

Research on path selection system based on green transportation

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Abstract. The transportation sector already accounts for 14% of global greenhouse gas emissions. Therefore, controlling carbon emissions in the transportation sector has become a top priority for China and other countries around the world. In addition to the technological development of clean energy transportation, the most critical aspect of the globalization of new energy transportation industry and market is the optimization of access routes. This paper will be based on road travel time estimation and optimal path selection of energy efficient transportation research hotspots. Firstly, the accuracy of road travel time estimation is improved according to the basic law of traffic flow. At the same time, this paper defines the optimal route into two cases of shortest path and shortest time for solving. Finally, the actual solution process is given according to the actual problem, as well as the optimal route, aiming to promote the strong development in the field of intelligent navigation system and energy-efficient transportation.

1 Introduction

1.1 Problem Background

In the current era, the global resident motor vehicle holdings are increasing, which leads to the continuous growth of road traffic flow, the increasing congestion of road traffic, traffic congestion will cause a series of problems, such as: traffic accidents, noise pollution, air pollution and so on. And now people often use a series of navigation software on mobile devices to plan their travel routes. When choosing travel routes, people often consider the time and distance of routes.

1.2 Literature Review

The estimation of travel time is a hot topic in intelligent transportation system. A sensor is embedded at different points on the road section, and the flow rate is obtained by detecting the pulse signal of the vehicle, and the instantaneous speed [1] of the vehicle through this point can be obtained by two sensors very close. From the existing research results, the relationship model between highway traffic speed and flow is gradually developing to piecewise function. most studies have obtained the same conclusion in the process of reducing flow from actual capacity to zero (high density, crowded flow, unstable flow state), that is, velocity is a quadratic function of flow. During the process of increasing the flow rate from zero to the actual capacity (low density, stable flow), there are two different views: one is that the velocity decreases linearly with the increase of the flow

rate, the other is that the velocity decreases [2] with the increase of the flow rate.

2 The Description of the Problem

2.1 The restatement of the Problem

- If a vehicle passes the detector at time t , how long will it take for this vehicle to travel to the fifth sensor? Please design an algorithm for estimating such travel times. Make sure that you demonstrate the rationality and accuracy of your algorithm. If traffic data is provided every 20 seconds rather than every 2 minutes, how this information is going to affect your estimate?

- All the conditions stay the same as in the previous problem. If detectors can measure not only vehicle speed, but also traffic volume per unit time, does this additional information help to improve the rationality and accuracy of your algorithm? If your answer is yes, please redesign your algorithm.

- Improve the system based on question 1, provided link travel times are mutually independent random variables. Please design an algorithm for the system to address optimal route selection and travel time estimation. Make sure to clarify your definition of optimal route.

- Travel times on individual links are dependent on departure time, as well as are mutually correlated. A time dependent covariance matrix $Cov(ij,kl)$ is typically used to quantify such a time-varying correlation relationship, in which $i, j, k,$ and l represent the two nodes of two links. Use the maps above to design a rational matrix and design an algorithm for optimal

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routing. Be sure to clarify your definition of the optimal route.

- Find an optimal route from node 3 to node 14, and from node 14 to node 3, respectively. Also, please provide a travel time estimate for each route.

2.2 Analysis of Problems

For problem I, the first is the analysis of travel characteristics on highways. We mainly determine whether the expressway travel is crowded according to the main parameters and basic laws of traffic flow v , the q and time change of vehicle speed and vehicle flow. Another is the estimation of travel time on the highway. The data in the table give the average speed of the last 20 s every two minutes. When estimating the total travel time, we first divide the five detectors into four intervals. The total estimated time is obtained by summing the time of all intervals. Estimate the time of each interval, to estimate the speed of each interval, we use the method of average speed, the average speed is given by the detectors on both sides of the interval. Since the data in the table only give the last 20 s of vehicle speed every two minutes, we extend the table. According to the influence of traffic flow on driving time, we modify the model and add traffic flow to the model [3].

