ABSTRACT

In 2021, the U.S. experienced over 45,000 road accident fatalities and approximately two million injuries, resulting in both emotional trauma and tangible economic impact. Road safety management traditionally depends on crash data, which though invaluable, is reactive, takes a long time to aggregate and has certain limitations. Traffic conflicts, the most used surrogate measure, promises to enhance road safety estimation without the drawbacks of crash data using a short amount of data collection.

After decades of debate, a definition for traffic conflicts that can be practically applied (Tarko, 2018, 2021) and a bridge method to estimate number of crashes given conflicts (Tarko, 2018) have emerged. The predictive validity of the bridge method has been successfully demonstrated for naturalistic driving data using a framework to extract conflicts (Tarko & Lizarazo, 2021). The only hurdle remaining for adoption of traffic conflicts to estimate safety at a given location is a means to record trajectories of all road users at that location.

Traditionally, video cameras and associated image processing techniques have been used to track road users at a given location. Cameras capture a 2D projection of the 3D world, therefore incur a loss of information and cameras are sensitive to ambient light conditions.

Over the past decade, LiDARs have emerged as an alternative to cameras for tracking road users. The advantage of LiDARs is that they record 3D information directly and are insensitive to ambient light conditions. Furthermore, they are less affected by adverse weather conditions than cameras. Spurred by the adoption by autonomous vehicle manufacturers, LiDAR sensors are projected to achieve cost parity with cameras over the next several years.

This dissertation explores the various aspects of LiDAR based tracking starting with sensor selection. The simulation work done shows the advantage of a multi-LiDAR setup in effectively covering an intersection. A novel self-aligning procedure to achieve spatial congruity proposed is shown to outperform the state of the art.

New methods for identifying and removing background points that work even under moderate congestion have been proposed. New methods for clustering the non-background points and estimating a bounding box with proper orientation are proposed. The results of the experiments show that they work better than the corresponding state of the art methods. The rest of the processing follows the framework introduced by (Bandaru, 2016).

A thorough evaluation of positional accuracy, orientation accuracy and accuracy of estimated vehicle dimensions has been undertaken using data from an instrumented vehicle acting as ground truth to prove that the trajectories generated are of sufficient quality to identify traffic conflicts.

Further, the framework proposed by (Lizarazo, 2020) has been adopted to identify traffic encounters from the trajectories obtained. A new method to select an alternative trajectory for a vehicle exhibiting an evasive maneuver, used in the counterfactual analysis to estimate time to collision is proposed. Data collected at three different intersections using a LiDAR are processed to extract trajectories and the framework is applied to identify safety relevant events. The spatial distribution of the identified events is compared against the spatial distribution of crashes.

While the spatial distribution shows promise, the actual number of claimed conflicts was too low. The rare nature of failure caused traffic conflict that can be linked to crashes could be a reason. A more permanent installation is suggested to ascertain the duration required to observe sufficient number of traffic conflicts, that could be used to reliably estimate crashes.

References:

Bandaru, V. K. (2016). Algorithms for LiDAR Based Traffic Tracking: Development and Demonstration. *Open Access Theses*. https://docs.lib.purdue.edu/open_access_theses/922

Lizarazo, C. (2020). *Identification Of Failure-Caused Traffic Conflicts in Tracking Systems: A General Framework* [PhD Thesis]. Purdue University.

Tarko, A. (2018). Estimating the expected number of crashes with traffic conflicts and the Lomax Distribution–A theoretical and numerical exploration. *Accident Analysis & Prevention*, *113*, 63–73.

Tarko, A. (2021). A unifying view on traffic conflicts and their connection with crashes. *Accident Analysis & Prevention*, *158*, 106187. https://doi.org/10.1016/j.aap.2021.106187

Tarko, A., & Lizarazo, C. (2021). Validity of failure-caused traffic conflicts as surrogates of rear-end collisions in naturalistic driving studies. *Accident Analysis & Prevention*, *149*, 105863.

Defense Information:

Date: November 17th (Friday)

Time: 10:00 am to 12:00 pm (Eastern Time)

Room: HAMP G212

Meeting link:

https://teams.microsoft.com/l/meetup-join/19%3ameeting_ZmNmZTNiNGQtOWViNC00ZjMxLTg3NDYtODhkOTM1ODYwZGNh%40thread.v2/0?context=%7b%22Tid%22%3a%224130bd39-7c53-419c-b1e5-8758d6d63f21%22%2c%22Oid%22%3a%22ea5d6856-1e1e-451f-b52a-6d48baa51d34%22%7d