Your Smartphone Can Watch the Road and You: Mobile Assistant for Inattentive Drivers

[Extended Abstract]

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ABSTRACT

Motor vehicle accidents are one of the leading causes of death. While lane departure warning, blind spot warning, and driver attention monitoring systems for avoiding collisions have been in development for quite sometime, to date mostly luxury cars are only equipped with these safety features. As a cheaper and ubiquitous alternative, we explore how a smartphone can assist an inattentive driver by leveraging its front and back cameras apart from other sensors. The challenge, however, is given the resource constraints of a smartphone, how quickly and accurately can it detect an unintended maneuver and alert the driver. In this paper, we describe our on-going attempt to address this challenge.

Categories and Subject Descriptors

I.4.8 [**Image Processing and Computer Vision**]: Scene Analysis—Sensor Fusion; K.4.1 [**Computers and Society**]: Public Policy Issues—Human Safety

Keywords

Smartphone, Driver Inattention, Accident Avoidance

1. INTRODUCTION AND MOTIVATION

According to National Highway Traffic Safety Administration (NHTSA), more than 6 million police-reported motor vehicle crashes occurred in the United States in 2007 [1]. Around 41000 people lost their lives and another 2.5 million people were injured in these crashes. The core cause of these crashes is that drivers fail to pay attention to the road and the traffic either because they are drunk, distracted, or drowsy. Apart from advocating defensive driving, developing and deploying technologies to detect and alert inattentive drivers of unintentional actions is essential to avoid vehicle accidents and save human lives.

There has been active research towards developing systems that make driving safer [2, 3]. These include lane departure warning, blind spot warning, and driver attention monitoring systems. While these systems are quite valuable in enhancing the safety, they are pricey too. Therefore these safety features are commonly fitted only in luxury vehicles such as Lexus and Cadillac. While third party equipment is available from manufacturers like Iteris [3], the cost of custom hardware and inconvenience of its installation can discourage drivers from adopting these systems.

Towards developing an affordable alternative for bringing safety features to economy cars such as Corolla and Pontiac, we propose to leverage smartphones that are always present with people. These smartphones are armed with front and back cameras apart from other sensors. The driver's smartphone may be placed above the dashboard or on the windshield such that it can watch the driver and the road too. The back camera can see the lane markings on the road ahead and detect lane crossings. The front camera can observe the driver's face for inattention and also cover the blindspot on the driver's side. The microphone can help infer driver's intention by identifying the sound of lane change signal. By combining the capabilities of these sensors and employing image processing algorithms, a smartphone may be able to approximate the safety features of luxury cars. In other words, our core conjecture can be posed rhetorically as, *can a smartphone turn a Pontiac into a Cadillac?'*

There are several challenges in realizing a smartphone based system for alerting inattentive drivers. First, currently only one of the two cameras can be active at a time. It is not possible to continually access the front and back camera views. Instead, the application needs to switch between them which results in increased latency and decreased frame rate. Fig. 1 shows the frame rate achieved with varying time between camera switches on a Samsung Galaxy Note. With the march of technology, it is hoped that soon both cameras can be used at the same time. Second, given the computational resource constraints of a smartphone, standard computer vision and image processing algorithms are not directly applicable. Finally and more importantly, the application should detect an unintended action and alert the driver quickly and accurately. This paper makes a case that these challenges can be addressed adequately.

We argue that even with any shortcomings, smartphone based approach is appealing. As smartphones become more advanced, the proposed system gets better over time and makes safety features affordable and available to all drivers.

2. RELATED WORK

Luxury cars from Mercedes-Benz and BMW have lane departure warning system to alert the driver with a vibrating steering [4]. The systems used by many auto manufacturers are based on core technology from Mobileye [2]. Iteris [3] is another company which offers similar systems. Both Mobileye and Iteris use radars as well as cameras for this purpose.

