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Result Analysis on Planning and Evaluating Road Network Configuration in Urban Context

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Abstract: *One of the biggest issues with urban mobility is traffic congestion. Particularly in areas near junctions, it has been rising. Numerous techniques have been devised to alleviate traffic jams. Social network analysis (SNA) is one of the analysis techniques. The ability to swiftly locate the most important intersections in transportation networks has led to an increase in the use of this technique. Enhancements to the principal intersections within a road network structure expedite the movement of traffic throughout the network. The Istanbul highway transport network has been analysed in this study, and the SNA has been used to compute values for a number of network centrality metrics. A machine learning approach was used to compare the centrality values' accuracy and error scales*

Keywords: Central Intersections, Machine Learning, Transportation Planning, Urban Transportation.

I. INTRODUCTION

One of the major issues of daily living in cities is traffic congestion. People may not be able to arrive to their destinations on time due to traffic congestion. It is vital to conduct studies that would reduce the congestion in order to avoid this predicament. To assess options for transport planning and to forecast congestion, a wide range of specific data is needed. The manual calculation of traffic and reporting of traffic problems is the conventional way. The use of this technique has dramatically declined in the last several years. Conventional models are not cost-effective because they can take a lot of time and work. Furthermore, traffic congestion makes driving more difficult for drivers by extending journey times and delaying arrival at destinations. To lessen these adverse consequences, numerous, There were transport studies carried out. For instance, additional long-term fixes for the road network can be found by making upgrades at crossings with heavy traffic. Transport planners must simultaneously take into account a variety of aspects in order to comprehend network performance and create the optimum transportation plan (such as traffic volume, intersection locations, and road connectivity). Unpredictable weather and traffic problems might have an impact on travellers' travel schedules. As a result, modelling and analysing various traffic situations is challenging. It is necessary to supply a variety of numerical traffic data for these models and assessments. It is quite simple to obtain thanks to advancements in technology and intelligent transportation systems, which make use of motion detection cameras, computers, counting units, and vehicle counting hoses. The development of these counting techniques has made traffic analysis and counts extremely useful. Over the last few years, a number of computer network subfields have made network traffic analysis a topic of ongoing research. Effective network traffic algorithms have been put into practice by numerous academics for network traffic analysis and prediction. Likewise, the technical data utilised in these analyses is helpful in establishing the connection between the safety of ring roads and traffic composition, as well as in developing suggestions for the development of vehicle safety enhancement plans.

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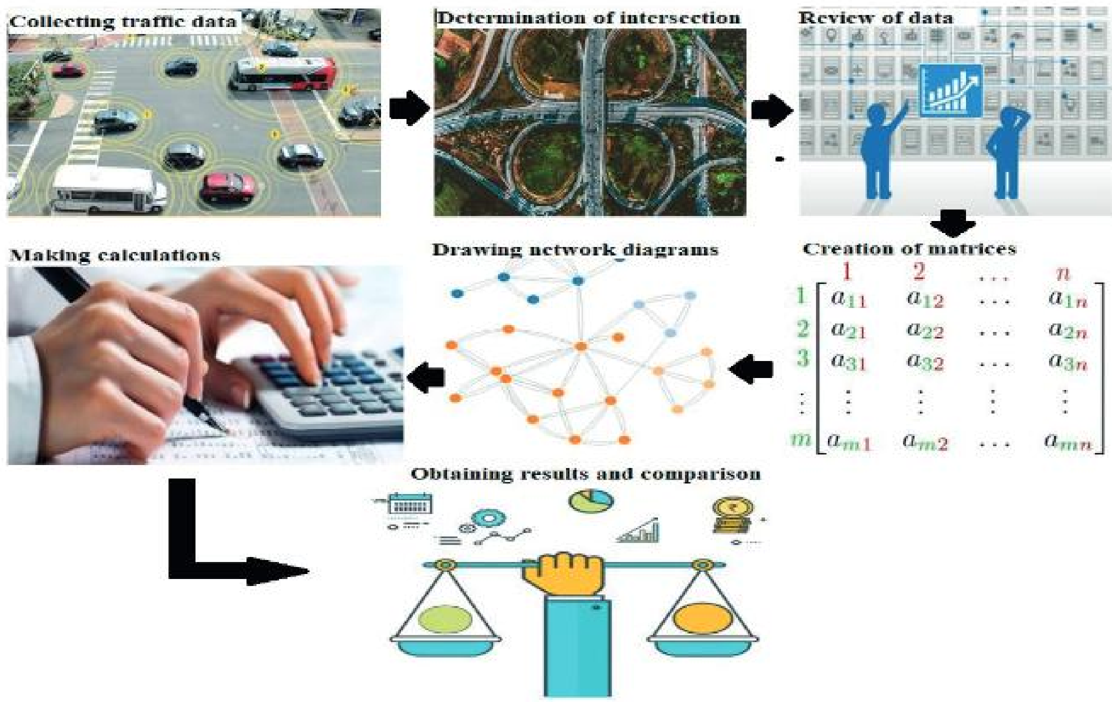

