A Study on Vehicle Trajectory Analysis

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Thesis submitted in
May 2014
to the department of

Computer Science & Engineering
of
National Institute of Technology Rourkela

in partial fulfillment of the requirements
for the degree of

Bachelor of Technology
In
Computer Science & Engineering
by

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May 5, 2014

Certificate

This is to certify that the work in the thesis entitled ***A Study on Vehicle Trajectory Analysis*** by ***Banoth Kotesh*** is a record of an original work carried out under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

Dr. S. K. Jena
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Acknowledgment

I take this opportunity to express my profound gratitude and deep regards to my guide **Dr. S. K. Jena** for his exemplary guidance, monitoring and constant encouragement throughout the course of this project. The blessings, help and guidance given by him time to time shall carry me a long way in the journey of life on which I am about to embark. I also take this opportunity to express a deep sense of gratitude to *Mrs. SwathiLanka, Ph.D Scholar*, for her support and motivation which helped me in completing this task through its various stages.
I am obliged to the faculty members of the Department of Computer Science & Engineering at NIT Rourkela, for the valuable information provided by them in their respective fields. I am grateful for their cooperation during the period of my assignment.

Lastly, I thank Almighty, my parents and friends for their constant encouragement without which this assignment would not have been possible.

Banoth Kotesh

Author's Declaration

I hereby certify that all the work contained in this report is done by me unless otherwise acknowledged. Also, all of my work has not been previously submitted for any academic degree. All sources of quoted information have been acknowledged by means of appropriate references

Banoth Kotesh
Date: 05-05-2014

Abstract:

Successful developments of effective real-time traffic management and information systems demand high quality real time traffic information. In the era of intelligent transportation convergence, traffic monitoring requires traffic sensory technologies. The present analysis extracted data from *Mobile Century* experiment. The data obtained in the experiment was pre-processed. Based on the pre processed data experimental road map has generated. Individual vehicle tracking has done using trajectory analysis. Finally an attempt has been made for extracting association rules from mobile century dataset using Apriori algorithm.

Contents

Chapter 1

Introduction

1.1 Intelligent Transport System

Over the years many research efforts have been devoted to ad-hoc networking. The basic objective of ad-hoc network is delivers the data to the given destination [1].Vehicular Ad- Hoc Network is one of the key enabling technology which can provide the communication between the vehicles which are connected through wireless links. It has got a wider implementation in various countries across the world. It is a component of Intelligent Transportation System can bring a noticeable improvement in transportation system towards decreasing congestion and improving safety and traveller convenience [2]. Many works has done on several applications of VANET, including vehicle-vehicle communication, protocols designing, in-vehicle communication etc. Intelligent Transportation is one of the primary applications of VANET in order to direct the future in terms of smart vehicle designing. In Intelligent Transportation, existing works providing solutions either for traffic congestion, or for alternative route generation, journey time estimations. There must be a framework with driving assistance must provide all necessary information about road-traffic to the vehicle driver without his intervention and a continuous monitoring on individual vehicle movement has to be done as well. Existing works generating road information with Variable Message Signs. Intelligent management of traffic flows making commuters more informed about traffic and road status can reduce the negative impact of congestion. This is the idea behind Intelligent Transport Systems [3]. Intelligence requires the ability to sense the environment, to make decisions and to control actions. Vehicles, roads, traffic lights and message signs are the main elements of intelligent transportation system. Vehicle can become intelligent by embedding it with microchips and sensors, by empowering with wireless technologies it can communicate each other. Many of nations in the world had beneficial with significant improvement of transportation system performance, including reduced congestion, increased safety and traveller's convenience [4]. Increased rate of loss due to road accidents and recent trends in wireless technologies necessitate the development of intelligent transportation system.VANET is a visualization scheme of ITS. In the part of it vehicles can talk with each other through inter vehicle communication; vehicles can communicate with base stations which are usually placed at roadsides. In this case, conversation is possible through roadside-to-vehicle communication. The aim behind all these actions is to have a less risky and more thoroughly organised roads through well-timed information both for drives and authorities as well.DSRC,Wi-MAX and Wi-Fi are various wireless methodologies for implementing VANET.ITS integrates hardware, software, electronics and communications which can support various services and products to address transportation problems [5]. The primary goal of ITS is to improve traffic safety, efficiency and travelling comfort by designing advanced road traffic systems. Cooperative systems in transportation can bring new intelligence for vehicles, roadside systems, operators and individuals by creating a communications platform allowing vehicles and infrastructure to share information [6]. Various ITS activities are showed in Figure 1.