Recently, there has been active work on using smartphones

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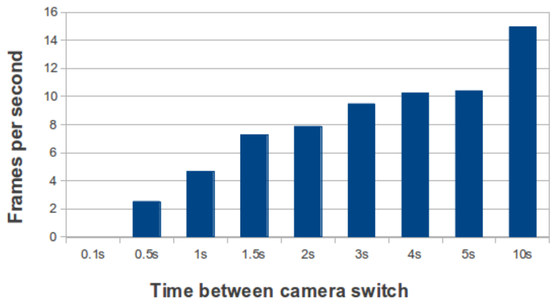

Figure 1: The resulting frame rate on a Samsung Galaxy Note with varying time between camera switches. Frequent switching reduces frame rate.

to assist drivers. SignalGuru [5] advises the driver to maintain a certain speed while approaching a signal for fuel efficiency. iOnRoad [6] is an app that warns drivers when they get too close to a vehicle. To the best of our knowledge, currently there is no smartphone based system that monitors both the driver and the road to ensure safety.

3. OUR PRELIMINARY IMPLEMENTATION

An obvious first step in using the proposed system is to mount a phone on the windshield or above the dashboard of a car. Fig. 2 shows a reasonable setting where a phone is fixed to the windshield above the drivers gaze on the road.

Figure 2: From left to right: Smartphone mounted on windshield; Back and front camera views.

Real-time performance for image processing is challenging on the phone, whose computational resources are limited compared to the type of desktop platform usually used in computer vision. The methods are chosen keeping in mind that there should be less computational overhead, since we do not have that luxury in a smart phone. OpenCV [7], is used on a Samsung Galaxy Note, running GingerBread, with 1.4 GHz processor, 8 MP back camera and 2 MP front camera. We observed a lag of around 30 ms while switching from the back to front camera, and a lag of around 120 ms while switching from the front to the back camera.

Lane Change Detection: Canny edge detection is run on back camera frames and then Hough transform is used to find lanes. The lines with slope outside a predefined range are eliminated. The resulting lane markers are shown in Fig. 3. The closest pair of markers with opposing slopes are then identified as the driving lane. A region is fixed between the two lanes which covers around 80% of the lane width. If a lane marker enters that region, it means a lane change is going to occur. Depending on which lane marker enters the region, the direction of the lane change can also be found.

Vehicle Detection: By training a Haar classifier over positive and negative samples, we can detect vehicles as in Fig. 4.

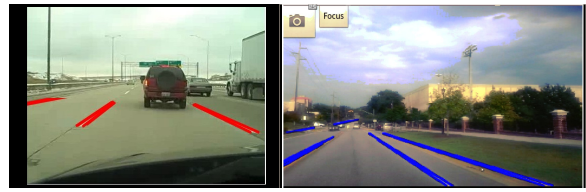

Figure 3: Lane tracking.

Figure 4: Vehicle tracking.

4. ON-GOING AND FUTURE WORK

Driver Attention Detection: Eye gaze detection may not be possible with the current smartphone cameras. However, the driver's head pose can be detected using smartphones. There are some well known ways to detect the head pose, but we have to choose a lightweight method. A geometric method would be appropriate, which detects the pose based on the relative configuration of eyes, nose, and the mouth. As an alternative, we can train classifiers for different kinds of head poses, and use it for detecting driver's attention.

Lange Change Signal Detection: The periodic nature of the lane change signal sound makes its detection feasible. But at high decibel levels of music and traffic noise, it may not be quite audible. However, since the frequency of the signal sound is low, we can use a low pass filter and then perform signal detection, yielding high detection accuracy.

Blind Spot Detection: The front camera covers the driver side windows. It can track vehicles in the driver's side blind spot, and alert the driver if she attempts a lane change. Since the front end of each class of vehicles look similar, we can train a classifier that can detect vehicles. We can also use optical flow to detect moving objects in the blind spot.

We plan to implement and integrate the above methods into a reliable warning system. Our goal is to push the smartphone based system far enough that it is considered an acceptable alternative to safety features in luxury vehicles.

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