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Investigation of the Use of Bluetooth Sensors for travel Time Studies under Indian Conditions

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Abstract

Travel time and its reliability are becoming increasingly important for a variety of real time applications such as Advanced Traveller Information Systems (ATIS), Route Guidance Systems (RGS) etc. which are a part of the Intelligent Transport Systems (ITS). They assist the road users in making timely decisions regarding their trip such as departure time, mode choice, route choice etc. There are various sensors which capture and monitor the travel time across a study corridor. However, their performance under Indian conditions is a major concern due to the vast heterogeneity in vehicle classes and the lack of lane discipline. Data from the GPS units equipped in the public transport buses are the current source of reliable travel time information. But these buses account for only 1% of the total traffic and have an inherent modal bias. One such technology which can capture data from across the vehicle classes and from any roadway of interest is the Bluetooth sensor. This study reports on the use of a Bluetooth based sensor to capture the travel time data and evaluate the reliability along two alternate routes in Chennai, India. Results from the cumulative frequency diagrams (CFD's) which are used to evaluate the reliability are also compared against the various reliability index measures.

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Keywords: Travel time; Reliability; Bluetooth; Raspberry Pi

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1. Introduction

With the advent of Intelligent Transportation Systems (ITS) deployments, there has been a rapid shift in the methods of assessing and reporting traffic characteristics. Travel time, average speed, average headway and delays are important performance measures for monitoring the transportation system. Travel time is one of the most popular indicators of the corridor performance as this can be easily understood by general public.

There are various sensors which capture and monitor the travel time across a study corridor, such as automatic license plate readers (ALPR), electronic tag identifiers, probe vehicles and other image processing sensors. However, under the Indian traffic conditions, where there is a lack of lane discipline and vast heterogeneity among the vehicle classes, the performance of majority of these sensors becomes a concern. Currently, GPS units deployed in the public transport buses are the only sources of reliable travel time information under Indian scenario. However, the buses account for only 1% of the total traffic, have an inherent modal bias, and travel along only selected routes. Hence, there is a need for a sensor which is capable of collecting data across all vehicle modes and roads of interest. One such sensor is the Bluetooth sensor.

The Bluetooth wireless protocol has been extensively used by the consumer electronics industry in many portable devices such as smartphones, laptops and headsets. A substantial amount of these devices are Bluetooth enabled with a unique Media Access Control (MAC) address, allowing them to be detected by a Bluetooth sensor as they pass along the corridor. A MAC addresses matching algorithms can be developed to estimate the travel time and origin – destination matrices from the obtained MAC addresses. This Bluetooth based travel time estimation is gaining popularity due to its low cost, possibility of anonymity of the detections and flexibility in both installing and maintaining the sensors.

The MAC addresses are 48-bit electronic identifiers for each device in the form of “12:34:56:78:90:ab”. The first three octets “12:34:56” represent the Organizationally Unique Identifier (OUI) which gives information on the manufacturer and the last three “78:90:ab” are assigned by the manufacturer in order to give a unique address to the device. Bluetooth radios are classified into three groups based on their communication range: Class 3 has a range of up to 1 metre, Class 2 up to 10 metres, and Class 1 up to 100 metres. However, only a minimum range is mandated by the Bluetooth specification and manufacturers can tune their devices for the required ranges. The Bluetooth transceivers transmit their MAC addresses for the purpose of identifying other devices. This inquiry mode is used to establish a link with responding devices. Inquiries can be made to a device even when it is engaged in communication to another device. When a device communicates with another, it responds to the inquiry scan with its MAC address and clock information. This facilitates the identification of Bluetooth enabled devices in vehicles, provided the discovery of the device is enabled. If the same address is detected at two different locations, the time difference between the two detections can give the time taken to travel that stretch. Also, the journey speed can be computed, given the distance between the two sites is known. Aggregating results from multiple devices can be used to estimate the average travel time and space mean speed along the corridor.

This paper reports on the development of a Raspberry Pi based Bluetooth sensor to capture the MAC addresses and estimate the travel time along two alternate routes in Chennai, India. Apart from the type of devices detected, the study also determines the penetration and match rates along the corridor. The cumulative frequency diagrams (CFDs) are used to assess the travel time reliability on the study corridor. This data is also used to generate the commonly used performance measures such as mean, standard deviation and travel time index. These measures were used to compare the different sections. In short, the study examines the ability of Bluetooth sensor to capture travel time and monitor the traffic conditions along the study stretch.

2. Literature review

Traditional travel time collection techniques include direct measurement techniques and indirect techniques. Direct measurement includes automatic license plate readers (ALPR) (Kennedy et al. 2004), automatic vehicle location (AVL) (Hunter et al. 2006), floating car techniques (Robertson 1994) and data from global positioning system (GPS) (Quiroga and Bullock, 1998) etc. Indirect estimation of travel time is achieved through various models which vary from the application of simple to complex algorithms for the estimation of stream travel time from other known parameters. All the aforementioned sensors have inherent disadvantages such as high capital, operating and