Figure 1 - Flow chart of SNA application in transportation planning

II. METHOD AND NETWORK MODEL

Regarding political, formal-informal, family, geographical, or any other factor, the SNA investigates the links between people or objects. Studying the relationships between different organisations or the networks these organisations form and significant events is done through SNA, which is also known as the digitisation and scientific creation of interpersonal relations. Network analysis, thus, makes it possible to investigate how the components, institutions, or systems that make up a network impact the network's overall performance. In addition to being less time-consuming and more practical than many other approaches, SNA has the advantage of focussing on relationships rather than individual behaviour, which sets it apart from many other methods. Additionally, it is an interdisciplinary approach to analysis that can be used in a variety of contexts, including political networks, including those for electricity and transportation. It is an undeniable reality that creative approaches to transport policy contribute to sustainable economic growth, making the SNA particularly significant when applied to a nation's transport networks. Figure 1 illustrates how the SNA is implemented in transportation networks.

(i) Closeness centrality- The degree of a node's proximity (or distance) to, or from, other nodes in the network, either directly or indirectly, is measured by its centrality. The capacity to access information indicates how quickly a node can connect to other nodes in the network, and closeness is the total of each person's shortest distances to other people in the network. The proximity measure can also determine how strong or weak the connections are between the nodes. Equations (1) and (2) are used to compute it. It is not required for a node to have a high degree of proximity in this centrality concept. In Equation (1), closeness centrality is defined as C iC ^ h. Equation (2) defines normalised closeness centrality as C icl^ h. In which case d (i, j) represents the distance between vertices i and j; N represents the number of nodes in the network.

$$C_C(i) = \left[\sum_{j-1}^{N} d(i,j)\right]^{-1}, \quad (1)$$

(ii) Degree centrality- The quantity of linkages (ties) that connect one node to another is its degree of centrality. It depends on the size of the network in addition to each node's connectivity to other nodes. Stated differently, the

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maximum degree of centralisation increases with network size. Therefore, a node with a specific degree of centrality either has a large number of ties in a large network or a large number of connections in a small network. Equation (3) illustrates how to calculate the total of the tie values associated with a node in order to determine its degree of centrality. The network nodes are i and j, and the factor is X.

$$C_c'(i) = (C_C(i))/(N-1). \quad (2)$$

III. RESULTS AND DISCUSSION

After the road network was established, it was possible to look at the SNA centralisation scenarios. Following a comparison of the centrality values, the top 10 nodes in the network with the highest values have been identified. The proximity centrality is among the most fundamental ideas in centrality. The network's structure is more significant in this centrality than the tie values inside the network. To calculate this centrality, the geodesic distances between nodes must be accurately calculated. Once the closeness matrix with the shortest distances has been identified, calculating the closeness centrality values is simple. It presents the determined closeness centrality values for both scenarios. In the initial instance, node In the second instance, both values were the same, but H was somewhat greater than node G's. As was already mentioned, the regions in the network's midpoints have higher closeness centralities. The degree of centrality is an additional primary metric of centrality. The total of the tie values for every network node is determined in this centrality. The node's position within the network structure is irrelevant in the case of this centrality, in contrast to the closeness centrality. The tie values connecting the nodes are the only thing that count. Upon examining the degree of centrality values, it was noted that node L's value was higher in both situations because Node L was where the traffic volume values on the road network peaked. In the first case study, the traffic volume figures peaked at node J, whereas in the second case study, they peaked at node K. This occurred simultaneously. The tie values connected to the newly inserted I node in the network structure were found to be low. Thus, in terms of degree centrality, the I node in the second case study had little effect on the other nodes. Betweenness centrality is a shortest-path-based centrality notion, just like closeness centrality. The distinction is that a node's location is determined by how much it participates in the shortest pathways between the instead of considering how near it is to the other nodes. For instance, the shortest paths between the other nodes and the number of nodes that pass through it are found while determining the betweenness centrality of a node. The node's betweenness centrality value increases with the amount of time it spends on the shortest paths. The possibility that there may be more than one shortest path between the nodes is the most crucial aspect to take into account when determining the betweenness centrality of the nodes.

