LEAST-CONGESTED ROUTE ESTIMATION USING GPS EQUIPPED VEHICLES IN URBAN ROAD NETWORKS

Prof. D. N. Rewadkar¹, Tuhina Dixit²

¹,²Department of Computer Engineering, RMD Sinhgad School of Engineering, University of Pune, India.

ABSTRACT

Modern vehicle tracking systems commonly use Global Positioning System (GPS) technology for locating the Vehicle. This Paper presents an efficient technique to estimate the least-congested route from source to destination in large-urban road networks. The concept is based on the GPS base stations which are equipped with tracking software and geographic map useful for determining the vehicle location. As the vehicles move along the road networks, their coordinates are updated in the base station and hence this information can be used to estimate the speed of the vehicle along that particular road. This information gathered in the base stations can then be stored and processed immediately when the base stations receive GPS data of every vehicle. Depending on the speed of the vehicles, each vehicle will be assigned a status-code in the database which will be helpful to process the GPS data based on the request made by the driver before leaving from source. After this step, the source-to-destination least-congested route is estimated by making communication among the servers attached to various base stations in the city.

Keywords: Base Station, Global Positioning System (GPS) Probe Vehicles, Route Estimation, Traffic State Estimation.

1. INTRODUCTION

In recent years, many advanced sensor techniques have been adopted to collect real-time traffic information, such as loop detectors, Global Positioning System (GPS) probe vehicles, cameras, cell networks and magnetic sensors. These sensor techniques all bear their advantages and disadvantages; they are thereby applied according to the different environment requirements. A variety of sensors may be accustomed to get traffic data. GPS receivers are used within vehicles and periodically transmit data like vehicle’s location and speed, in conjunction with the associated GPS time, to a central system. A GPS-based vehicle tracking system will inform where your vehicle is
and where it has been, how long it has been. The system uses geographic position and time information from the Global Positioning Satellites.

A systematic solution to efficiently estimate the traffic state of large-scale urban road networks is presented in [1]. In this paper a new approach is used to construct the exact GIS-T digital map. Then, two effective methods based on GPS probe vehicles for the traffic state estimation are presented: 1) the curve-fitting-based method and 2) the vehicle-tracking-based method. An information-fusion-based technique for the estimation of urban traffic states is proposed in [2]. The approach can fuse online data from underground loop detectors and global positioning system (GPS)-equipped probe vehicles to more accurately and completely obtain traffic state estimation than using either of them alone. Some large-scale field-testing results of real-time freeway network traffic surveillance tool have recently been developed to enable a number of real-time traffic surveillance tasks. [3] Introduces the related network traffic flow model and the approaches employed to traffic state estimation, traffic state prediction, and incident alarm. To estimate and predict traffic conditions in arterial networks using probe data have proven to be a substantial challenge. R. [4] proposes a probabilistic modeling framework for estimating and predicting arterial travel time distributions using sparsely observed probe vehicles.

An application of the Sequential Monte Carlo which will help to improve the accuracy of travel time estimations in historical data is presented in [5]. Estimation filter is relay on the Monte Carlo Method and was modeled in such a way that it will be applicable to new kind of information in order to estimate travel time per section of road. A signal process approach is planned to collectively filter and fuse spatially indexed measurements captured from several vehicles in [6]. Measurements from affordable vehicle-mounted sensors (e.g., accelerometers and world Positioning System (GPS) receivers) square measure properly combined to provide higher quality road roughness information for cost-efficient paved surface condition observance. Period GPS location knowledge is collected to implement the vehicle pursuit algorithmic program throughout the urban GIS network. Average velocities on these tracks are calculated and distributed proportionately in [7]. By integration the speed contributions on every road link, traffic states are finally calculable on rolling time periods. In order to estimate the state of urban traffic flow, a Probe-Vehicle-Tracking based technique is projected by [8] [9]. The tactic collects traffic flow information with international Positioning System (GPS)-equipped taxies and introduces the Curve-Fitting Estimation Model (CFEM) [9], which is one of the typical methods using GPS data to estimate the traffic flow state.

In this paper, we propose an algorithm for route estimation as per traffic on roads. This algorithm provides least-congested route from source to destination to the driver before he leaves from the source. The concept presented is based on the base stations which receive precise coordinates of the GPS vehicles which might be utilized in personal computers for process. Each base station receives coordinates of every GPS vehicle. With every base station we are attaching a server and a database as shown in Fig.1.
Base stations are equipped with tracking software and geographic maps useful for determining the vehicle location. Maps of every city and landmarks are available in the base station that has an in-built Web Server. The position information or the coordinates of each visiting point are stored in a database, which later can be viewed in a display screen using digital maps. However, the users have to connect themselves to the web server with the respective vehicle ID stored in the database and only then can they view the location of vehicle traveled.

