A graph theoretic approach to control the traffic congestion on road network

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Introduction

Many relations in real world problems can be represented by graph networks, where each node represents data and links represent the relationship between them. Web graphs, internet graphs, communication networks, biological networks such as food web are some of the examples of the existing social networks. All of those networks are analyzed to identify the communities or to find the importance of certain nodes in the networks. Therefore centrality measure plays an important role in social networks analysis. Since massive financial and man-hour loss due to traffic congestion, it becomes a major issue for all of cites in the world to analyze the traffic networks. In order to control traffic congestion, it is essential to understand the development of traffic flows. Therefore, finding a way to control traffic is needed. Most authors analyze road networks from the viewpoints of shortest path, cost minimization etc. Recently, a model for determining traffic assignment and optimizing signal timings in road networks were presented (Yang,*et al*.,1995) and way of the speed of the dynamics are affected by the underling network structure were studied (Holme,*et al*.,2003).Network representation was used to analyze the patterns in a street (Masucci,*et al*.,2009). An efficient algorithm to find the shortest route between two nodes of a large scale, time-dependent graph were developed on road network (Nannicini,*et al*.,2008). Cut-set of a graph were used to find optimal control of the traffic system (Baruah,*et al*.,2012).In this research, the centrality measures to analyze the congestion in the road network is used.

Methodology

Considering main and alternative paths from Thorana Junction to Kiribathgoda in Colombo-Kandy main road, a road network is constructed as a weighted,undirected,labeled graph, where each node represents an intersection, junction, or a special place and each edge represents a road segment between those intersections. Weights of edges are taken as the distances between nodes. Due to the complexity of the networks, 118 nodes initially have selected to construct this network. All centrality measures(Degree,Closeness,Betweenness, Eigenvector) and network criticality for all nodes in this road network are calculated. Besides that clustering coefficients are also calculated. All simulations are carried out using Mathematica and MATLAB programs.

Result and Discussion

For each node in the road network, all centrality measures are shown in the Figure 1. Figure 1(a) shows that the nodes around the Kiribathgoda Hospital represent traffic. Closeness centrality values are obtained in the analysis carried out range from 0.2985 to 0.62.Figure 1(b) shows that node 71 (Junction of New Hunupitiya road) has the highest closeness centrality and it is the most accessible node from the source node. Looking at Figure 1(c), Furthermore nodes 73,71 and 72(3 nodes from New Hunupitiya junction to Kiribathgoda junction) have the highest betweenness centralities. This shows that the road segments from New Hunupitiya road junction to Kiribathgoda junction is an important part in this network and also nodes belongs to this segment, are crucial to maintain node connections. Figure 1(e) shows that the nodes 100,102,97 (nodes around the hospital) have high eigenvector centralities. The graph implies that these nodes are around Kiribathgoda hospital. That means the intersections around the hospital are well connected.