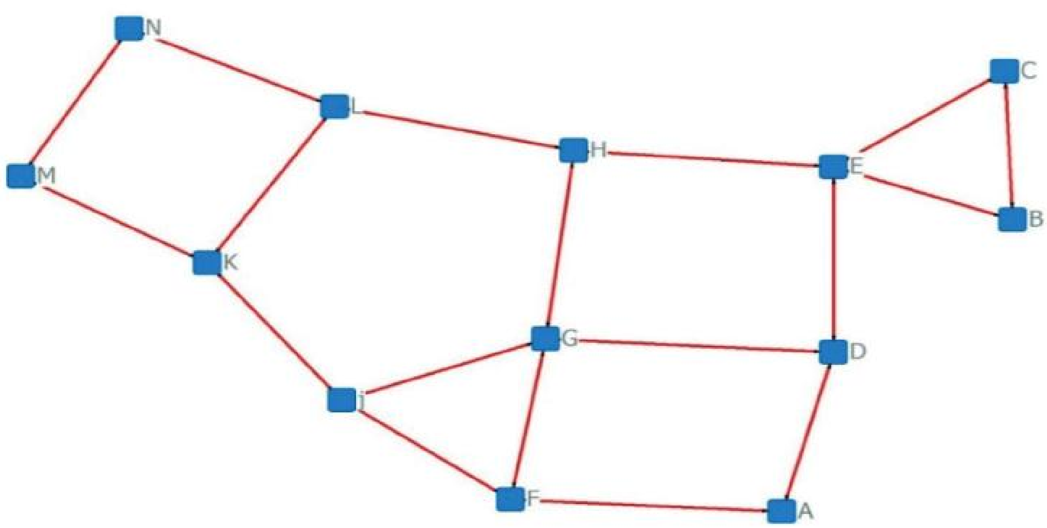

Figure 2- The first case study network structure

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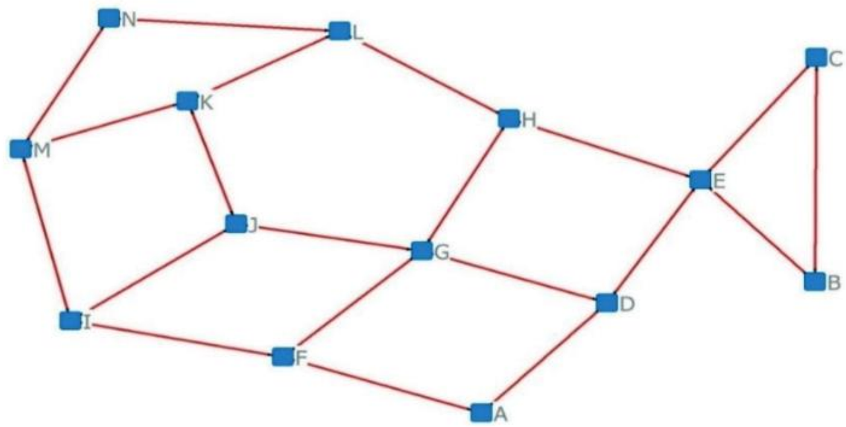

Figure 3- The second case study network structure

Degree centrality				Closeness Centrality			
First Case		Second Case		First Case		Second Case	
L	516549	L	508555	H	0.52	G	0.50
J	421119	K	402090	G	0.5	H	0.50
K	401575	J	395673	E	0.46	L	0.43
N	166094	N	163792	L	0.44	J	0.43
G	142994	G	154385	J	0.44	D	0.43
H	106491	H	118348	D	0.44	E	0.433
E	65959	M	96047	K	0.41	F	0.42
M	45230	E	73950	F	0.40	K	0.39
D	45077	D	51787	A	0.36	I	0.38
C	20812	I	40762	C	0.33	A	0.37

Table 1- Closeness and degree centrality values of case studies

Bonacich power, which takes into account the tie values and node locations within the network topology, was put forth by Phillip Bonacich as a crucial technique in SNA. The node in the network structure is an all-encompassing approach that takes into account the nodes' neighbours throughout the entire network, not just their immediate neighbours.

Figure 4- the first case study; traffic volume map from before the construction of the 3rd Bosphorus Bridge and the Northern Ring Motorway

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Upon analysing the Bonacich power centrality values of this investigation, which are displayed in Table 7, it was noted that the L node exhibited the highest value in the initial instance. In both case studies, the K node had the highest Bonacich power centrality value, but the L node, with the biggest volume value, placed first in eigenvector centrality and degree centrality. It was noted that In the second case study, with the inclusion of the I node, the highest Bonacich power centrality value moved from the L node to the K node. Stated otherwise, the node shifted to a position further north. The new bridge and the node that was added to the network structure are actually situated in the northern section of Istanbul, as these data demonstrated.

IV. CONCLUSION

The increasing amount of traffic on the planet has made modelling and analysing road networks crucial. For this reason, numerous modelling and analysis techniques have been created. SNA software with a useful and creative structure, Netdraw and Ucinet, were used in this study to model and analyse the traffic networks. Support vector machines with Weka Software, a machine learning tool, were used to compare the outcomes. After looking at the various centrality measures, it was found that the idea of Bonacich power centrality, which looks at the positions and degrees of nodes in a network structure, was the most relevant one for the transportation network this study evaluated. The configuration of the road network is ideal in this case. Since the In road network structures, the intersection locations and traffic volume values are used to determine which intersection is the most central. Using this centrality measure, the L intersection located south of the Anatolian side was determined to be the most central intersection for the first case study. This crossroads is where the extension of the first Bosphorus Bridge and the ongoing ring road of the second Bosphorus Bridge meet. The K intersection was determined to be the most central intersection in the second case study. In contrast to the L intersection, this intersection is also on the Anatolian side and nearer the midpoints.

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