Smartphone based applications for Road Traffic Telematics

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Smartphone Based Applications for Road Traffic Telematics

Abstract

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Abstract

This research is concerned with Intelligent Transportation System (ITS), with two major points of focus. The first point is the collection and processing of data from road traffic using smartphones and other devices (such as On-Board Units (OBUs)). It aims at using smartphones that are ubiquitous and host various sensors whilst providing several communication interfaces, to collect data and to investigate the possible beneficial applications of such data for traffic management, awareness and safety. The collected data is of high value for relevant authorities such as city management, public transportation system, traffic police, vehicle insurance companies, etc. The second point is the use of machine learning techniques to predict the intensity of traffic using crowd-sourced data from a small segment of the traffic. The processed information about traffic intensity can improve the accuracy of Advanced Traffic Management System (ATMS) and reduce the costs incurred due to the use of dedicated traffic sensing hardware.

A number of facts motivated this work, some of which are as follows. First, the high demand for mobility: whereby more than 70% of all journeys are made by a car in the European Union (EU). Specifically in Italy, where the number of vehicles per 1000 inhabitants is 625, which places it the 2nd highest across the EU. Second, the cost of traffic congestion: one consequence of high motorisation rates is traffic congestion, which costs about € 100 billion in the EU every year. Third, the growing adoption rates of smartphones: smartphones are omnipresent and well-connected; almost 80% of Internet users in the EU surfed via a mobile device in 2016; the average Penetration Rate (PR) of smartphones in the EU is quite high at about 67.3% of its population. Fourth, the versatility of high-resolution and high-quality mobile sensor data: smartphones have high computational power, high capacity connectivity, and low-power Inertial Measurement Unit (IMU) which enable them to be orientation-aware with minimal power consumption. Nearly every single smartphone produced in the last decade has a 6 or 9-axis IMU built-in. And finally, cloud-based data crowdsourcing trend: thanks to affordable Internet connectivity, cloud-based crowdsourcing for data has opened new doors for providing rich services to users without any dedicated hardware for data collection.

To further elaborate on the first point, ITS applications that require data related to vehicle dynamics (e.g. acceleration, yaw angle, etc.) usually have low PR due to physical constraints on the placement of the smartphone. This work proposes a procedure, which is the first of its kind, to convert any measure taken in real-time by a smartphone sensor into the vehicle coordinate system called Vehicle Dynamics Data Acquisition (VDDA). It uses information from Global Positioning System (GPS) and low-power IMU (accelerometer and magnetometer). The

results are reasonably accurate with a very high increase in usability which is a factor of paramount importance for customer-oriented applications. This allows the use of ITS related applications by drivers/passengers without any constraints on the placement of their devices, which significantly improves the PR of such applications. This approach is embedded into a highly modular and customisable vehicle data acquisition and processing system called Vehicle Data Acquisition Platform (VDAP). Using VDAP and VDDA, an Android application called Driving Style Analysis (DSA) was implemented to collect sensor data in real-time then to process it to provide driving behaviour information to users. It does so by recognising driving events such as left/right turns, accelerations, decelerations, lateral accelerations, and stops by a freely-placed smartphone in the vehicle.

For what concerns the second point, Adaptive Traffic Control Systems (ATCSs) are crucial for smart cities; the data source for these control systems has mainly been conventional induction loops which are expensive to instal and maintain. In this work, a software-based mechanism for real-time road traffic sensing called Virtual Induction Loop (VIL) was devised to replace or complement real induction loops providing a nearly perfect accuracy assuming 100% PR of the technology. The feasibility of the approach was demonstrated along with a practical integration scheme to allow Urban Traffic Control (UTC) systems to benefit from VIL. Extensive tests on real traffic patterns in the city of Turin showed that Deep Learning algorithm can be used to forecast the intensity of traffic with a higher accuracy (approx. 95%) and lower complexity as reported in the literature. The results are not only accurate, but they have significant applications including optimisation of traffic light control programme and dissemination of forecasted congestion, etc. To overcome the possible low PR of VIL, extensive modelling, simulation and validation were performed to incorporate the concept of VIL with the benefits of Deep Learning. A detailed simulation of a real intersection in the City of Turin was conducted with real traffic flows in SUMO for traffic forecasting based on VIL for traffic sensing and Gradient Boosted Machine (GBM) for traffic modelling and prediction. Extensive tests with diverse scenarios and different types of data sets were conducted to replicate a real day's traffic situation and prediction. The system can achieve very high classification accuracy, up to 95% with a very low PR of 10%. Furthermore, a single trained machine can forecast the intensity of traffic at a high-resolution with roughly 80% accuracy with a varying PR from 1% to 10%. Moreover, tests showed that during the training phase of the real system, VIL data can be collected only once at a fixed PR, afterwards, lower PRs could be derived from it to make the system feasible.

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