Chapter 36
Recognizing Driving Behavior and Road Anomaly Using Smartphone Sensors

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ABSTRACT

Road traffic accidents are caused 1.25 million deaths per year worldwide. To improve road safety and reducing road accidents, a recognition method for driving events is introduced in this paper. The proposed method detected and classified both driving behaviors and road anomalies patterns based on smartphone sensors (accelerometer and gyroscope). k-Nearest Neighbor and Dynamic Time Warping algorithms were utilized for method evaluation. Experiments were conducted to evaluate k-nearest neighbor and dynamic time warping algorithms accuracy for road anomalies and driving behaviors detection, moreover, driving behaviors classification. Evaluation results showed that k-nearest neighbor algorithm detected road anomalies and driving behaviors with total accuracy 98.67%. Dynamic time warping algorithm classified (normal and abnormal) driving behaviors with total accuracy 96.75%.

INTRODUCTION

In the WHO's road safety report (Toroyan, 2013), road accidents are leading cause of death among young people aged between 15 and 29 years. Road accidents cost governments approximately 3% of GDP and up to 5% in low- and middle-income countries, which is an obstacle to future economic development. It is evident that this is a severe problem worldwide and a solution to this problem is needed. Driving is a relation between the road surface conditions and the driver's dynamic interaction to control the vehicle

(Evans, 1991). Therefore, monitoring road condition and driver behavior have received a significant amount of attention to reduce the number of road accidents (Caner Erden & Numan Çelebi, 2016). Road traffic accidents are directly attributable to driving behavior such as aggressive behavior; it is related to driver's dynamic interaction to control the vehicle such as sudden vehicle fall and sensitive to harmful road conditions such as bumps and potholes (Özkan, Lajunen, Chliaoutakis, Parker, & Summala, 2006) (Chliaoutakis et al., 2002). Bumps and potholes are two nuisances that disturb drivers on the road every day. Driving behavior can characteristically be categorized to normal (typical) and abnormal (aggressive) (Johnson, Trivedi, & others, 2011). Potentially abnormal driving behavior is currently a leading cause of road accidents. Abnormal behaviors such as fatigue, driving over the speed limit, changing vehicle lateral position, driving under sleepy condition or alcohol will produce abnormalities in driving. Driving events recognition is needed for effective intelligent transport systems (ITS) such as fleet management systems and road operators. Being able to recognize driving behaviors and road anomalies, allows ITS to monitor driving behaviors with specific road conditions. Also, provide the driver with feedback to change his driving style to reduce aggressive driving or avoid dangerous road condition.

Various monitoring systems available in the market have been developed using roadside sensors such as camera and in-vehicle sensors such as GPS and accelerometer to record information about information on the driver, the vehicle and their driving environment (Amditis, Pagle, Joshi, & Bekiaris, 2010) (Chen, Lu, Fan, Wei, & Wu, 2011) (Espinosa et al., 2011). Taxi operators and fleet management systems are examples of monitoring systems that deploy sensors in the vehicle for monitoring driver to ensure the driver is following the specified route and do not drive over speed (Balan, Nguyen, & Jiang, 2011). These recorders are fixed onto the vehicle and cannot be easily removed to be used with another vehicle (Coughlin, Reimer, & Mehler, 2011). A number of car manufacturers have developed an advanced driver-assistance systems (ADAS) such as collision prevention systems (Needham, 2001). These systems are targeted high-end cars as the sensors required for ADAS system are expensive. Therefore, they are difficult to get access to ordinary drivers that is limiting the overall applicability to the general public (Engelbrecht, Booysen, & Van Rooyen, 2014).

With the rapid development and widespread of smartphones, they become accessible to the majority of people and essential in daily life. Smartphones have a wide range of sensors on-board such as accelerometer, gyroscope, camera, magnetic sensor, light, and GPS. The multi-sensing capabilities of smartphones along with high computational efficiency have enabled it into an attractive platform for implementing sensing applications. Examples of such applications are gesture recognition (Kale & Patil, 2016) such as recognizing human handwriting by holding the phone like a pen and write short messages in the air (Xu, Zhou, & Li, 2012). Also, personal activities in ambient assisted living (AAL) applications (Dingli, Attard, & Mamo, 2012) (Najjar, Courtemanche, Hamam, Dion, & Bauchet, 2009) such as walking and running can be recognized and classified using smartphone internal sensors (Reddy et al., 2010). Therefore, smartphone is provided a platform to implement monitoring systems. Smartphones sensors are allowed us to recognize driving events when a smartphone is placed inside a vehicle to notify the drivers with their aggressive driving behaviors and harmful road conditions (Johnson et al., 2011) (Eren, Makinist, Akin, & Yilmaz, 2012).

In this paper, a recognition method is introduced for both driving behaviors (normal and abnormal) and road anomalies patterns detection and classification based on smartphone sensor-fusion. Many driving monitoring systems in literature have utilized gesture recognition algorithms such as dynamic time warping (Johnson et al., 2011) (Engelbrecht et al., 2014) in driving events recognition. Driving events recognition is performed in this work by dynamic time warping (DTW) and k-nearest neighbor (k-NN)

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