Enhanced Probe Vehicles for Vehicular and Road Data Collection and Analysis

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Abstract

Information collection and analysis play a key role in transportation system planning, implementation, and operation. Accurate information on average speed, fuel consumption, road condition (a measure of rider comfort level) of different road segments can be used in route planning to minimize travel time, costs and to increase rider comfort. Furthermore, such information is crucial in driving cycle estimation, greenhouse gas emission estimation and road development. Conventionally, the required data is acquired using manual surveys, probe vehicles with global positioning system (GPS), and with specialized vehicles. These processes can be time consuming, costly, and the information can be outdated unless updated regularly. In this work, we propose a cloud platform to acquire, store and process data related to transport system planning, implementation, and operation. The main novelty of the proposed work is that it can transform any vehicle into a probe vehicle which can collect and transmit real-time data such as average speed, acceleration, fuel consumption, and road roughness of predetermined road segments. The collected data is processed using statistical models and supervised machine learning algorithms to provide information to estimate driving cycles, route planning and international roughness index (IRI) prediction. The main components of the proposed work include a smartphone-based vehicle and road condition data acquisition and transmission platform, a cloud hosted data storing and analytics platform and a web based, real-time information retrieval platform. Vehicle and road condition data are acquired using smartphone sensors such as GPS, accelerometer, and magnetometer as well as from inbuilt vehicle sensors through the control area network (CAN) bus. The CAN bus data is fed to the smartphone through the onboard diagnostic II (OBD II) interface of the vehicle. Signal processing techniques are used to condition the data and filter out the effects of the ambience. The smartphone and CAN bus data are compressed using dictionary coding, and securely transmitted to the cloud hosted storage and analytics platform real-time via a mobile network using a client-server architecture. The communications are designed to minimize the data charges and energy consumption of the smartphone. Typical energy consumption is around 350mAh per 30mins. The received data are processed using micro trip method and K-means clustering to estimate driving cycle, calculate the average speed, number of ‘stop and go’ events, and average fuel consumption of defined road segments. A supervised learning model of four-layer perceptron neural network with L2 regularization is trained using IRI data obtained from the road development authority (RDA) is used to predict the IRI of a road segment based on the vehicle speed, GPS, accelerometer, and magnetometer readings. The results of the analysis is used to select routes based on multitude of criterion, in addition to duration of travel based routing. For an example, the data retrieval application can provide recommendation on routs based on fuel consumption and rider comfort. The proposed platform has numerous applications in fleet management, road development and overall efficiency improvement in transportation systems.

Keywords: *driving cycle, international roughness index, route planning, supervised learning*

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