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Vertex Importance Ranking Algorithm Based on Urban Traffic Network Design

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Abstract: With the rapid development of social economy and the continuous expansion of urban scale, urban rail transit, as the backbone of urban public transportation system, has gradually become the main carrier connecting urban space. The purpose of this article is to study the peak importance ranking algorithm based on urban transportation network design, and to discuss the efficiency evaluation method according to the main characteristics of urban transportation system and the performance evaluation method of infrastructure network and dynamic transportation network. Sort peaks using the Peak Importance Index and the Peak Structure Difference Index. Vertex ordering in static and dynamic urban transportation networks is discussed. Static networks are represented by infrastructure networks (weighted in kilometers), dynamic networks are weighted by dynamic travel times (based on perceived traffic data), and infrastructure network models describe the design structural properties of all vertices. Finally, two traffic scenarios are provided for the top ranking of dynamic traffic networks. The peak sorting results show that the edges between nodes 3 and 4 and between nodes 6 and 10 are congested, so the importance of nodes 3, 6 and 10 is significantly affected.

1. Introduction

It is necessary to provide reasonable, scientific, effective and optimal comprehensive transportation network improvement measures through the construction of urban comprehensive transportation facilities, and to gradually promote the improvement of urban comprehensive transportation conditions through appropriate comprehensive transportation investment allocation measures. Promote the development of various economic and social activities in the city. It is an important issue related to the long-term, sustainable, rapid, balanced and sustainable development of the national economy [1]. Therefore, the research results of urban traffic design not only have great theoretical significance, but also can be used to solve practical road traffic problems. Therefore, the research results of urban road network planning not only have great theoretical research value, but also can be used to Solving real road traffic problems also has a wide range of application prospects in real applications [2].

Scholars have carried out various researches on the vertex importance ranking algorithm for urban transportation network design. Kropiwnicki J proposes a rough and accurate fuel consumption model for road composition input data that is able to take into account new traffic conditions. The fuel efficiency model proposed in this paper has also been extended to regenerative braking systems. The final results of the analysis show that the fuel and energy consumption (including emissions) of vehicles in urban traffic can be successfully modeled with an expected accuracy of 5% using 5 specific variables that determine traffic conditions [3]. Abdel-Hafeez S proposed a new sorting algorithm that sorts input data objects without any comparison operation on the data - a comparison-free sort. The time complexity of our algorithm is about O(N) for single- and multi-threaded CPU and multi-core GPU applications. The results show that for input sizes from 27 to 230 elements, single-core CPU, 8-thread CPU, and multi-thread GPU achieve average speedups of 4.6x, 4x, and 3.5x, respectively, over the range-ratio distribution, compared to normal ordering [4]. Merkisz emphasized the need for cultural sensitivity when creating websites that can be read by different cultural groups at home and abroad. The link between culture and communication is established through research, which is related to networking, an increasingly important communication tool. A literature review of variables affecting cultural and cross-cultural comparisons based on possible effects on website content, design and structure [5]. It can be seen that the theoretical significance and practical significance of the vertex importance ranking algorithm for the study of urban transportation network design in this paper are obvious.

This paper proposes a new model for vertex importance ranking of urban transportation networks based on existing methods LM and NQ. First, this paper extends the LM approach to ELM for weighted network efficiency evaluation and uses ELM to rank vertices in static (infrastructure) networks. Then, new efficiency evaluation methods with and without "supersaturation faults" are introduced for coping with dynamic traffic networks. Finally, we propose a structural difference index to describe the deviation of vertex importance from its design in dynamic transportation networks. This paper studies the priority sorting algorithm based on urban traffic road network planning from the perspective of urban traffic planning, and puts forward the problem of urban road network planning.

2. Research on Vertex Importance Ranking Algorithm Based on Urban Traffic Network Design

2.1. Urban Transportation Network Design

The problem of urban transportation network planning is how to determine the best repair options so that limited funds can be fully used to achieve goals (reduce total travel time or improve social welfare). Theoretically, the transportation network planning problem is considered as a two-level decision problem, the upper layer is the traffic controller and the lower layer is the users in the transportation network [6, 7]. Top-level traffic managers optimize the goals of top-level traffic managers by altering the traffic network to influence the routing behavior of low-level users [8, 9].

2.2. Vertex Sorting

Given a directed graph G=(V,E), sorting is to assign a sequence number r(v) to all vertices v∈V, if a certain sort r can make all directed edges (u,v)∈E, all have r(u)<r(v), such an ordering is called a "proper" ordering. If we find a "suitable" ordering for the directed graph G, for unlinked vertex pairs u and v, we only need to compare r(u) and r(v): if r(u) ≤ r(v), then The link between them is u→v, otherwise v→u [10, 11].

