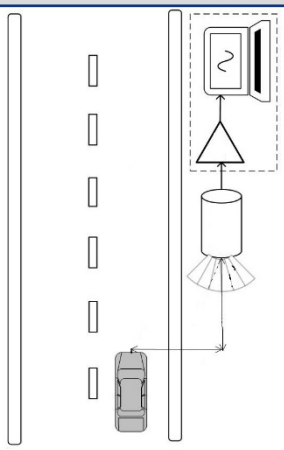
Vehicle Sensing and Communications using LED Headlights to Enhance the Performance of Intelligent Transportation Systems: Proof of Concept, Implementation, and Applications



Investigating and developing ViLDAR that utilizes visible light sensing technology to measure the variation of light intensity to estimate the vehicle speed

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Vehicular communication and sensing technologies are mainly based on the conventional radio frequency (RF) or laser technologies. These systems suffer from several issues such as RF interference and poor performance in scenarios where the incidence angle between the speed detector and the vehicle is rapidly varying. Introducing a new sensing technology will add diversity to these systems and enhance the reliability of the real-time data. This research investigates a new speed estimation sensing system named "Visible Light Detection and Ranging (ViLDAR)" that utilizes visible light sensing technology to measure the variation of the vehicle's headlamp light intensity and estimate the vehicle speed. This project will investigate the use of vehicle LED headlamp devices for improving the accuracy and reliability of traffic data measurements required for developing effective ITS technologies and solutions.

Background

Vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) sensing and communication technologies have received much attention by ITS researchers and industry in order to improve traffic operations and safety. Most of the wireless V2V and V2I systems use radio frequency (RF) technologies, which are well-established systems and operate at their highest potential. Examples of these systems include the RAdio Detection and Ranging (RADAR) and the Light Detection and Ranging (LiDAR) which determine the location and the speed of vehicles. The theory behind the RADAR and LiDAR systems is that they measure the change in the frequency or the travel time of the reflected RF waves from the targeted vehicle. Both RADAR and LiDAR have some limitations and issues that can make the speed estimations unreliable. One of these issues is the narrow beam-width required for accurate speed estimation.

Light emitting diode (LED) headlamps are being widely used by vehicle manufacturers because of their longer life and less power consumption. Many researchers have investigated the use of visible light technology in V2V and V2I sensing and communication. This research investigates the use of visible light sensing (VLS) for vehicle speed estimation and proposed the ViLDAR sensing system (patent is pending). ViLDAR utilizes the headlamp's light to calculate vehicle speed based on the change in power received at a photodetector (PD) located alongside the road and convert the power to distance. The performance of ViLDAR system will be investigated in different road scenarios. In addition to speed estimation, ViLDAR has potential useful applications in the "Advanced Vehicle Safety Systems" bundle of the national ITS architecture.

Project Summary

This project investigates the use of vehicle LED headlamp devices for improving the accuracy and reliability of traffic data measurements required for developing effective ITS technologies and solutions. The research team plans to attain the objective of this research by pursuing the following key tasks: (1) investigate the start-of-the-art photodetectors, LEDs, and computing platform, (2) develop software codes, (3) implement the ViLDAR system, (4) perform lab and field experiments, and compare with preliminary simulation results, and (5) test the performance of ViLDAR system in different applications.

Status Update

The research team has investigated and determined the hardware to be used for speed estimation part of the work, such as photo-detector, LED and computing platform. They have developed the software codes with the proposed algorithm (the software codes will be reiteratively optimized during the additional testing) and have implemented the first working ViLDAR setup for the speed estimation (Figure 1). The team has carried initial tests in lab environment and recently have started conducting field tests by

measuring the vehicles' received light intensity (Figure 1).

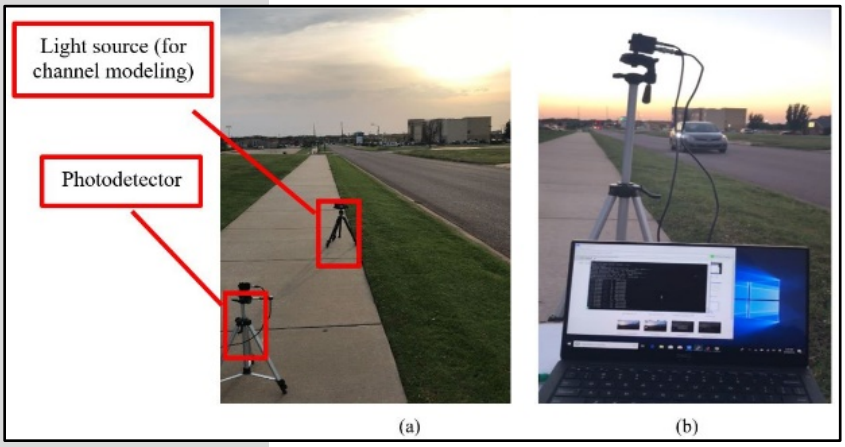

Figure 1. A prototype for ViLDAR: (a) road scenario under consideration and (b) ViLDAR setup.

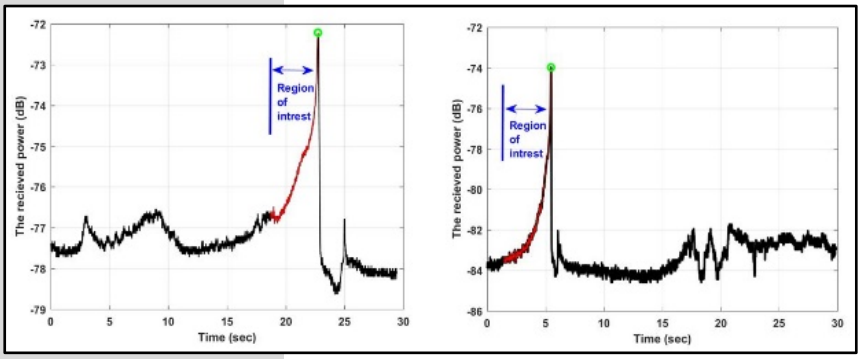

Figure 2. ViLDAR measurement for different vehicle speeds of 5 mph (left) and 30 mph (right).

Impacts

It is anticipated that the improved quality of sensing and detection information with the idea of ViLDAR system will help overcome the challenges associated with the implementation and enabling of new ITS technologies due to data reliability issues. This study will involve field and laboratory proof-of-concept and implementation of the ViLDAR system. The results of this study will help planners, designers and operators of ITS systems improve the accuracy and reliability of the basic traffic parameters needed to improve transportation system performance in six key goal areas: safety, mobility, efficiency, productivity, energy and environment, and customer satisfaction. If successful, the outcome of this project has great potential to be a commercial product. Since speed estimation and data transmission through vehicle's headlamp can greatly contribute to the concepts of autonomous- and connected-vehicles. Further, findings of this project can impact the policies for regulations on speed estimation and vehicular data transmission methods, range and usage.

Tran-SET

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