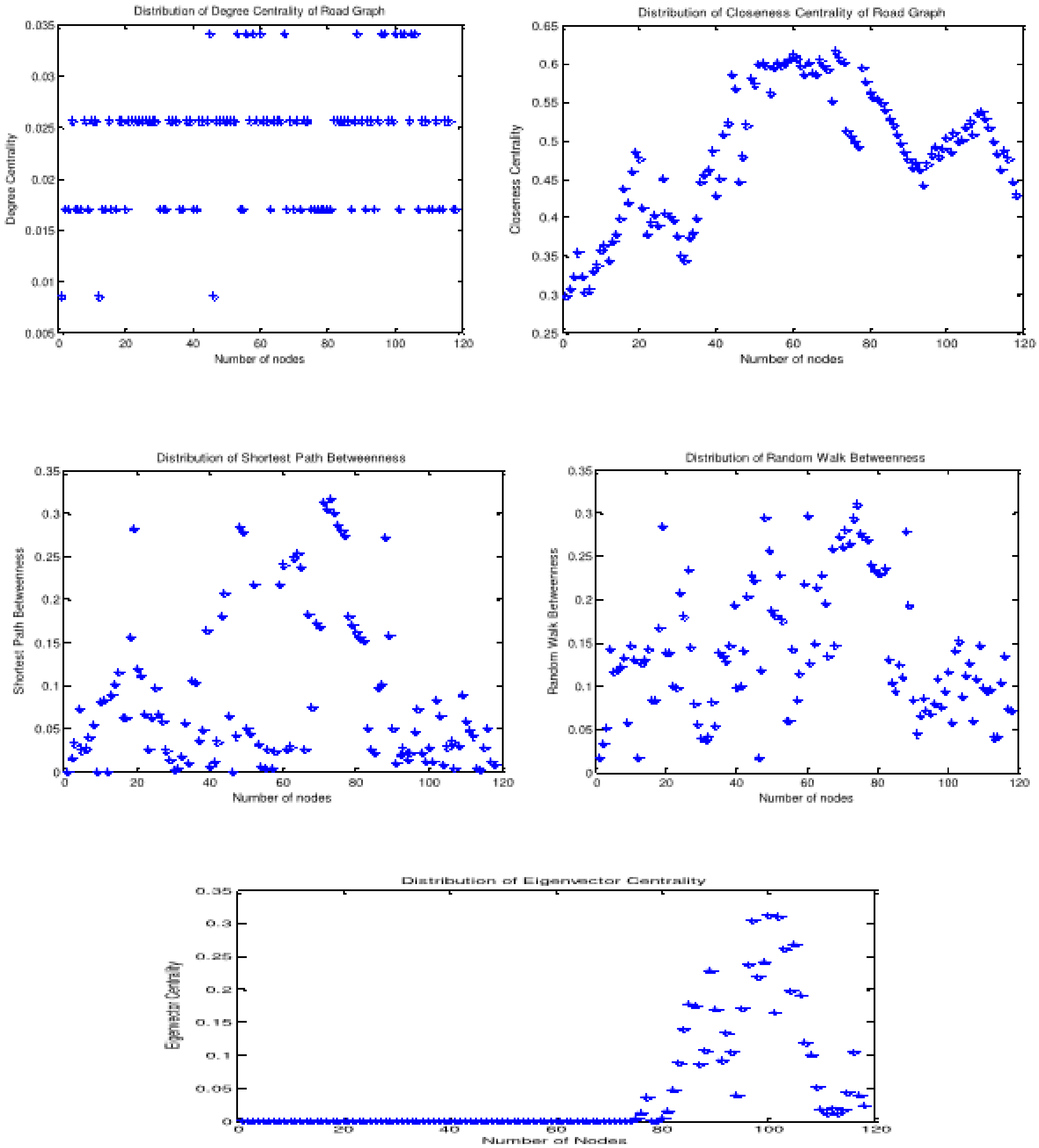

Figure 1: Centrality and Betweenness Measures

Table 1: Correlation coefficients for the centrality positions of the Road Network

	DC	CC	SPB	RWB	EC
DC	1.0000	0.1201	0.0100	0.0825	0.1845
CC	0.1201	1.0000	0.1792	0.2783	0.0086
SPB	0.0100	0.1792	1.0000	0.7891	0.0416
RWB	0.0825	0.2783	0.7891	1.0000	0.0416
EC	0.1845	0.0086	0.0416	0.0416	1.0000

Note: DC-Degree Centrality, CC-Closeness Centrality, SPB-Shortest Path Betweenness, RWB-Random Walk Betweenness, EC-Eigenvector (p-value 0.05)

Table 1 shows that the shortest path betweenness and random walk betweenness is highly correlated (79%), while other measures are weakly correlated. Thus, in general, vertices with higher shortest path betweenness tend to have higher random walk betweenness. .

Conclusions

In this research, road traffic network from Thorana junction to Kiribathgoda are constructed as an undirected weighted graph. Centrality and betweenness measures are calculated. According to the results, New Hunupitiya road junction is most valuable node in this road network. Besides that the road segment from University of Kelaniya to Kiribathgoda junction is also important road in this network. According to this study can be highlighted that New Hunupitiya road Junction is the most valuable node and there should be a traffic light to control the traffic on road network. By considering centrality measures, we can identify the important nodes and edges can be identified in this network in order to model traffic congestion accurately.

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