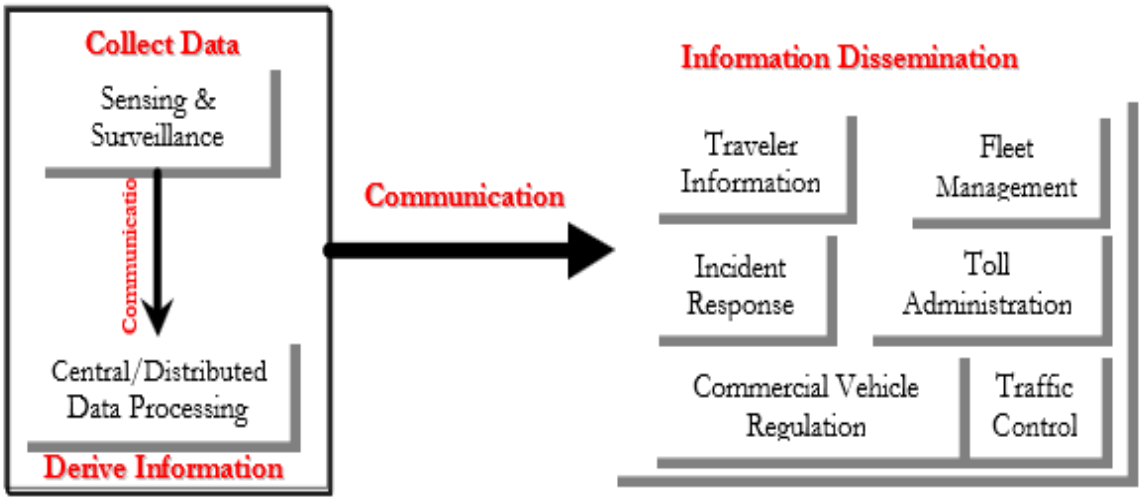

Figure 1: Various ITS activities

1.1.1 Benefits of ITS

The goal of intelligent transportation systems (ITS) is to improve the safety, effectiveness and efficiency of the transportation system. Long range planning for the deployment of ITS technologies depends in part on the knowledge of which technologies are most effective.

1.1.2 MEASURES OF BENEFITS

To help quantify ITS benefits, various measures of effectiveness have been used. These measures represent the ways that ITS programs improve traveler mobility, traveler safety, system efficiency, productivity of transportation providers, environmental protection and energy conservation. These measures include:

- **Safety**: "typical measures include overall number of crashes, and changes in crash, injury, and fatality rates. Surrogate measures include vehicle speeds, speed variability or changes in the number of violations of traffic safety laws."

- **Mobility**: "typical measures include the amount of delay (in units of time) and the variability of travel time."

- **Capacity**: "Throughput: measured by the maximum number of persons or vehicles per hour at a point. Throughput is the number of persons, goods or vehicles traversing a roadway section per unit time."

• **Customer Satisfaction**: "measures related to satisfaction include amount of travel in various modes, mode choices and quality of service as well as volume of complaints and/or compliments received. Typical results reported for customer satisfaction with a product or service includes product awareness, expectations of benefits, product use, response, realization of benefits, and assessment of value."

• **Productivity**: "measures include operational efficiencies and cost savings."

• **Energy and Environment**: "measures of effectiveness include changes in emission levels and energy consumption. Specific measures for fuel use and emission levels include emission levels (kilograms or tons of pollutants for carbon monoxide (CO), oxides of nitrogen (NOx), hydrocarbons (HC) and volatile organic compounds (VOC). fuel use (liters or gallons), and fuel economy."

1.1.3 Advanced Traveler Information System:

The Advanced Traveler Information System (ATIS) is one of the six components of ITS. ATIS provides solutions for intelligent transportation related applications. It implements emerging computer, communication and information technologies to provide vital information to the users of a system regarding traffic regulation, route and location guidance, hazardous situations and safety advisory and warning messages. ATIS requires a large amount of data for processing, analysis, and storage for effective dissemination of traveller information [3]. Traffic congestion has a significant negative impact on social and economic activities around many cities in the world. Road traffic monitoring aims to determine traffic conditions of different road links, which is an essential step toward active congestion control. Many tasks, such as trip planning, traffic management, road engineering, and infra-structure planning, can benefit from traffic estimation [4].Traditional approaches for traffic monitoring rely on the use of point traffic sensors, which can mount at a fixed location along the roadway and sense the traffic parameters at the particular location [5], [6]. After traditional approaches, with the increasing growth of mobile technology mobile sensors has got attention, will be placed in a vehicle can collect vehicle related data [6], [7]. Recently in the era of mobile internet services, with the shrinking cost and increased accuracy of GPS, and increasing penetration of mobile phones in the population makes Global Position System (GPS) with Floating Car Data (FCD) as an attractive traffic sensor[8], [9]. Table 1 shows particulars of commercially available traffic sensors. With the growing prevalence of GPS receivers embedded in vehicles and smart- phones, there have been increasing interests in using their location updates or trajectories for monitoring traffic [10]. Even though GPS is becoming more and more used and affordable, so far only a limited number of cars are equipped with this system, typically fleet management services. Traffic data obtained from private vehicles or trucks is more suitable for estimating traffic under motorways and rural areas [11]. In case of urban traffic, taxi fleets are particularly useful due to their high number and their on-board communication systems already in place. Currently, GPS probe data are widely used as a source of real-time information by many service providers [12].