2.3. Sorting Algorithm

2.3.1. First Come First Serve Algorithm

The FCFS algorithm relies on the aircraft's Estimated Time of Arrival (ETA) series to determine the flight path and landing pattern. When an aircraft to land enters the screening area of the extended terminal area, i.e. when the aircraft enters the entry point of the extended terminal area. The system calculates the estimated time of arrival (ETA) of the aircraft to the destination point based on the time the aircraft entered the terminal area, the performance and starting position data of the aircraft, and the weather force data at that time. In this case, the scheduled arrival time (STA) of the corresponding flight is given. If there is not enough space in the flight queue to insert a new landing flight, the system reorders the flight after that flight to delay processing while maintaining standard flight space. If the trailing aircraft cannot take off and stop again, delay procedures should be implemented for the newly arrived aircraft to take off in fixed airspace. Its advantage is that it is easy to operate [12, 13].

2.3.2. Constrained Position Exchange (CPS) algorithm

The position swap algorithm starts with a "minimum safe separation" that the aircraft type must maintain. By rearranging the order of the flight queue, find all possible flight alternatives to find the price (representing the sum of the time interval required for all two flights in the queue or the waiting cost and waiting time for each flight as parameters) is the smallest strategy, that is, the best alternative strategy for the flight group. But the received incomplete options will change the order of the original flight queue, which is not only a burden on managers, but also conflicts with the basis of important work, reducing the fairness of different flight schedules and increasing the difficulty of execution. Therefore, we recommend changing the limit position, i.e. the final position of the aircraft can only be delayed to the correct position between the distances that already exist before and after the starting position. Adaptive cruise control (CPS) algorithms typically allow the aircraft to transition between adjacent positions [14, 15].

2.3.3. Time-Advance Algorithm

The time advance algorithm checks for the first flight in each queue without changing the original order of the entire queue. Accelerate the first flight to arrive at the destination earlier than the normal arrival time [16, 17].

3. Model and Research of Vertex Importance Ranking Algorithm Based on Urban Traffic Network Design

3.1. Importance and Structural Differences

The importance of network component g is defined in existing methods such as LM and NQ:

$$Ig = \frac{E(G) - E(G-g)}{E(G)} \tag{1}$$

The importance of components representing structural features of components provides technical support for vertex ordering.

In network science, the self-network of vertices is an important concept, which consists of vertices and directly connected vertices and edges (if any) between vertices. In the urban traffic network, the ego network reflects the highly coupled characteristics of the traffic states of adjacent vertices. In this paper, we define the importance of node i's ego network as follows:

$$I^{ego} = I(ego(i))\frac{E(G) - E(G - ego(i))}{E(G)} \tag{2}$$

In this paper, we discuss vertex ranking on static and dynamic urban transportation networks. Static networks are represented by infrastructure networks (weighted by mileage). The dynamic network is weighted with dynamic travel time (based on detected traffic data). The infrastructure network model describes the design structural properties of all vertices. The dynamic network model reflects the actual characteristics of vertices under certain traffic conditions. The dynamic nature of traffic flow causes changes in vertex structural characteristics and changes in vertex ordering. Therefore, for vertex ordering, it is also important to consider the structural characteristics of vertices and vertex ordering.

3.2. Node Importance Evaluation Index

3.2.1. Degree Index

For directed networks, the node size is divided into outer size and inner size. However, for weighted networks, the connection strength of a node is usually represented by computing the sum of the weights of the edges connected to that node. Whether it is node degree or field strength, it is a function of its own characteristics, which can represent the importance in the network structure.

3.2.2. Proximity Indicators

Convergence describes the effect of nodes on the speed of information transmission in the network. The better the meeting's ability to convey information, the more important the meeting is. Compared with the degree index, the proximity index is more comprehensive and can reflect the network topology more truly.

3.2.3. Betweenness Index

The average intersection size is only related to the number of shortest paths through that intersection. When the number of shortest paths through a node is large, it indicates that the node has the greatest connection role in the network, and the node is the most important.

3.3. Mathematical Model

Definition 2.3 Set the graph G={V,E,F(t)}, where f(t) is a function of time t, t∈[a,b], b>az0, then G is called time-dependent network TDN.

Definition 2.4 In TDN, let pun(t) be a path from 1 to n, its length is a function of t, pu is the set of all paths from 1 to n, if there is pi, (t), such that:

$$W(p_{1,n}^{*}(t^{*})) \le W(p_{1,n}(t)), \forall p_{1,n}(t) \in p_{1,n} \tag{3}$$

If it is established, pi(t) is called the minimum time path TDSP of time-dependent network. W() is the path time length (including node waiting time). Then the mathematical model of the TDSP problem is as follows:

$$\min Z(x,t) = \sum_{i,j \in V} x_{i,j} \times f_{i,j}(t_i) \tag{4}$$

4. Analysis and Research of Vertex Importance Ranking Algorithm Based on Urban Traffic Network Design

4.1. Vertex Ranking Comparison

In this paper, we present two traffic scenarios for vertex ordering of dynamic traffic networks. One is that we assume that at time t1, the traffic on each edge is free-flowing. Second, at time t2, the edges between nodes 3 and 4 and the edges between nodes 6 and 10 are congested, which means that the traffic state on these edges is oversaturated and the traffic state on other edges is undersaturated of, as shown in Table 1 and Figure 1.

