[3] The shortest path problem is involved in determining the shortest possible path or route from a starting point to a finishing point.[7]

2. Basic Definitions of Graphs and Graph Models

Graph: A graph G = (V,E) consists of V, a nonempty set of vertices (or nodes) and E, a set of edges. Each edge has either one or two vertices associated with it, called its endpoints. An edge is said to connect its endpoints.[6]

Directed graph: G = (V,E) consists of a nonempty set of vertices V and a set of directed edges E. Each directed edge is associated with an ordered pair of vertices. The directed edge associated with the ordered pair (u,v) is said to start at u and end at v.

Road Networks: Graphs can be used to model road networks. In such models, vertices represent intersections and edges represent roads. When all roads are two-way and there is at most one road connecting two intersections, a simple undirected graph could be used to model the road network. Model road network, some roads are one-way and some roads are more than one road between two intersections. To build such models, undirected edges to represent two-way roads and directed edges to represent one-way roads.

Tree: A connected graph that contains no simple circuits is called a tree. A tree is a connected undirected graph with no simple circuits. A tree with *n* vertices has *n*-1 edges.

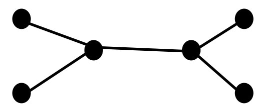

Figure 1. Tree diagram

Spanning trees: Let G be a simple graph. A spanning tree of G is a subgraph of G that is a tree containing every vertex of G.A simple graph is connected if and only if it has a spanning tree.[6] A spanning tree is not unique.

Path: A path is a sequence of edges that begins at a vertex of a graph and travels from vertex to vertex along edges of the graph. As the path travels along its edges, it visits the vertices along this path, that is, the endpoints of these edges.[6]

Minimum spanning tree: A minimum spanning tree is a tree that links all the nodes of the network using the shortest total length of the connecting edges.

The algorithm of Dijkstra is a graph search algorithm that solves the shortest single-source path problem for a graph with non-negative edge path costs, generating a shortest path tree.[5]

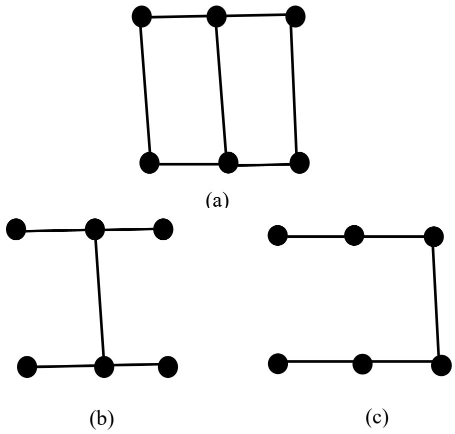

Figure 2. (a) simple graph G and (b),(c) are subgraph of G

3. Description of Algorithm with Application

Dijkstra's algorithm: Before going into details of the pseudo-code of the algorithm it is important to know how the algorithm works. Dijkstra's algorithm works by solving the sub problem k, which computes the shortest path from source to vertices among the k closest vertices to the source. For the Dijkstra's algorithm to work it should be directed-weighted graph. The edges should be non-negative. If the edged are negative then the actual shortest path cannot be obtained.[7] The proposed algorithm that restrict the search in a subgraph based on the distance between the two nodes given.

3.1. Algorithm Steps

Step 1.Assgn node s be a distance value of zero, and label it as permanent, [s = (0,p)] and assign every other node be a distance value of ∞ and label them as temporary,[(∞,t)].

Step 2.Distance value update and current node designation update. Suppose i be index of current node.

(i)Find a link (i,j) that can reached the set J of nodes with temporary labels from the current node i.

For $\forall j \in J$, new

$d_j = \min\{d_j, d_i + c_{ij}\}$ update the distance value d_j of node j, given in the network problem c_{ij} is the path of link (i,j).

(ii)Find node j that has the smallest distance value d_j among $j \in J$, and j^* such as $\min_{j \in J} d_j = d_{j^*}$.

(iii)Change the label of node j^* to permanent and designate this node as the current node.[4]

3.2. Analysis of Application

The above algorithm can be explained and understood better using part of Loilem District map application. The distance between each location in the graph measured in miles.

