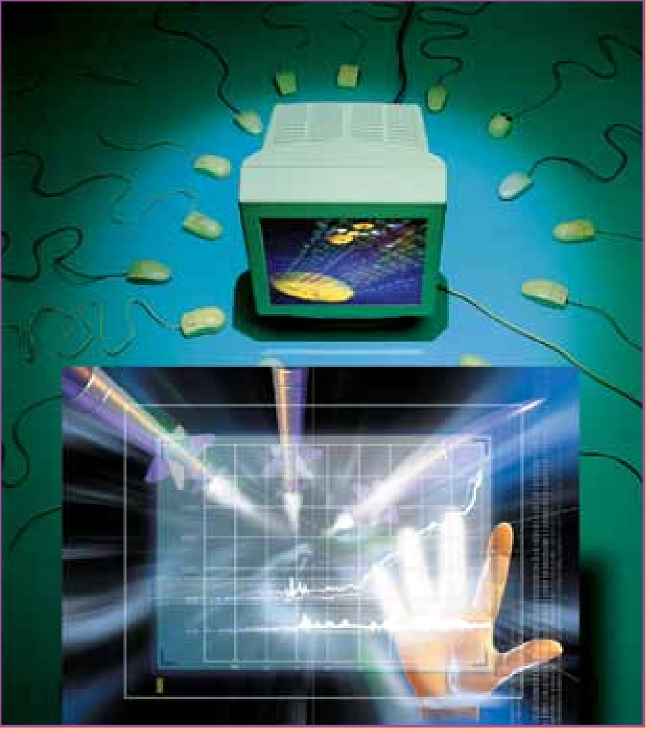

Algorithm for Detection of Hot Spots of Traffic through Analysis of GPS Data

Dr Deepak Garg, Jitesh P. Tripathi, Department of Computer Science & Engineering, Thapar University, Patiala (Punjab), India, Email - deep108@yahoo.com

Abstract

Traffic congestion continues to be one of the major problems in various transportation systems. The ever increasing demand for mobility in urban centers has resulted in increased traffic congestion and a multitude of problems associated with it. Peoples are especially concerned about those areas of the city which are regularly congested, because these areas could magnify the impact area and the duration of congestion. A prior knowledge about these areas and better understanding of impact of these areas could helps into more appropriate traffic management strategies. This report present the method of detecting these areas ,which we call as 'Hot-Spots' in terms of road traffic and analyses the impact of these 'Hot-Spots' on traffic, both in terms of time and space. The Global Positioning System (GPS) data is used for this objective, as GPS has become a reliable, accurate and economically feasible positioning technology for probe vehicle. In the report, we present an algorithm for the detection of the 'Hot-Spots', one is based on the speed of the probe vehicle before and after the concerned area.

Keywords: - Traffic congestion, GPS, Probe vehicle, Hot-Spots.

1. Introduction

Traffic congestion continues to be one of the major problems in various transportation systems. The dramatic increase in traffic volume worldwide is leading to massive congestions causing various social, environmental and economic problems. Congestion are often caused by or made worse by traffic incidents. A sudden traffic surge immediately after special events or some special location ('Hot Spots') in the city can create substantial traffic congestion in the area related with these incidents or Hot Spots.

Hot-Spots and road incident's induced traffic congestion provides real threats to the mobility and safety of our daily travel. Congestion may be alleviated by providing timely and accurate traffic information so that motorists can avoid congested routes by using alternative routes or changing their departure times. In general, the public tends to think more in terms of travel time rather than volume in evaluating the quality of their trips. Accordingly, hot spot information is a key element for avoiding congestion as well as for making informed driving route decision [1, 9].

Therefore timely and accurate detection

of road incident and hot-spots is an essential part of any successful advanced traffic management system. If any incidents or Hot Spots are detected quickly, they can be cleared swiftly, resulting in less traffic congestion, and then more appropriate traffic management strategies can be applied to provide better service to the road users. So it is desired that the Hot-Spots related traffic performance to be measured so that the traffic flow can be improved.

1.1 Objective

The GPS (Global positioning system)data provides sufficient information for identifying general traffic patterns, such as the average speed on a specified road, abnormal behavior of a vehicle like unusual deceleration or change in direction. Such real-time information may be able to infer the occurrence of an accident. GPS has become a reliable, accurate, economically feasible and the most recent positioning technology to be used for travel time data collection [1].In this paper the aim is to identify the different 'hot-spots' of the city.
The study involves the detection of the 'hot-spots' and their impact on the traffic, as the prior knowledge of these areas is very important for better traffic management strategies. GPS data is used for this purpose.

