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A Network Centrality Application: Examination of Structural Coherence of Colombo Road Network

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1. Introduction

Urban streets demonstrate a hierarchical structure in the sense that a majority is trivial, while a minority is vital [1]. Jiang claimed that "coherent urban streets demonstrate a scaling law and characterised by the 80/20 road hierarchy principle, i.e. 80% of streets are less central (below the average), while 20% of streets are more central (above the average); out of the 20%, there is 1% of streets that are extremely well central" [1]. Recent works on structural analysis of urban street networks in terms of topological centrality in European and USA cities done by Yang et al. [2], Hillier et al. [3], Huang et al. [4], Levinson [5], Wang et al. [6], Gao et al. [7], have also supported the above claim. Accordingly, network centrality is used as a strategic planning tool to identify the structural coherence of transport networks. Inspired by the previous works, this study examines the structural coherence of the road network of Colombo city from the perspective of topological centrality.

2. Method of Study

The study is principally built upon the database of 'CoMTrans-2014, JICA'. The study used 'Natural-street' approach to convert street segments into meaningful streets. "Natural streets are naturally merged street segments with a good continuity according to the Gestalt principle" [1]. The threshold angle for the merging process was set as 45^0 [1], which implies that the deflection angle between two adjacent segments greater than 45^0 should not be merged to form a part of a natural-street. This operation applied to road network of the Colombo city and it led to 2,323 natural streets. Then, the natural-street network is converted in to a topological

graph, in which vertices representing individual streets, and edges if two streets are intersected. Utilising the topological graph, centralities of each street was calculated in term of 'Connectivity' (Cn), 'Global Closeness' (GC), and 'Betweenness' (Be). The study analysed statistical distribution of centrality values of streets and the relationship between hierarchies of natural street according to the network centrality values.

3. Results and Conclusions

Figures 1 and Figure 2 demonstrate the spatial pattern of street hierarchies and the cumulative probability distribution according to the network centrality values.

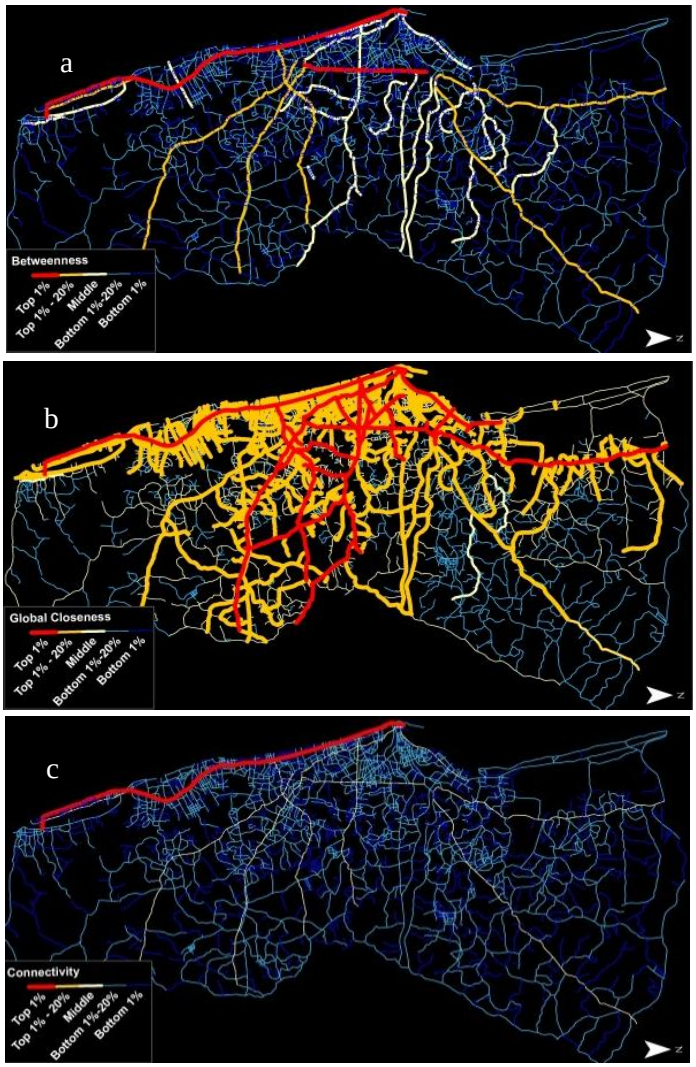

Figure 1: A Spatial Pattern of Street Hierarchies of Natural-Streets Based on A) Be, B) GC, And C) Cn

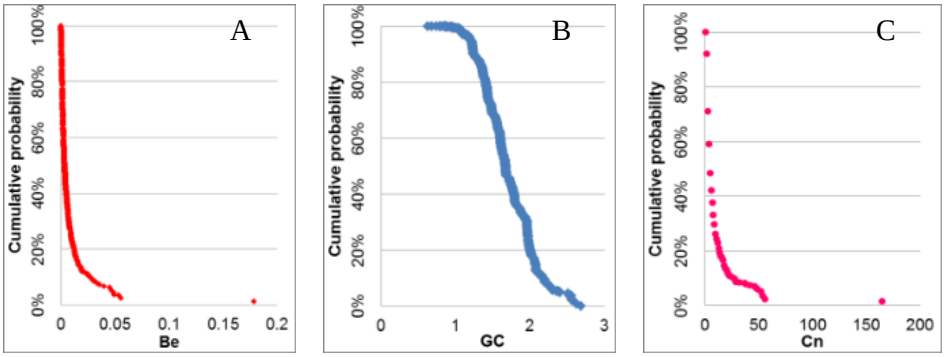

Figure 2: Cumulative Probability Distribution (Based On Street Length) of A) Be, B) GC and C) Cn

The distribution of Be and Cn values of Colombo road network are highly right-skewed whereas GC values are close to normal distribution. The average Be, GC and Cn are 0.09, 1.65 and 54 respectively; and the percentage of streets, whose Be, GC and Cn being less than the average are 93.2%, 47.3% and 96.5% respectively. This deviates from the 80/20 principle. Further, the study noted in terms of Be and Cn, percentage of top 20% streets is less than 20% of length of total street network, while percentage of top 20 streets in terms of GC is more than 20% (i.e. Be=4.9%; Cn=1.4%, GC=40.5% refer Table-1). It indicated that the centrality of Colombo's road network is far below the 80% rule in terms of Be and Cn values, while it exceeded the 80% rule in terms of GC values.

Table 1 - The Percentage Distribution (Street Length) of Natural Streets by Hierarchy of Centrality Values

Levels	Be	%	GC	%	Cn	%
Top 1%	>0.17	1.1	>2.20	8.4	>163	1.4
Top 20%	0.17-0.14	4.9	2.20-1.78	40.5	163-131	1.4
Bottom 20%	0.02-0.01	85.9	1.43-0.63	25.7	31-3	71.1
Bottom 1%	<0.01	32.1	<0.63	1.0	<3	29.9

Results of the study revealed that the topological centrality of the Colombo road network does not follow the scaling law and is far from 80/20 road hierarchy principle. It indicated that, the road network of Colombo city lacks structural coherence which causes inefficiency and capacity problems. "The urban web self-organises itself as a hierarchical and it reinforce the heterogeneity and diversity that

characterise living cities, therefore multiplicity rule that can be applied to urban planning and design" [1]. The study recommends for planners and traffic engineers to focus the ongoing and future redevelopment scenarios in Colombo city with strong concerns on the structural coherence of road network from the perspective of topological centrality

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