1.2 Global positioning System

The **Global Positioning System** (**GPS**) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. These GPS are attached to each vehicle and data is collected for every 3 seconds.

1.2.1 How it Works

GPS satellites revolve around the earth twice a day in a very precise orbit and sends signal information to earth. GPS receives this information and calculate the user's exact location. Essentially the GPS receiver compares the time a signal which is transmitted by a satellite with the time it was received. This time difference is used to calculate how far away the satellite is. Now, with the distance measurements from few other satellites, the receiver can determine the user's position and displays it on the electronic map.

1.3 Collecting Data Through Sensors

Wireless sensor networks offer an attractive choice for low-cost and easy-to-deploy solutions for ITS. Ultrasonic and magnetic sensors give accurate and reliable detection of vehicles in parking lots. Stardust is a new concept for wireless sensor networks which offer tiny, low power integrated devices for sensing and networking. It suits for transportation applications in terms of gathering and disseminating useful information in a convenient way. UK Department for transport funded 3 projects in which smart dust is used namely ASTRA(Application soft Smart dust in Transport,2005),TRACKSS(Technologies for Road Advanced Cooperative Knowledge SharingSensors,2007)and EMMA(Embedded Middleware in Mobility Applications,2007) [13].Detector technology allows variety of detectors such as magnetic,infrared,ultrasonic,radar,microwave,inductiveloop,seimic,inertia-switch and video detectors. These detectors measure the change in magnetic/seismic/optical/acoustic fields caused by passage of vehicles and calculate traffic parameters (volume, occupancy, speed) based on the measurements. Many of these detectors are placed either in vehicle or on the roadway to provide real-time information about the road. RFID tags and readers can be used with a cheaper cost. Global Positioning System usually equipped in a specific vehicle provides fast, flexible, relatively intensive data to determine a vehicle’s position and velocity in a real time [14].

Technology	Sensing parameters	Strengths	Weakness	Suitable applications
Inductive loops (Point sensor)	Vehicle volume, occupancy, time, speed	Conventional standard can obtain accurate occupancy measurements, flexible design can satisfy large variety of applications, adoptable and less sensitive for all weather and lighting conditions	Installation is intrusive to traffic, maintenance and installation cost is more, gives less detection accuracy when large number of vehicles are involved, reinstallation is needed whenever road is repaved.	Traffic flow detection, congestion detection, traffic-density detection
Pneumatic tubes [6](Point sensor)	Speed, direction of flow, time, volume	Ideal for short term engineering studies, less maintenance and installation cost, portable device can be reused in many locations.	Has limited lane coverage, intrusive to traffic, system damage causes to inaccurate data collection	Vehicle count, traffic flow detection
Video Image Processors [6], (Point sensor)	Road vehicle images, video streams of traffic	Rich array of data collection, can monitor multiple lanes and detection zones with minimum installation and maintenance, insertion and deletion of detection zones is easy	Performance may be affected by weather, vehicle shadows, vehicle projections, occlusions, strong winds, day-night transitions and water, dust on the camera lens. Setup cost is high.	Traffic count, vehicle speed detection, vehicle classification
Acoustic/Ultrasonic Sensors [6] (Mobile sensor)	Occupancy, count, speed	Multiple lane operation is possible, capable to detect high occupancy vehicle with high accuracy, in sensitive to precipitation	Environmental conditions may affect the performance, cold temperature may affect vehicle count accuracy, and occupancy measurement accuracy may be degraded when vehicle travelling with high speed.	Vehicle parking assistance, vehicle detection, pedestrian count
Active/Passive Infrared Sensors [6] (Mobile sensor)	Vehicle position, speed, count,	Can be operated both day and night, multiple lane operation is possible, usage of sophisticated signal processing algorithms gains better accuracy	Sensitive to inclement weather conditions and ambient light, installation and maintenance cost is more	Road obstacle detection, distance measurement
RFID Sensors [7] (Point & Mobile sensor)	Vehicle ID, time	In expensive Less installation and maintenance cost non intrusive to traffic	Only detect equipped vehicles Collect poor array of data Privacy concerns and actors interest is required	Automatic Vehicle Identification, E-Z pass, Electronic Toll Collection
Microwave Radar [6] (Mobile sensor)	Speed, occupancy, presence	A single detector can cover multiple lanes, usage of efficient signal processing techniques increases detection accuracy	Multi path coverage causes redundant vehicle detection, false detection sometimes, unable to detect stopped vehicle	Calculates vehicle speed, vehicle detection
Magnetometer [6] (Point sensor)	Vehicle count, time	Can be used where a point or small-area location of a vehicle is necessary, can be used where loops are not feasible (e.g, bridge decks), insensitive to weather conditions	Installation requires pavement cut, requires multiple units for full lane detection, maintenance cost is more	Vehicle presence detection, vehicle passage detection
GPS with FCD [8],[9] (Mobile sensor)	Longitude, latitude, time, speed	In vehicle sensor simple to install and operate, less maintenance cost, easy penetration due to raped increase of mobile phones, works under all weather and lighting conditions, never suffer with energy consumption problem since GPS will be equipped in a moving vehicle, collects on road real-time information, non intrusive to traffic.	GPS signals may be obstructed by tall buildings and trees, actor interest is required and Signal strength may be degraded under bad weather conditions.	Congestion detection, collusion detection, intersection safety, Road safety