2. Hot-Spots

In any city 'hot-spots' are the locations or those area of the city, which are regularly congested and where the flow of traffic is very slow that is traffic is moving very slowly or traffic is completely stopped. These areas could increase the severity of congestion. Hot-spots can be of two types; regularly and occasionally.

Multiplexes, Commercial buildings, Hospitals, Schools/ Colleges etc. are prime examples of regular hot-spots. Occasionally hot-spots are the areas where any incident has taken place. An incident is "an unexpected event that temporarily disrupts the flow of traffic on a segment of a roadway". For example, area where an accident has taken place could be a VIP passing area.

Hot-spots detection is the process that brings hot-spots to the attention of those responsible for maintaining traffic flow and safe operations. The impact of hot-spots can be reduced through a variety of actions, including the use of traffic information, ramp restrictions or closure, and advice on alternative routes. Therefore, faster detection of these areas is of extreme importance for maintaining a higher level service for road users, also enables agencies to respond more quickly in removing the problem, to warn the oncoming traffic, and to reduce the danger of secondary incidents.

3. Literature Review

Jiann-Shiou Yang (2005) focused on the study of the arterial travel time prediction using the Kalman filtering and estimation technique. He used travel time as a performance measure due to the following reasons: (1) it is the most common way that users measure the quality of their trip; (2) it is a variable that can be directly measured; and (3) it is a simple measure to use for traffic monitoring. He studied how easy it is to exit the area where traffic is very congested regularly? And how much does that "ease of movement" vary after the special events? The Global Positioning System (GPS) test vehicle technique is used to collect after events travel time data. Based on the real-time data collected, a discrete-time Kalman filter is then applied to predict travel time exiting the area under study [7, 11].

Shoaib Kamran and Olivier Haas (2007) presented a multilevel approach for detecting traffic incident causing congestion on major roads. It incorporates algorithms to detect unusual traffic patterns and vehicle behaviors on different road segments by utilizing the real-time GPS data obtained from vehicles [4]. The incident detection process involves two phases:

1) Identification of road segments where abnormal traffic pattern is observed and further divides the 'abnormal segments' into smaller segments in order to isolate the potential incident area.
2) Detection of any occurrence of abnormal behavior within the 'abnormal' road section identified in phase 1.

The strength of such approach lies in analyzing vehicle data specific to the identified road segment. In this way, the processing of vast data is avoided which is an essential requirement for the better performance of such complex systems.

Chaminda Basnayake (2005) presented a study in which a transit vehicle fleet was used as the probe system for traffic incident detection [5 and 7]. Since transit vehicles operate for a primary purpose other than traffic monitoring, the data they provide may be biased in that they may not represent the behavior of a majority of vehicles in the traffic flow. For instance, transit vehicles have to stop at designated stops and hence the reported travel times may contain dwelling times and lost times in approaching and departing the transit stop zones. This paper addresses such issues and proposes several algorithms to modify transit data for incident detection purposes. The detection algorithm is based on two intuitive characteristics of traffic flow. First characteristic is the time taken for a vehicle to travel through a street segment, referred to as the travel time in this paper. The second characteristic is a measure of increased interactions between vehicles after the onset of congestion created by incidents, known as acceleration noise.

Y. Li and M. McDonald (2004) presented a probe-vehicle-based algorithm to detect incidents on motorways (A broad highway designed for high-speed traffic) [10]. The algorithm is based on a bivariate analysis model (BEAM) using two variables: the average travel times of probe vehicles, and the travel time differences between adjacent time intervals [7]. The premise of the model is that link travel times increase more rapidly as a result of a change in capacity (i.e. when an incident occurs) than as a result of a change in demand. The statistical principles of bivariate analysis have been used to study the relationships between the two variables in incident and non-incident conditions.

4. Data Collection & Representation

4.1 Data Collection

To provide traffic information there are several collaborative efforts from private company, government agencies to collect traffic information from major roads and report traffic condition to the public. They collect the traffic information through loops, camera, electronic toll tags, which are very effective but very expensive system. So we need an alternate way to collect traffic data at a lower cost with wider coverage to estimate the traffic situation. Traffic Incident Detection Systems (IDS) is an area of Intelligent Transport System(ITS) use a variety of technologies to detect incidents so that bottlenecks created by incidents or hotspots can be cleared quickly [7].