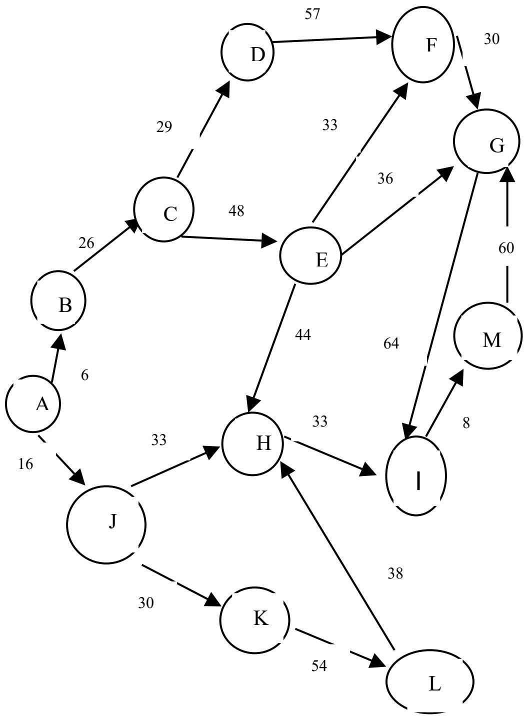

Figure 3. Permissible route of road network for Loilem District

Table 1.

Location	Nodes
Loilem	A
Pang Long	B
Laihka	C
Mong Kung	D
Mong Naung	E
Keythi	F
Mong Hsu	G
Kho Lam	H
Kunhing	I
Namsang	J
Mongnai	K
Kyaing Taung	L
Karli	M

Assign the permanent label A [0, ∞]

Table 2. Iteration 0

Nodes	Label	Status
A	[0, ∞]	Permanent

Node A can reached to node B and node J, and the list of labeled nodes is permanent or temporary .

Table 3. Iteration 1

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[0+6,A]	Temporary
J	[0+16,A]	Temporary

For the two temporary labels B[6,A] and J[16,A], the smaller distance is node B (u_B=6). The status of node B[6,A] is changed to permanent.

Table 4. Choose node B

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Temporary

The new starting node is node B. Node B can reach to node C. The list of labeled nodes is updated as:

Table 5. Iteration 2

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Temporary
C	[6+26,B]	Temporary

For the two temporary label J[16,A], C[32,B], node J (u_J=16) is the smallest distance , the status of node J[16,A] is changed to permanent.

Table 6. Choose node J

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Temporary

The new starting node is node J. Node J can reach to node H and node K. The list of labeled nodes is updated as:

Table 7. Iteration 3

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Temporary
H	[16+33,J]	Temporary
K	[16+30,J]	Temporary

For three temporary labels C[32,B], H[49,J], K[46,J], the smallest distance is node C (u_C=32). The status of node C[32,B] is changed to permanent.

Table 8. Choose node C

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Permanent
H	[49,J]	Temporary
K	[46,J]	Temporary

The new starting node is node C. Node C can reach to node D and node E. The list of labeled nodes is updated as:

Table 9. Iteration 4

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Permanent
H	[49,J]	Temporary
K	[46,J]	Temporary
D	[32+29,C]	Temporary
E	[32+48,C]	Temporary

For the four temporary labels H[49,J], K[46,J], D[61,C], G[80,C], the smallest distance is node K (u_K=46), the status of node K[46,J] is changed to permanent.

Table 10. Choose node K

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Permanent
H	[49,J]	Temporary
K	[46,J]	Permanent
D	[61,C]	Temporary
E	[80,C]	Temporary

Similarly fifth , sixth, seventh,...,twelveth iterations are calculated by using Dijkstra's algorithm. And then, iteration thirteenth is reached.

Table 11. Iteration 13

Nodes	Label	Status
A	[0, ∞]	Permanent
B	[6,A]	Permanent
J	[16,A]	Permanent
C	[32,B]	Permanent
H	[49,J]	Permanent
K	[46,J]	Permanent
D	[61,C]	Permanent
E	[80,C]	Permanent
L	[100,K]	Permanent
I	[82,H]	Permanent
F	[113,E]	Permanent
G	[116,E]	Permanent
M	[90,I]	Permanent

For every node, the shortest paths are as followed.

Table 12. Shortest paths

Nodes	Routes	Distance
A	A	0
B	A-B	6
C	A-B-C	32
D	A-B-C-D	61
E	A-B-C-E	80
F	A-B-C-E-F	113
G	A-B-C-E-G	116
H	A-J-H	49
I	A-J-H-I	82
J	A-J	16
K	A-J-K	46
L	A-J-K-L	100
M	A-J-H-I-M	90

The shortest route from node A to node G is determined the shortest path or route. The desired route is A-B-C-E-G.