1.4 Literature Review

There has been a significant amount of work contributed by many researchers in different directions. The literature in this field can be highly motivated to design more efficient vehicular system. Hartenstein et al. [15] surveyed on key challenges of VANET, impact of VANET on traffic safety and efficiency via simulations. With respect to simulation methodology, a set of standardized benchmarks and test scenarios would be useful to make protocol and model proposals comparable with each other. Van et al. [16] contributes Co-operative Competition for future mobility for increasing public awareness regarding vehicular technologies and specifically their potential with respect to throughput, safety, and environmental aspects. They focused on IEEE 802.11p-based communication protocol stacks. Faezipour et al. [17] surveyed on progress and challenges in Intelligent Vehicular Area Networks envision future VAN combining wireless local and wide area network technologies using portable IP-centric devices, sensors, signal processing, and driver behaviour analysis techniques. This would ensure reliable and informative communication while vehicles are in motion.Wei Cheng at al [18] proposed a systematic approach for designing and deploying RFID Assisted Navigation System (RFID-ANS).RFID-ANS consists of passive tags deployed on roads to provide navigation information while the RFID readers attached to the centre of the vehicle. Barjesh et al.[19] designed an effective data warehousing system deployed in any RFID applications, the data extracted from the RFID reader is essentially to be exact, the data to be stored in the repository to be transformed efficiently. Chengqi et al. [20] investigates how agents and data mining can enhance each other, and, how these two cutting edge technologies can be integrated. Equipping agents with data mining capabilities, the agents become smarter and adaptable. Roshandeh et al. [21] found that fuzzy logic gives more benefits for traffic control. Fuzzy logic, simply put, transforms vague concepts such as ’very slow’, ’slow’, ’medium’ and ’high’ into the mathematical form which is then used by variable message signs in performing problem solving actions. Maroto et al. [22] developed a traffic model for implementing a driving simulator in an urban environment. Therefore, the model needs to be suitable for real-time simulation and, in turn, provide a high degree of realism. Bishop [23] surveyed on intelligent vehicle applications worldwide. Intelligent Vehicle (IV) systems use sensing and intelligent algorithms to understand the environment immediately around the vehicle, either assisting the driver in vehicle operations (driver assistance) or fully controlling the vehicle (automation). Fogue et al. [24] presented an article, with a e-NOTIFY system, which allows fast detection of traffic accidents, improving the assistance to injured passengers by reducing the response time of emergency services through the efficient communication of relevant information about the accident using a combination of V2V and V2I communications. Tom et al. [25] discussed on intelligent transportation system regarding travel and traffic management, public transportation operations, emergency management, ITS architecture and national ITS architecture and ITS planning.

1.5 Motivation

The aim behind all these actions is to have a less risky and more thoroughly organised roads through well-timed information both for drives and authorities as well. The primary goal of ITS is to improve traffic safety, efficiency and travelling comfort by designing advanced road traffic systems. Cooperative systems in transportation can bring new intelligence for vehicles, roadside systems, operators and individuals by creating a communications platform allowing vehicles and infrastructure to share information**.** This can reduce the traffic and can provide information to drivers for the alternate paths if they are struck in the traffic.