In this paper, we use GPS technique to collect the data to identify the various hot-spots of the city. Using this technique, a GPS receiver is connected to a portable computer and collects the latitude and longitude information that enables tracking of the test vehicle. Also with longitude and latitude of the probe vehicle, we also collected the vehicle id, their speed and their status that is either the vehicle is running or stopped at particular time [8,9].

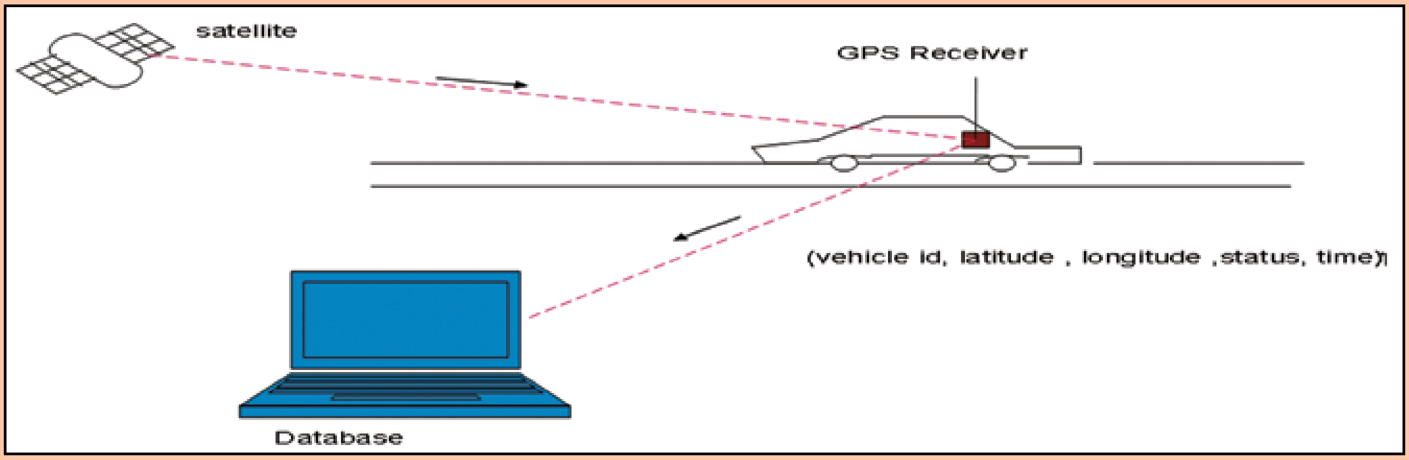

Figure 4.1. GPS enabled probe vehicle

For example: we have data in the form.......

Vehicleid	stringdatetime	Vehstatus	Speed	Lat	Lon
357023002922368	23-Aug-09	S	0	19.1797734	72.835045
357023002922368	23-Aug-09	S	0	19.1797533	72.834941
357023002922368	23-Aug-09	S	0	19.1795633	72.835255
357023002922368	23-Aug-09	S	0	19.1797033	72.835190
357023002922368	23-Aug-09	S	0	19.1798467	72.835135
357023002922368	23-Aug-09	S	0	19.1797667	72.835135

4.2 Mapping of Data:

We have mapped the GPS data of different dates on to the road map of a city for which we need the traffic information and the identification of the 'hot-spots'. For example ... small dots on the city map are the GPS data on a particular day.

5. Analysis of Data

Identifying traffic pattern is quite difficult, identifying individual vehicle behavior is even more difficult, as it involves analyzing factors such as vehicle type, timing, speed, road type, location, conditions [2]. The traffic pattern is a cumulative behavior of vehicles, such as their number or the average speed of vehicles on certain road sections.

