Preventing Collisions Caused by Red-Light Running Scooters with Smartphones

Newsletter No. 23
March 2013

Scooters are one of the most important transportation among several European and Asian countries. In Taiwan, scooters and motorbikes make up approximately 70% of the registered vehicles and an average of 1.6 persons owns one scooter. With the high density of vehicles, road traffic safety is always the main concern for scooter riders. Statistics shows that, in Taiwan, more than 90% of injuries and more than 80% of deaths in traffic accidents are contributed by those involving scooters. Contrary to the common belief that road traffic safety has been gradually improved over the years, the ratios and the actual numbers have actually been increasing in the past 10 years. In this period, cars equipped with numerous active and passive safety features have gradually become standard, while very few safety features have been developed and added to scooters. This is the main reason that scooters have an increasing contribution to the majority of injuries and deaths in traffic accidents. In addition, the cost of safety facilities prevents their popularity. With a sale price of TWD$60,000 (USD $2,000) per scooter, it does not make much sense to incorporate existing vehicle safety system, which requires costly sensors and processing circuits. In this sense, to come up with a new safety system that is low cost, effective, and feasible on regular-priced scooters is therefore crucial in enhancing overall road traffic safety in Taiwan. Since 2008, Ministry of Transportation and Communications in Taiwan have considered lowering the number of scooter traffic accidents as their priority. Statistics shows that red-light running (RLR) is one of the major causes for fatal scooter accidents: in 2011, out of 3,346 deaths in traffic accidents in Taiwan, 232, or 6.93%, are caused by violation of traffic signals.

At National Taiwan University, we have developed fundamental technologies for a smartphone-based collision avoidance system to prevent those accidents caused by RLR scooters. As shown in Figure 1, the smartphone onboard a scooter utilizes a set of machine learning algorithms to predict whether the rider will run the red light a few seconds before it reaches the intersection, and uses the WiFi radio to broadcast a warning message to neighboring vehicles in that case. The warning

Monthly Events

- Speech on March 11, Aswin Sankaranarayanan, a professor of Carnegie Mellon University—"Breaking the Resolution Limits of Sensors: Compressive Sensing of High-dimensional Visual Signals"
- Early acceptance of summer internship program on March 15
- M2M Project Monthly Presentation on March 27—Two Projects, "Low-power Circuit Techniques for Intelligent Sensor Nodes" and "Low Power Heterogeneous Sensor-System-on-Chip (S2oC) in M2M Networks" of SIG Green Sensing Platform Group

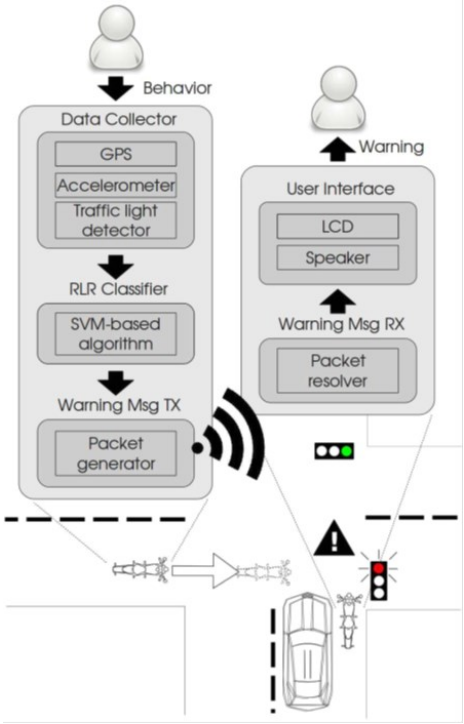

Figure 1. The system block diagram of our collision avoidance system

message is then presented to the drivers or the riders nearby in time so that they can slow down or stop the vehicles to prevent the collision. Due to the prevalence of smartphones, this system does not increase any additional cost of a scooter, and can be used as an after-market solution for existing scooters. Moreover, compared to solutions requiring pre-deployed infrastructure (radar, laser scanner, or camera detectors installed at the intersection), this system is more feasible, due to the fact that the former only functions at locations where the infrastructure is installed, while the latter functions at every intersection.

The technical challenges for the system lie in the design of the RLR prediction algorithm, which needs to overcome the difficulties caused by the inaccurate sensor data available from the smartphone. Existing literatures show that the positioning error of a consumer-grade GPS range from 2 up to 10 meters, which create great difficulties for the system to determine the latest time of the prediction based on the current distance to the intersection in order to allow sufficient reaction time. Making a correct but *late* prediction will not be able to prevent the collision; the algorithm needs to be able to balance the accuracy and the earliness of the prediction. Our proposed algorithm aims to make the prediction based on the confidence level of the observed data, and predict as early as possible thus avoiding most of the failed cases.

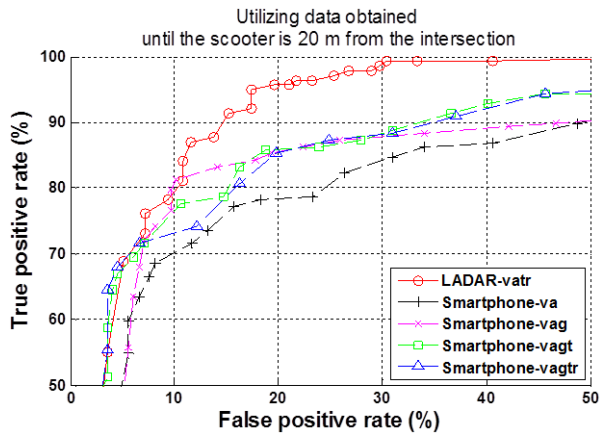

Figure 2. Receiver operating characteristics of our prediction algorithm. (v: GPS velocity; a: GPS acceleration; g: G-sensor acceleration; t: time to red light estimation; r: traffic signal status)

We evaluated our prediction algorithm with a large set of measurements, consisting of 360 runs of RLR/Non-RLR behaviors collected from 15 different scooter riders and 2 different emulated intersections. Figure 2 compares the prediction accuracies of our smartphone-based system (using smartphone sensors) and a solution using a costly and highly accurate laser ranging device (LADAR). It can be seen that our system can achieve a pair of true positive (TP)/false positive (FP) as high as 80%/10% (TP: RLR predicted as RLR; FP: non-RLR predicted as RLR), while using the data from a LADAR has almost no benefit when keeping the FP lower than 10%. With this prediction algorithm, we expect that 80% of the collisions caused by red-light running scooters can be prevented.

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Acknowledgments

This work was also supported by National Science Council, National Taiwan University and Intel Corporation under Grants NSC101-2911-I-002-001 and NTU101R7501-1.