In section II, the proposed approach and its system architecture diagram is depicted. In section III, we are presenting the implementation and results achieved. Finally, conclusion and future work is predicted in section IV.

2. METHODOLOGY

The section is subdivided into four parts, as follows:

1) The first section uses analogy to show the fundamental idea behind the method.
2) The second section describes a detailed concept to estimate the least congested route from source to destination.
3) The third section proposes an algorithm to estimate the least-congested route. It considers traffic flow along the coordinates and better estimation of route is expected.

2.1 System Architecture

The basic concept used in this paper is to provide a least-congested route to the driver when he starts from the source. The inputs which he enters in his GPS receiver of the vehicle are source (from where he leaves) and the destination. Based on these inputs, the system estimates the traffic on the route.

![System Architecture Diagram](image)

**Fig.2: System Architecture**
In Fig.2, it is shown that map of the city and the vehicle coordinates are loaded. As soon as the driver enters the source and destination, this request is sent to the nearest base station’s server. Then according to the requested route this server will search for other base stations required to estimate the traffic in this route. And also sends the request to other base stations to reply the status of vehicles along the route which are moving under their range. As each base station holds the latest status of the vehicles (in its range) in the database, this information can be immediately sent to the first server by other servers. Based on the information collected by first server, it will show the status of traffic with different colours in the GPS receiver of the vehicle.

2.2 Vehicles status in the database

As the vehicles move, their latest coordinates are received by base stations. This information is stored and processed in the database immediately. The database will hold the information such as Base-station-code, vehicle_id, Coordinates and the status-code of the vehicles. Base-station-code is required because a number of base stations have to be mounted just like mobile-phone towers. This is because each base station has a particular range to get vehicle’s coordinates. This range may be between 2-4 miles (3-7 kms) depending on the type of base station used. The status-code of the vehicle represents whether the speed of the vehicle is good, slow or it is stuck in the traffic (i.e. stopped). This code is updated depending on the coordinates of the vehicle along a particular road.

If server finds in the database that several of the vehicles coordinates don’t seem to be moving in any respect for few min (eg:3 min) then it means there is a traffic congestion and status code will be set to 0. If the status code is set to 1 then it represents that the coordinates of particular vehicle is changing continuously and it’s in moving state. If many vehicles are finding traffic and there coordinates are not changing continuously or smoothly but they are in moving condition then the status code of these vehicles will be changed to -1 as shown in Fig.3.

Each base station will hold the information of the vehicles which are moving under its range as well as it will also hold the information sent by other base stations. This concept is presented by the table shown in fig.3. This table shows the entries for base station2 in the database. Assume that vehicles with mentioned vehicle_ids are moving along the base station’s range such as BS2, BS6 etc. In this table, the vehicles which are moving in its range are shown as well as the vehicles with BS1, BS6 and BS2 are also shown. This information is actually sent through base station1, base station 6 and base station 2 on request of base station 2. Based on the data collected by base station 2, the traffic status based on status_id (along the route) is then reflected to the GPS receivers of the vehicle.

Consider base station range to be 5kms and each server stores road map of the city. If the driver asks for source = ‘A’ and destination = ‘B’, then this request will be sent to the nearest server. As within 5kms of range of B.S., there will be many roads in different directions but this server will check the status code only those vehicles which are moving along the requested route. Also this server will pass the request to only those servers which are needed to compute the traffic along this requested route. And each server will similarly check the status of vehicles and will send back the reply to the 1st server. After getting replies from all the servers, the first server will send the traffic status to the driver’s vehicle which is then displayed in the GPS receiver of the vehicle as:

a) Smooth run of vehicles: Green
b) Slow run of vehicles: Yellow
c) No run of vehicles (traffic Congestion): Red
2.3 Algorithm

1. Map and Vehicle information as input (.xml file)
2. Forming efficient map
   a. Points: Longitude and Latitude.
   b. Line: Connection to different longitude And latitude Points (roads represents connection of two points)
3. Vehicles movement is presented on road map.
4. As cars moves on roads each car’s information like (stop, fast, slow, longitude, latitude) is stored into database. For example, slow car’s value is set to -1 with its vehicle_id, longitude and latitude.
5. Load particular road map scenario
   5.1. Select source and destination
   5.2. Estimate traffic by the information stored in the database.
6.3. Find estimated route as
   6.3.1. Select randomly one route from source to destination.
   6.3.2. Compute traffic according to data obtain from database as:
     For each route from source to destination
     For each car on route
       If status-code of car is 0 then
         Stopcount++
       
       If status-code of car is -1 then
         Slowcarcount++
       
       If status-code of car is 1 then
         Fastcarcount++
     
     End for
     End for
   6.3.3. Compute route with minimum count of stop and slow car.