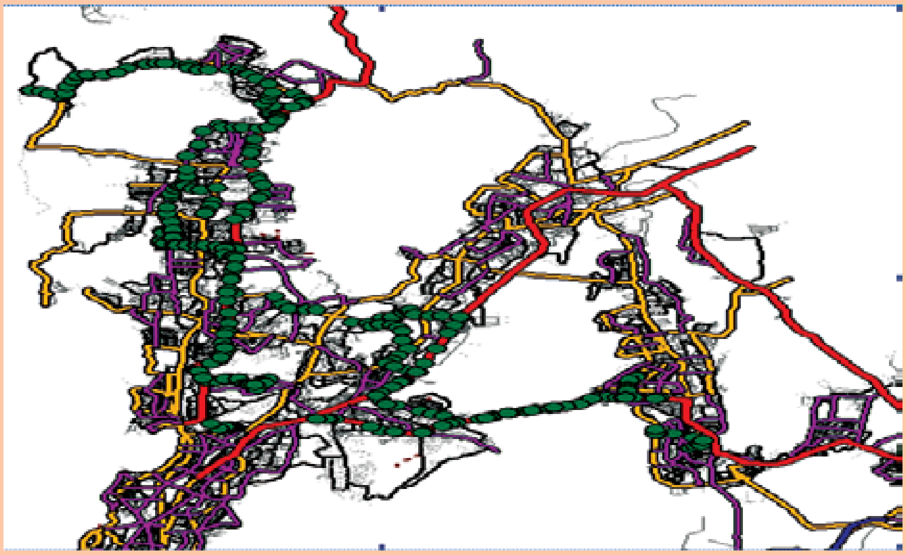

Figure 4.2. GPS data mapped on the road map of Mumbai

5.1 Proposed algorithm for identifying the Hot-spots

Here we present a method for detecting the location of traffic incidents or 'hot-spots', that causing the congestion in the normal traffic flow. The algorithm works in several steps. Below we explain the necessary steps of the algorithm.

Step 1: To analyze the traffic behavior efficiently, segment the road (i.e. roads are divided into the grids) and after the segmentation assign a normal average speed to each road segment depends on the time, type of the road, and day. For example 500 meters segments for a motorway type on weekday's peek time with normal average speed between 45-60 Km/h under normal weather conditions.

Normal_average_speed = 45-60 Km/h

Step 2: Calculate the average speed of the vehicles in a certain direction in segment which has most no. of the GPS data.

Current_average_speed = (1/ N) ∑ vehicle_speed

Where N is the no. of vehicle in that segment and summation runs over N.

Step 3: If current _average_spped < Normal_average_speed, for any segment, then mark the segment for further analysis, and move to the next step.

Step 4: Determine the current average speed of the road segments in front and behind of the marked segment, If the average speed in the 'front' segment is much higher than the 'marked' segment then a blockage

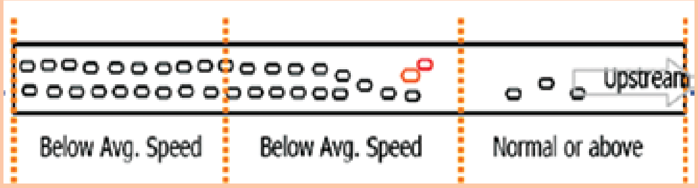

Figure 5.1. Segment of road causing congestion

within the slowest is likely. Since there are possibilities, that segments could include normal stoppage points such as traffic lights, junctions and roundabouts.

Step 5: Compare the average speed of the vehicles in the neighboring segment with that of the marked segment.

The average speed in segments in front and behind the marked segment is found in order to detect if there is an incident in the slowest marked segment or there is just a general congestion. If there is just a general congestion in the segment (as it consist of a place or is close to a place, where traffic is usually congested, for e.g. traffic lights, junction or level crossing)the average speed will be similar in adjoining segments. However, if there is an incident or hot spots causing a blockage in the marked segment then the average speed of the segments in front of that blocked/marked segment will be higher and with less number of
vehicles.

5.2 Results

From the analysis of the GPS data of different days, we have identified some of the 'hot-spots', locations where traffic congestion has been taken place, on different days of the week.

Also we have estimated the duration, in which these 'hot-spots' have impact on the traffic pattern, on different days of week.

Each identified 'hot-spots' are in the form of (location, duration, affected area).

Here is the list of different 'hot-spots' on different days as the result of above algorithm.

On 16th Aug.-

TIME		LOCATION	DURATION (hrs.)	AREA (m)
FROM	TO			
7:21:18 AM	8:53:51 AM	Samrudhhi Commercial Complex	1.35	700
11:35:04 AM	12:40:14 PM	Kripa Shankar Tower	1	650
1:10:15 AM	2:42:12 PM	Jagdamba complex	1.2	800
5:14:35 PM	7:30:12 PM	Samrudhhi Commercial Complex	2.15	1200

On 17th Aug –

TIME		LOCATION	DURATION (hrs.)	AREA (m)
FROM	TO			
7:01:28 AM	8:15:32 AM	Samrudhhi Commercial Complex	1.15	900
9:15:24 AM	11:20:19 PM	Infinity Tower	2.05	1100
4:10:42 PM	5:00:45 PM	UTI Bank near Surya Hospital	.50	570
7:14:37 PM	9:10:38 PM	Samrudhhi Commercial Complex	1.55	800