Table 1: Comparison of vertex rankings for dynamic traffic networks under free flow

node	The new approach	Structural difference	The new approach over-saturated failure	Structural difference
1	4	-0.1156	4	-0.1156
2	8	-0.2135	8	-0.2135
3	6	0.054	6	0.054
4	9	-0.2145	9	-0.2145
5	10	-0.2265	10	-0.2265

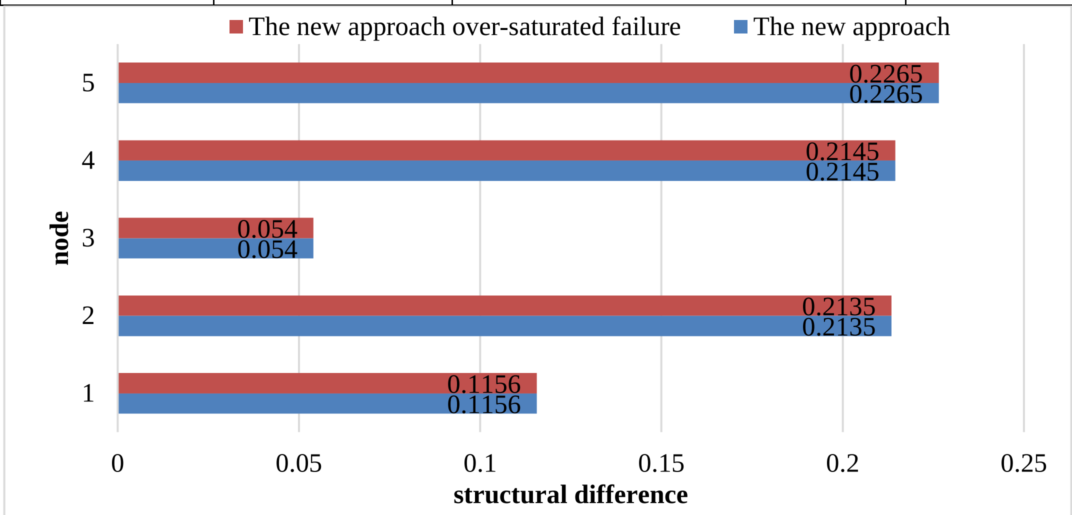

Figure 1: Vertex ranking comparison

Since congestion occurs at the edge between nodes 3 and 4, and at the edge between node 6 and node 10, the importance of nodes 3, 6, and 10 is significantly affected. The results of the method ordering without the "supersaturation failure" rule do not correspond to the actual situation. Instead, it is more reasonable to consider the outcome of the rule.

4.2. The Importance of Nodes and Self in Congested Flows

In Figure 2, we can see that the importance of self-equity is higher than that of individual nodes. Also, it helps to clearly distinguish intersections of similar importance. If single nodes are of similar importance, we cannot get an unambiguous comparison.

Based on the combined results of the importance values, we adopt the structural difference values of the ego network. The value of μ is 0, i.e. the importance of node i in this case has reached its design. The larger the μ, the more transport functions the node adopts, and vice versa.

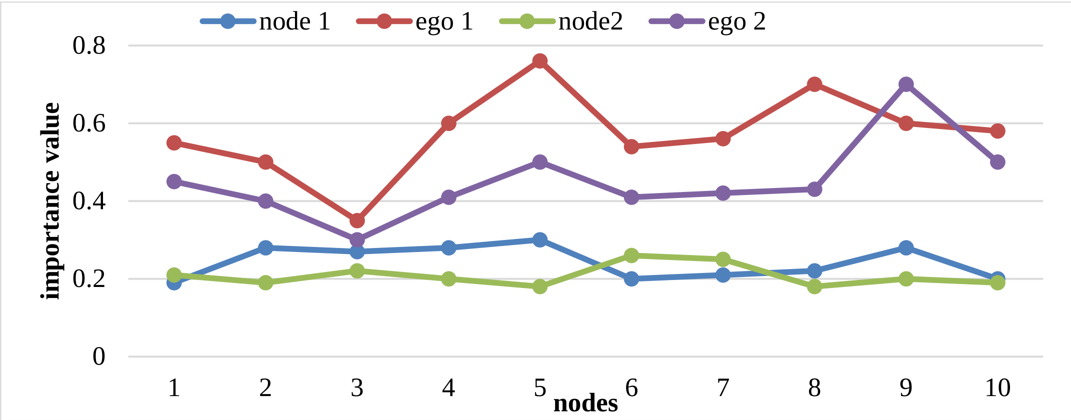

Figure 2: Importance values of node and self under congested flow

5. Conclusions

The vertex importance ranking algorithm based on urban traffic network design studied in this paper is an interesting attempt to solve the actual urban traffic flow control problem. It is of great significance to the development, improvement and final implementation of the actual management of urban traffic flow in the terminal area. Urban rail transit network is a very typical complex network, so it is possible and possible to use basic complex network technology to analyze urban rail transit network. A structural difference index is proposed to describe the deviation of vertex importance from its design in dynamic transportation networks. In addition, a series of experimental vertex ordering analyses based on an example network that is part of Beijing's road traffic network are presented. The experimental results show that the proposed new method considering "supersaturation failure" is more reasonable and effective.

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