1.6 Objectives and Scope of work

- Each vehicle is equipped with GPS. Then data is collected by using GPS.
- Collected data is preprocessed. Then by using the latitude and longitude points the location of a vehicle is tracked on the google map.
- Now all the points are joined of each vehicle so the trajectory of each vehicle is traced on the road.
- Now Association rules are applied to find the vehicle which is present on the road at particular time.

1.7 Out Line of Thesis

The position of vehicle is collected from source to destination using GPS. Then the collected data is preprocessed. Then the trajectory of a all the vehicles are plotted on the google maps, now by applying Association rule mining the vehicles which are on the road for longer times and also vehicles which are moving at similar speeds can be determined.

Chapter 2
Proposed Work

2.1 Problem Formulation

The aim of this project is to implement an algorithm to a vehicle moving on the road, the objective is to analyze the trajectory of the individual vehicle; integrating trajectory analysis in to association rule mining imposes noticeable vehicle movement.

2.2 Data Set

Vehicle trajectories are typically collected from GPS equipped vehicle based mobile phone from Mobile Century experiment took place on February 8th, 2008. It consisted in deploying 100 GPS- equipped Nokia N95 cell phones on a freeway in 100 vehicles during 8 hours (from 8 February at 19:00:00 pm to 9 February at 03:00:00 am). The experiment was conducted on Highway I-880, near Union City, California; between Winton Ave. to the North and Stevenson Blvd. to the South. This 10-mile long section was selected for field experiment. Data has collected on four lane road with a regular time interval of 3 seconds.

Table 1:

V ID	Date & Time	Latitude	Longitude	Speed
1	08-02-08 19:00:02	37.60043	-122.064	0.009
1	08-02-08 19:00:06	37.60043	-122.064	0.01
1	08-02-08 19:00:09	37.60043	-122.064	0.013
1	08-02-08 19:00:12	37.60043	-122.064	0.015
1	08-02-08 19:00:16	37.60043	-122.064	0.016
1	08-02-08 19:00:20	37.60043	-122.064	0.017
1	08-02-08 19:00:24	37.60043	-122.064	0.017
1	08-02-08 19:00:27	37.60043	-122.064	0.015

Table 2:

V ID	Date & Time	Latitude	Longitude	Speed
1	08-02-08 19:00:08	37.6105	-122.069	5.002
1	08-02-08 19:00:08	37.6220	-122.078	67.776
2	08-02-08 19:00:09	37.6004	-122.064	0.013
1	08-02-08 19:00:09	37.6430	-122.092	52.402
5	08-02-08 19:00:09	37.6141	-122.072	3.143
8	08-02-08 19:00:09	37.6087	-122.068	65.229
1	08-02-08 19:00:09	37.5934	-122.057	68.11
7	08-02-08 19:00:09	37.6005	-122.062	66.612

2.3 Trajectory Analysis

A trajectory is a sequence of sampled time stamps and along the route of a moving object. One of the main challenges is to characterize, compare, and generalize trajectories to find general patterns and trends. Existing methods often treat each trajectory as an independent object and compare trajectories based on their properties such as geographic locations, distance, and angles. Another challenge is to generalize individual locations into regions of interest. To overview large data sets of trajectories it is also required to aggregate individual (every single) locations into geographic location. Within the help of vehicle movements, the research develops a method that establishes topological relationships among trajectories and locations and uses a spatially constrained graph partitioning method to discover natural regions defined by trajectories. Let X and Y are two points that are geographically near. If the trajectories are involving X never intersect the trajectories that involve Y, then X and Y are “far” from each other in the trajectory space

2.3.1 Plotting the path of a Particular Vehicle on Road using Google Maps

The latitude and longitude points which are collected through GPS are plotted on the Google maps by using the function plotOnMap in python.

Algorithm:

To draw the path of a particular vehicle, by using the latitude and longitude points which are collected from GPS.

Map Drawing Algorithm1

Step1: Read latitude and longitude points from .csv file.

Step2: Store these points in a two dimensional matrix.

Step3: Call the function plotOnMap by passing input matrix as an argument.

Step4: Repeat the step5 to 6 for each point in the matrix.

Step5: set the color of the point.

Step6: Draw the point on Google Maps using pygmaps module.

Step7: Finally an HTML File containing all the plotted points is generated.