On 18th Aug -

TIME		LOCATION	DURATION (hrs.)	AREA (m)
FROM	TO			
6:40:18 AM	8:45:51 AM	Samrudhhi Commercial Complex	2.05	1200
10:30:13 AM	11:42:26 PM	Bank of India	1.10	600
12:23:31 PM	2:32:01 PM	Samrudhhi Commercial Complex	2.12	1300
4:06:57 PM	5:27:13 PM	Mumbai Mahanagar Palika	1.25	850

On 21st Aug –

TIME		LOCATION	DURATION (hrs.)	AREA (m)
FROM	TO			
10:25:45 AM	11:09:53 AM	UTI Bank	.50	800
1:13:11 PM	2:15:44 PM	Mohras Tower	1.02	1100
4:06:57 PM	5:02:13 PM	Sankat Mochan Mandir Near Hotel Visava	1.00	500
9:09:08 PM	11:10:47 PM	Samrudhhi Commercial Complex	1.50	1250

On 23rd Aug –

TIME		LOCATION	DURATION (hrs.)	AREA (m)
FROM	TO			
7:24:15 AM	8:30:25 AM	Samrudhhi Commercial Complex	1.06	1000
8:45:42 AM	9:49:30 AM	Sankat Mochan Mandir Near Hotel Visava	1.0	550
11:10:52 AM	12:21:16 PM	Sai Nath Hotel	1.10	900
3:39:20 PM	4:58:53 PM	UTI Bank	1.11	1200
10:34:07 PM	11:37:38 PM	Gayakwad Bus Terminal	1.03	750