For problem II, we first give the definition and meaning of the best route. By defining the best route, we get two best routes, one is the shortest best route, which solves the shortest path problem by Floyd algorithm, the other is the shortest path. We need to judge the interaction between the two sections according to the event correlation between the sections.

For problem III, we combine the algorithms of problem I and problem II, and get the best route by programming the simulation of the problem.

3 Models

3.1 Basic Model

3.1.1 Notations

Important notations used in this paper are listed in Table 1.

Table 1. Notations.

Symbols	Description
v	Vehicle speed
v_i	Average velocity measured by Detector i
t_i	Driving time in interval i
l_i	Distance in interval i
T	Total time required to pass the Detector 5
q	The number of vehicles passing the specified section in 20s
d_i	The Detector i
k	Number of vehicles passing a specified section length at a given time

3.1.2 Assumptions

To simplify the problem, we make the following basic assumptions, each of which is properly justified.

- **Assumption 1:** Suppose the vehicle has no lane change, runs on a single lane and is not affected by traffic lights, and there will be no accidents on the road, such as landslides, road damage, etc.
- **Assumption 2:** It is assumed that there is only uniform acceleration, uniform deceleration and uniform speed in the driving process.
- **Assumption 3:** Assume that the traffic data of the detector at the last 20 s of every two minutes can represent the traffic data within the two minutes.
- **Assumption 4:** Assuming that the vehicle reaches the first detector at t time, the detector calculates its average speed.

3.1.3 The Foundation of Model

According to assumption 4, at t moment the vehicle reaches the detector, after passing through d_1 , d_1 gives the average speed of the vehicle named v_1 . When reach d_2 after t_1 , based on assumption 3 we can get v_2 . In this way, we can get v_i in turn. From this, we can first calculate average velocity of each interval [4].

v_i represent the velocity at each begin of the interval and v_{i+1} represent the end, then the estimated travel time of each interval t_i can be obtained.

l_i represents the length of each interval, get the total time T after each period of driving time.

In the case of unobstructed traffic flow, both the basic model and the model with flow data are close to the measurement results of the direct method. In the case of congestion, the flow can reflect the congestion in the section to a certain extent, so the effect is better. The setting of detection points determines whether the information of traffic flow changes can be detected, thus affecting the accuracy of the final results.

The p_i refers to the average vehicle flow in each interval, L represents the total distance between the five detectors, so the basic driving time estimation model has been preliminarily established.

3.2 The Solution of Model

Analysis of Travel Characteristics on Highway: In modern urban life, common sense tells us that the greater the speed of vehicles, the greater the density, the stronger the road capacity. However, the higher the speed, the greater the braking distance, and the restriction on the density of vehicles. We use q to represent vehicle flow, v to represent vehicle speed, k to represent vehicle density. In analyzing the designated road section, we can draw the following conclusions according to physical knowl-edge:

$$q = vk \quad (1)$$

Experience and observation show that there is a close relationship between speed and density. When the number of vehicles on the road increases and the density

of traffic increases, the driver considers that the braking distance must be forced to reduce the speed. In 1935 Greenshields proposed a linear model between speed and density through statistical analysis of observed data:

$$v = v_f(1 - k/k_j) \quad (2)$$

v_f is the speed when $k=0$, is the theoretical maximum speed. k_j is the density when $v=0$, called blocking density. The relationship between flow and density can be deduced:

$$q = k v_f(1 - k/k_j) \quad (3)$$

The relationship between flow and speed can also be derived:

$$q = v k_j(1 - k/k_j) \quad (4)$$

That is, the maximum flow appears at the speed $v = v_f/2$.