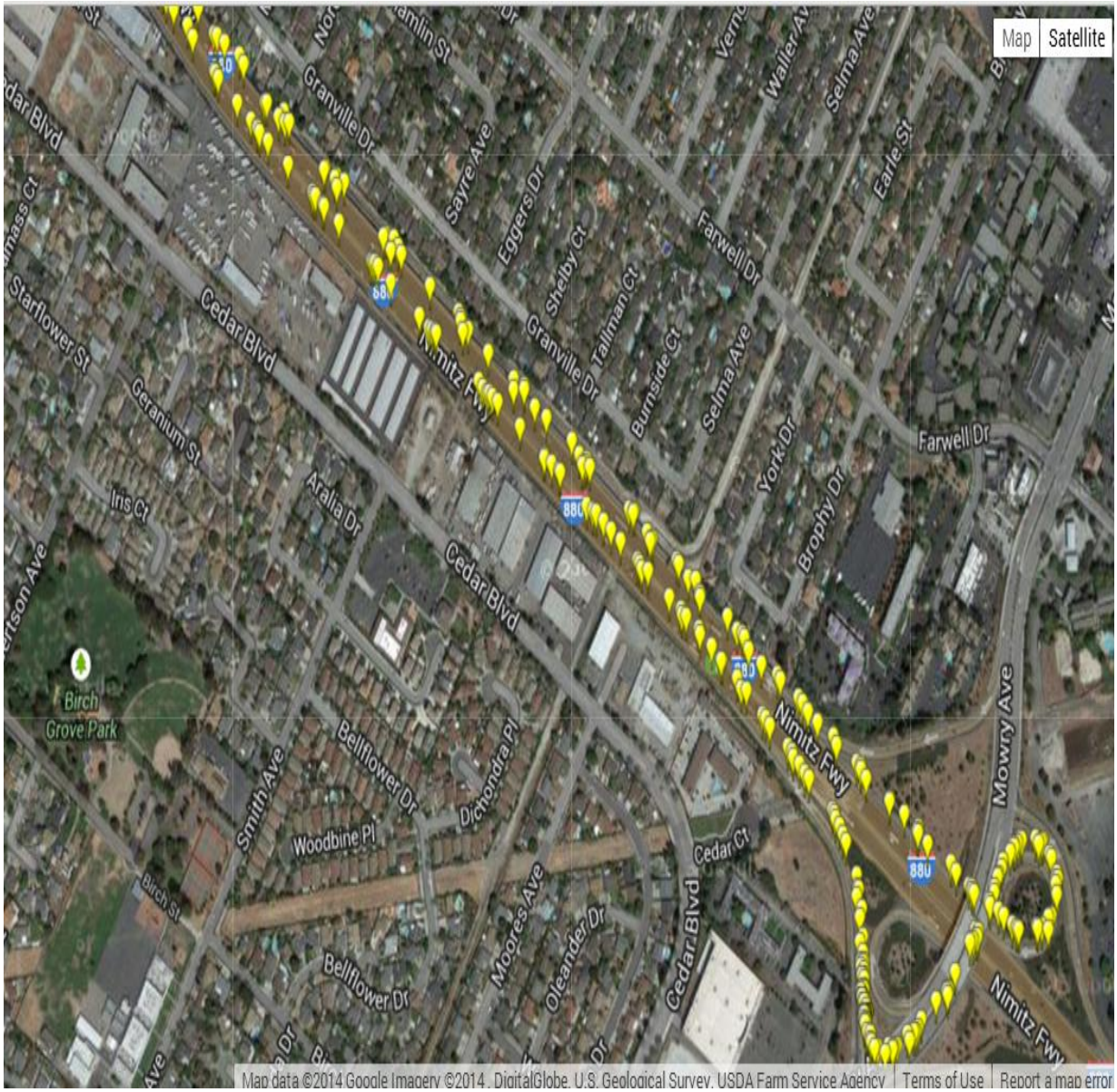

Figure 2.3.1: Path of a particular vehicle on the road using Google maps

2.3.2 Plotting the Trajectory of Vehicle on Road using Google Maps

Each point which had plotted is joined to trace the trajectory of a particular vehicle.

Algorithm:

To plot the path of a particular vehicle, by joining the latitude and longitude points which are collected from the GPS.

Map Drawing Algorithm 2

Step1: Read vehicle id, latitude and longitude points from .csv file.

Step2: Store these points in a two dimensional matrix.

Step3: Call the function plotOnMap by passing input matrix as an argument.

Step4: Repeat the step5 to 6 for each point in the matrix.

Step5: set the color of the point and path connecting those points for each vehicle.

Step6: Draw the point and path on Google Maps using pygmaps module.