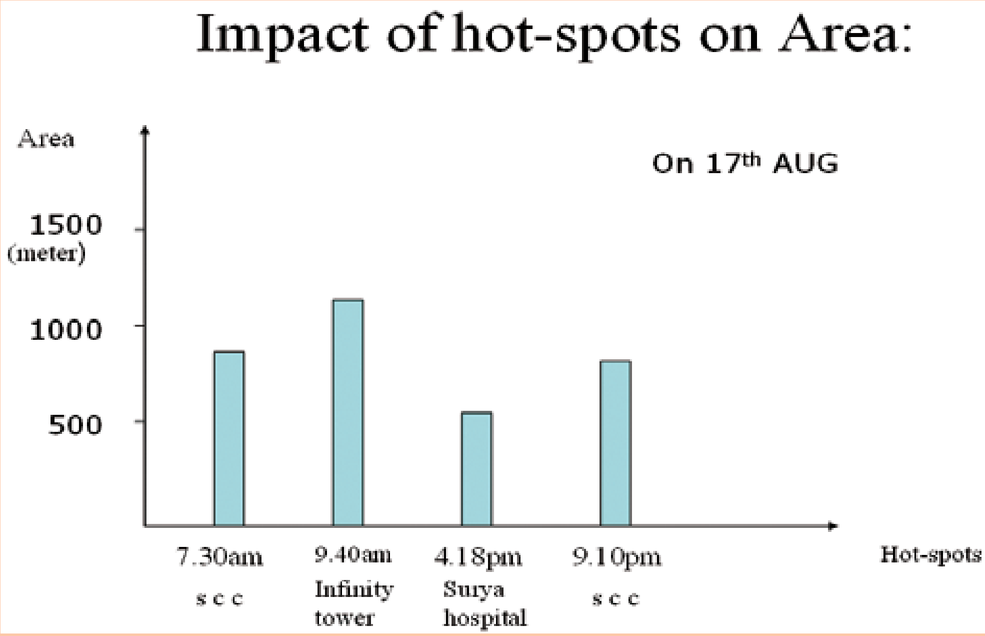

Figure. 5.2.1

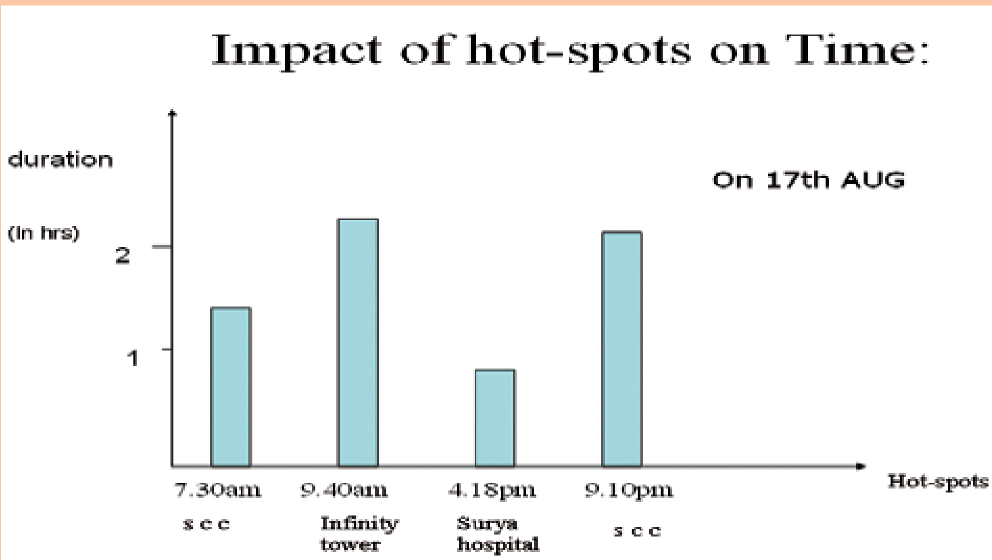

Figure. 5.2.2

6. Conclusions & Discussion

6.1 Concluding remarks

This paper focuses on the detection of the hot-spots (those areas of the city, where traffic is regularly congested and motorist tries to avoid these areas on their trip).Global Positioning System (GPS) data is used for this objective. An algorithm is used for this purpose; based on the speed of the probe vehicle. We have compared our results with the website www.yahoo.com, which provides live traffic conditions and also inform about the congested area of the city of interest. 'Hot-spots' which are identified as the result of algorithm are very much similar.

The findings from this study are expected to help road users, while they are on their trip.

Information about the 'hot-spots' can be provided to them by traffic management system, so they can choose alternative root if available, by this way we can reduce the severity of congestion.

6.2 Future prospectus of the project

Estimation of 'hotspots' is very important in modern day city planning because of the ever-increasing pressure of traffic on public travel. In particular, as many people have to travel/ commute for their daily earnings identification of hotspots can save a lot of travel time. In particular we feel that the following points, further works need to be done:

1. One should use the techniques to identify 'hotspots' in different cities, and see the efficiency/correctness of our algorithms.
2. How can 'hot-spots' are utilized in performance monitoring, evaluation, planning, and management of road traffic system more efficiently.
3. To study how 'hot-spots' can be used in designing efficient of path finding algorithms in travel forecasting models, especially in calculating delays in important road junctions and at important time points.

References

[1] K. Ozbay, and P. Kachroo, "Incident Management in Intelligent Transportation Systems," London: Artech House Inc., pp.41-59, 1999.

[2] M.W. Sermons, and F.S. Koppelman, "Use of vehicle positioning data for arterial incident detection," Transportation Research- Part C, vol.4, pp.87-96, 1996.

[3] C. Basnayake, "Automated traffic incident detection with equipped probe vehicles," Proceedings of the 17th International Technical Meeting of the Satellite Division of the Institute of Navigation, 741-750, 2004.

[4] J. Gallagher, "Travel time data collection using GPS," National Traffic Data Acquisition Conference, Albuquerque, New Mexico, pp. 147-161, May 1996.

[5] T. Nakata, and J.I. Takeuchi, "Mining Fuzzy Rules for a Traffic Information System,"7th International Conference on Knowledge Based Intelligent Information and Engineering Systems, LNAI 2773, Oxford, pp. 237-243, 2003.

[6] Balke K., Dudek C. L. and Moutain C. E., "Using probe-measured travel times to detect major freeway

incident in Houston, Texas," Transportation Research Record 1554, 213–220, 1996.

[7] Sethi V., Bhandari N., Koppelman S. and Schofer J. L. , "Arterial incident detection using fixed detection and probe vehicle data," Transportation Research Part C, No. 2, 99–112, 1995.

[8] Hellinga B. and Knapp G., "Automatic vehicle identification technology-based freeway incident detection," Transportation Research Record 1727, 213–220, 2000.

[9] Shoaib Kmaran, "A Multilevel traffic Incidents Detection Approach: Using real time GPS data", Proceedings of the 2007 IEEE Intelligent vehicles Sympossium, Istanbul, Turkey, June 13-15, 2007.

[10] Y. Li, and M. McDonald , "Motorway incident detection using probe vehicles," Proceedings of the Institution of Civil Engineers, Transport, vol.158, pp.11-15, February 2005.

[11] R. Weil, J. Wootton, and A. Garcia-Ortiz, "Traffic incident detection: Sensors and algorithms," Mathematical and Computer Modeling, vol.27, pp.257-291, May 1998.