7. Show estimated route to user (driver on GPS vehicle)

Section III describes the current state of implementation and results achieved. Some conclusive remarks are given in the final section.

3. RESULTS

3.1 Input Dataset
   For input data, we take each vehicle’s location, i.e. by which direction vehicle is travelling. In this section we are presenting practical environment, dataset used, and metrics computed. Base Stations are assumed as they are really not mounted on the roads. We have used an XML file and a road map on which vehicles movement along different routes are shown. In this map, we have assumed that there are few base stations and the vehicles are communicating with the base stations. The coordinates of the vehicles are getting stored in the database.

3.2 Outcomes
   Following figures are showing results for practical work done. In Fig 4, map for road is loaded. This can be done by selecting the needed XML files for map and the scenarios (i.e. to load the vehicles on road). After this step, the moving vehicles can be seen along the routes of the map.

Fig.4: Maps of Roads
When any of the vehicles is clicked then a circle is drawn around it and the path is shown to its destination which contains less traffic. Fig. 5 shows the moving vehicles on road and by click on vehicle its source, destination, vehicle id is displayed.

![Fig.5: Vehicle moves on road.](image)

In Fig. 6, it is shown through a static diagram that what concept is basically used to estimate the least-congested route. Consider, the scenario that red dots are representing vehicles which are stuck in the traffic, yellow dots represents slow cars and good traffic flow is represented with green colour. So, if we select a source and a destination, then it shows the 'suggested route' with minimum no. of red and yellow cars.

![Fig.6: Suggested Route for Scenario](image)

Based on the demand from the driver, it’s shown in Fig. 7 that how queries can be executed in the database. For example if we need to calculate that how many vehicles are there between, say, Longitude=35.2387463738 and Longitude =51.487477362728 and Latitude=121.37261728 and Latitude=130.283746372 then after processing the request whose status code is -1 (slow run of vehicles) or 0(cars stopped due to traffic congestion), the output is shown in Fig. 7. For this example, the output(count) for the above query is 13. That means there are 13 vehicles which are either moving slow or are stopped within these coordinates.
As there are many base stations and with each base station there is attached a server and database in which the information of the GPS vehicles is updated immediately, it will take less time for computation. This is because each base station is holding information of the vehicles in its range and this information is sent to other base stations on their request. So, there will be no overload on any of the servers and information can be stored and retrieved immediately. And therefore accuracy will increase and computation time decreases as shown in Fig.7.

Finally, conclusion and future work is predicted in section IV.

4. CONCLUSION

This paper presented an effective and efficient solution on how we can estimate the traffic status of routes from source to destination on large-scale urban road networks with an outsized variety of GPS probe vehicles. The concept is based on the base stations which receive precise coordinates of the GPS vehicles which might be utilized in personal computers for process. Each base station receives coordinates of every GPS vehicle. With every base station we are attaching a server and a database. The base station are used to collect the information of vehicles and this information is saved into database. As the coordinates of the vehicles changes, based on their speed each vehicle is given a status-code to represent that whether the vehicle is moving slowly, fast or stopped. This information is stored and processed by each base station and its associated database and server. As base stations have limited range of about 2-7 kms, many base stations or repeaters have to be used. To compute the traffic of the route, if any base station needs status of the vehicles which are not under its range then its server send this request to only other servers which are required to compute traffic along the requested route. After receiving status of vehicles from other servers, this server will display the traffic status of slow, fast and stopped cars on the GPS receiver with different colors. It may happen that there are many possible paths in the map of the base stations to reach the destination. So, this paper can further be extended to calculate the optimal route which contains least traffic. The benefit of extending the paper in such a way is that all the base stations can compute the best route (in its range) according to the traffic and send the status of vehicles of that route to the server which initiated the request.
REFERENCES

[1] Qing-Jie Kong, Member, IEEE, Qiankun Zhao, Chao Wei, and Yuncai Liu, “Efficient Traffic State Estimation for Large-Scale Urban Road Networks”, IEEE Transactions On Intelligent Transportation Systems, Vol. 14, No. 1, March 2013