Step7: Finally a HTML File containing all the plotted points and paths connecting those points is generated.

Figure 2.3.1: Trajectory of vehicle on the road

2.4 Conventional Association Rule Mining

Definition1. Let $I=I_1, I_2, \ldots\ldots\ldots I_n$ be a set of n distinct attributes, T is a transaction database contains set of items {I} such that $T \subseteq I$. D is a database with different transaction records T_r. An association rule is an implication in the form of $A \Rightarrow B$ means A implies B, where $A, B \subseteq I$ and $A \cap B = \Phi$. Here A is called antecedent while B is called consequent. Two measures, namely Degree of Support (D_{Sup}) and Degree of Confidence (D_{Conf}) are used to validate the rule accuracy. Let α, β are user defined minimum support and minimum confidence thresholds should satisfy the following conditions to include/exclude item set.

$$D_{Sup}(A \Rightarrow B) = ||AUB|| / |T| \quad (1)$$

$$D_{Conf}(A \Rightarrow B) = ||AUB|| / |A| \quad (2)$$

If $((D_{Sup}(A) \geq \alpha)$ && $(D_{Conf}(A) \geq \beta))$

A is frequent item set and rule is considered

Else

A is excluded item set and rule will be pruned

TABLE- II: Spatio-temporal database

V-ID	Date & Time	Latitude	Longitude	Speed
1	08-02-2008 19:00:02	37.60043	-122.0642	67.776
2	08-02-2008 19:00:06	37.60056	-122.0643	52.402
3	08-02-2008 19:00:10	37.60067	-122.0644	45.229

Chapter 3

Simulation and Results

3.1 Data set

1) The dataset taken consists of 5 vehicles and 21174 transactions.

2) The dataset taken consists of 50 vehicles and 288000 transactions

The actual dataset file(.csv) is converted to tab delimited file(.txt) with only 2 columns data(VehicleID, Time);

Table.py

Table.py is program to read the data set . First reads the tab delimited file and stores all the lines of the file in a list. For every line in the list it deletes '\n' (replaced with ''), then '\t' is replaced with ','. The time list is set to contain only distinct time values. For each element in the set compare the value with the data list and if add all the VehicleID's at a particular time to a file in a line

1) Read the tab delimited file and store all the lines of the file in a list.
2) For every line in the list do
    i) Delete '\n'. (Replace '\n' with '')
    ii) Replace '\t' with ','.
    iii) Split the data separated by ',' and add the two elements generated for each line back to the list.
3) Make a new list consisting of only the values in the time field.
4) Convert the time list to set so that it contains only distinct time values.
5) For each element in the set compare the value with the data list and if add all the VehicleID's at that particular time to a file in a line.

New.py

In New.py the file generated in the previous program and stores the value in the list. Create a (no. of vehicles)*(no. of distinct time values) list and initialize the values to 0 and call it the "final list". For each line of the data list do, set the value in the final list to 1 corresponding to the VehicleID in the data list. Write the final list to a file named "transa.txt".

1) Read the file generated in the previous program and store the values in a list.
2) For each line in the list
   i) Replace ' \n' with ''(Delete the ' \n')
   ii) Split the data with respect to ' '(Space)
   iii) Store the new elements generated as a list back into the main list.
3) Create a (no. of vehicles)*(no. of distinct time values) list and initialize the values to 0 and call it the "final list".
4) For each line of the data list do
   i) Set the value in the final list to 1 corresponding to the VehicleID in the data list.
5) Write the final list to a file named "transa.txt".

Config.txt

It consists of three lines, each line is an integer. The input for the program is given here. The number of transactions is taken from the "transa.txt" and minimum support is given randomly

1) line 1 - number of vehicles
2) line 2 - number of transactions
3) line 3 - minimum support(%)

transa.txt

Transaction file, each line is a transaction; items are separated by a space. This is generated from New.py

Apriori

Pseudo-code:

1) C_k: Candidate itemset of size k
2) L_k: frequent itemset of size k
3) L_1= {frequent items};
4) for(k= 1; L_k!=∅; k++) do begin
5) C_{k+1}= candidates generated from L_k;
6) for each transaction t in database do
   i) increment the count of all candidates in C_{k+1} that are contained in t
7) L_{k+1}= candidates in $C_{k+1}$with min_support
8) end
9) return $\cup_k L_k$;