Adoption of data on tables given in the title, we show the variation of average velocity and time given by each detector:

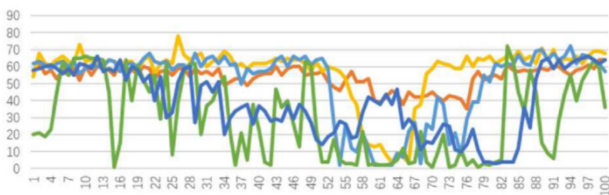


Fig. 1. Average velocity-time diagram of five detectors.

As we can see from the diagram, it is most likely to congestion between 5:30 and 5:48 p.m, and there may still be congestion after 5:48 p.m.

Estimation of Highway Travel Time by Basic Model: The data given in the table shows that the shortest distance between the two detectors is 417m, The average speed of a vehicle needs to reach 100 mile/hour within 10s, in order not to be measured by the next detector. So when we analyze, we think that the average speed of the vehicle can be measured by each detector. On the basis of the programming simulation, we obtain the estimated time image of the vehicle passing through five detectors on the road after reaching the d1 at the t time [5].

According to the analysis data, we can conclude that when the vehicle reaches the detector at 5:32 to 5:50 p.m, it takes the longest time to pass through the five detectors, indicating that the vehicle is the most congested in this period, and then there will be a period of congestion. The data obtained from this model are consistent with the results of the analysis of the travel characteristics of the tabular highway.

If we provide traffic data every 20s rather than every 2 minutes, then this information will affect the accuracy of our model data. In theory, we divide every 20s of time every two minutes in the basic model analysis. It is not accurate to use the last traffic data of two minutes to represent the traffic data accurate enough.

If traffic data are given every 20s, the results we get will be more accurate and the data more reliable.

If the detector can not only measure the speed, but also measure the traffic volume per unit time. We also add the traffic volume to the model, and we program the model to solve the model, and get a new time estimation diagram.

After adding the flow data, the estimated time of the blocked section changes obviously, but the estimated time of the non-plugged section changes little. It shows that the main influence on the data after the flow is added is in the blocked section, which is consistent with the facts.

Problem II: Choosing the best route in the road network and following the best route is the best choice for travelers, but because of traffic jams, it may interfere

with the choice of the best route. If the vehicle can find the best route from the starting point to the end in such a road network, it not only saves fuel and time, but also can improve traffic condition macroscopically and reduce or avoid traffic jam. However, in either case, the optimal route can be attributed to the problem of searching the target route with the smallest total cost in a specific road network.

Definition of optimal route: We define the optimal route from two aspects of road obstruction. The first is that when the road is smooth, we think that the vehicle is running at a uniform speed, and the optimal path is equal to the shortest path to solve the problem. The second is the problem of traffic jam, and there are independent random variables between the travel time of the road section. This is a time when we define the optimal route with the average shortest driving time. It is obvious that the shortest path as the optimal route is a special case in which the shortest time as the optimal route.

In the description of the problem, we regard each intersection in the traffic network as a point, and each route is used as the edge to construct a traffic network diagram. In both cases, we can add weights to each edge of the graph for shortest path the length of each section is taken as the weight of each edge and for shortest time the average driving time is taken as the weight of each edge.

The shortest path as the optimal route: Dijkstra single source shortest circuit algorithm is used here. The main characteristic is to extend the starting point outward layer by layer until the end point. The idea of the algorithm is as follows: Assume $G = (V, E)$ is a weighted directed graph, and divide V into two sets. The first set is the set of vertices that have found the shortest path (With the S representation, there is only one source point in the initial S , and each shortest path will be added to the set S until all the vertices are added to the S , and the algorithm will end). The second group is the set of vertices of the remaining undetermined shortest paths (With the U representation), Add the vertices of the second group to the S in order of increments of the shortest path length. The shortest path length from the source point v to each vertex in the S is not greater than the shortest path length from the source point v to any vertex in the U . Moreover, each vertex corresponds to a distance, the distance of the vertex in the S is the shortest path length from the v to the vertex, and the distance of the vertex in the U is the