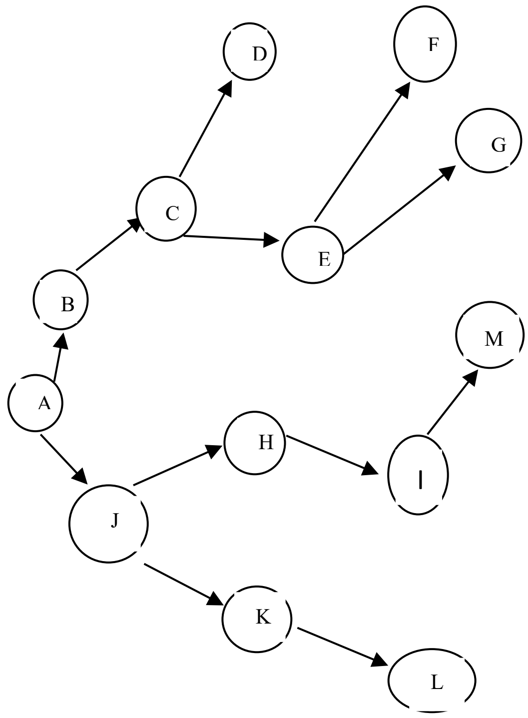

Figure 4. Minimum spanning tree of town to town distance in Loilem District

As shown in figure (4), by applying Dijkstra's algorithm to the network in figure (3), the minimum spanning tree provide town-to-town network in Loilem district. The shortest path distance is 116 miles from Loilem to Mong Hsu by using Dijkstra's algorithm.

4. Conclusion

This paper extends the Dijkstra's algorithm to solve the shortest route problem with fuzzy length. One is how to agree on what edges to add. The other is how the distance between two difference paths can be determined when the length of their edges is described by numbers which are fuzzy. The proposed method is found to be the shortest path. The minimum spanning tree is 116miles from Loilem to Mong Hsu. The observation in this paper is the algorithm of Dijkstra is very useful in many applications such as optimal network for distribution purposes, communication, computer scheduling, gas and pipelines, etc. Since most of these networks were developed in the Loilem area, it would still be useful to network architecture in this work for other applications.

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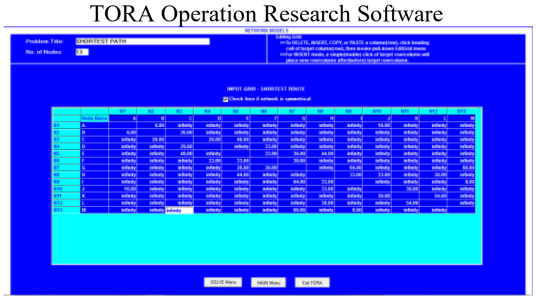
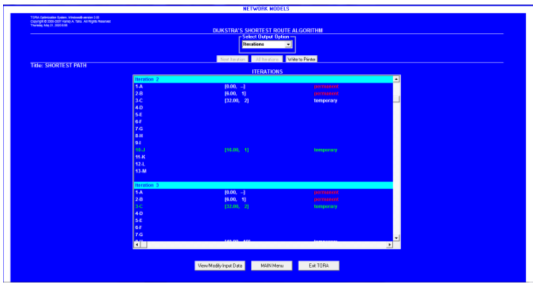
APPENDIX A

TORA Operation Research Software

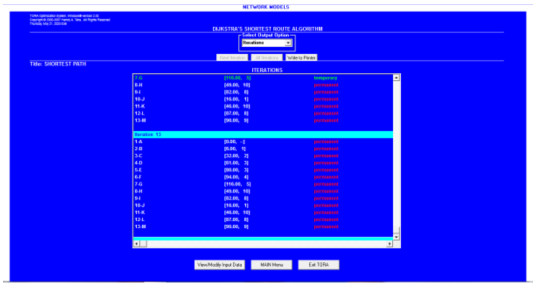


Data Input for Dijkstra's Algorithm

Iteration 1\



Iteration 2-3



Iteration 13

APPENDIX B

Map showing the different route and their distances in the area of research.