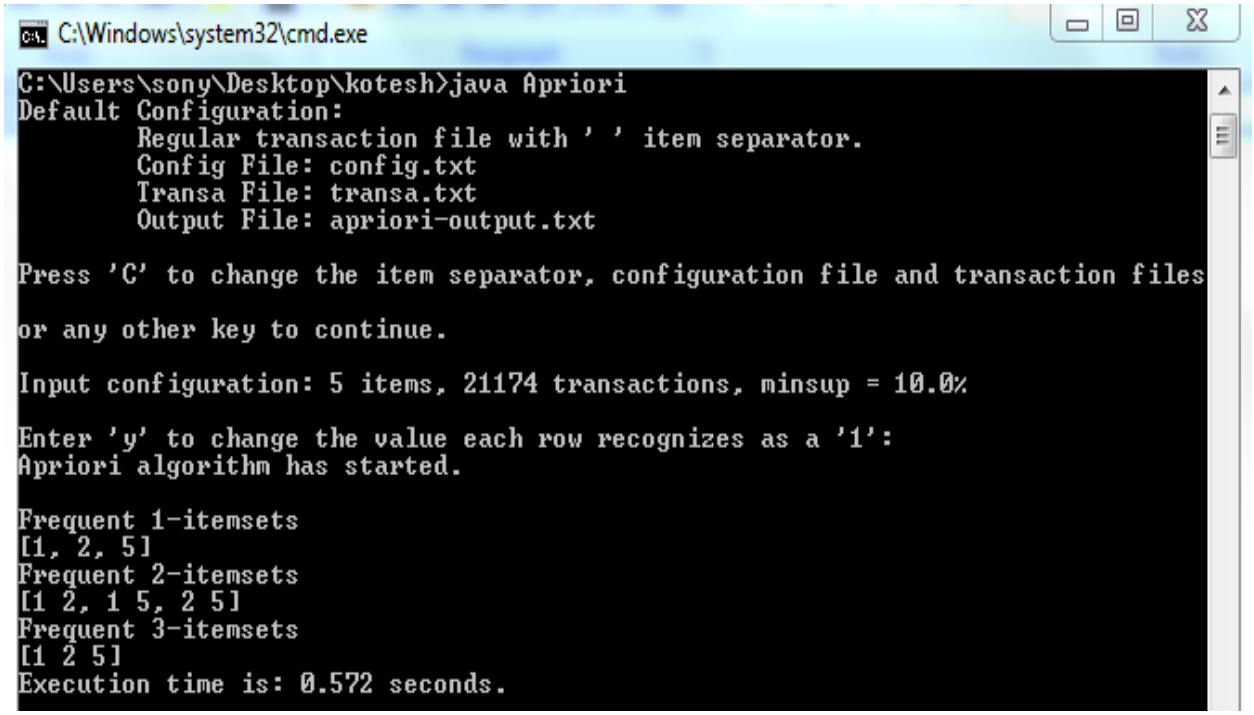

Figure 1: The dataset taken consists of 5 vehicles and 21174 transactions with minimum support 10%.

```
Frequent 10-itemsets
[1 2 3 4 5 6 7 8 9 10, 1 2 3 4 5 6 7 8 9 50, 1 2 3 4 5 6 7 8 10 50, 1 2 3 4 5 6
7 9 10 50, 1 2 3 4 5 6 8 9 10 50, 1 2 3 4 5 7 8 9 10 50, 1 2 3 4 6 7 8 9 10 50,
1 2 3 5 6 7 8 9 10 50, 1 2 4 5 6 7 8 9 10 50, 1 3 4 5 6 7 8 9 10 50, 2 3 4 5 6 7
 8 9 10 50]
Frequent 11-itemsets
[1 2 3 4 5 6 7 8 9 10 50]
Execution time is: 29.185 seconds.
```

Figure 2: The dataset taken consists of 50 vehicles and 28800 transactions with minimum Support 60%

3.2 Result:

1) From the figure 1, Frequent 1-itemsets we can conclude that those vehicles are on the road for maximum period. The definition of maximum period here depends on the minimum support value chosen.
2) From figure 1 Frequent 2-itemsets and above we can conclude that those combination of vehicles maybe travelling at similar speeds.
3) In figure 2 the number of vehicles are 50 and the transactions are 28800, with minimum support 60% . Total 11 frequent item sets are generated.

Chapter 4

Conclusions and Future Work

This is a graph-based approach that converts trajectory data to a graph based representation and treat them as a complex network. Within the context of vehicle movements, the research develops a sequence of methods that extract representative points to reduce data redundancy and size, interpolate trajectory to accurately establish topological relationships among trajectories and locations. In future: Extracting association rules using genetic algorithm.

However with the Apriori algorithm it is difficult to track the exact vehicle movement, by applying some soft computing techniques to it, we can trace the exact vehicle movement. This will helps to have a prominent future congestion prediction

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