SJSU SAN JOSÉ STATE UNIVERSITY

CAL STATE LA
CALIFORNIA STATE UNIVERSITY, LOS ANGELES

Artificial Intelligence for Pedestrian and Bicyclist Safety: Using AI to Detect Near-Miss Collisions

Project 2350
September 2024

Mohammad Pourhomayoun, PhD

Introduction

According to the latest reports by the U.S. Department of Transportation, the Insurance Institute for Highway Safety (IIHS), and the National Highway Traffic Safety Administration (NHTSA), the number of traffic fatalities has significantly increased and reached a 16-year high as of 2021. The most vulnerable groups in traffic accidents are pedestrians and cyclists. However, there is no efficient automated system for detecting and predicting pedestrian and cyclist collision risks in major urban areas.

For this project, we developed an end-to-end system based on advanced artificial intelligence (AI) models and effective computer vision algorithms to detect and report near-miss collisions as an important indicator to identify and measure safety risks, especially in specific circumstances such as right turn on a red light. The main objective is to improve the safety of pedestrians and bicyclists by applying automated AI-powered systems to detect accident risks for pedestrians and cyclists.

Study Methods

In this project, we developed an end-to-end system including a series of image/video processing, computer vision algorithms, machine learning, and optimal state estimator and tracking algorithms. The developed system receives traffic videos and monitors, recognizes, and tracks pedestrians, cyclists, cars, trucks, and buses, and then detects the directions and predicts the future locations of each object. Then, the algorithm detects and reports near-miss collisions as situations where a slight shift in time or position of the person or car could have caused an actual collision (Figure 1 shows the high-level system architecture).

The first step in our end-to-end traffic vision system is the raw video preprocessing, which includes a series of algorithms for quality enhancement, and brightness/contrast adjustment. After data preprocessing, the next step is to extract and select the best set of computer vision features that can be used in machine learning algorithms for object detection. In this project, we trained and used deep learning models, particularly

the Convolutional Neural Networks (ConvNet), R-CNN (Regions with CNN features) and YOLO (You Only Look Once) algorithms (Ren et al., 2015, Redmon et al., 2016, Zarchan and Musoff, 2000).

After detecting a target object (e.g., a pedestrian or bicyclist) in several sequential frames, we use Optimal State Estimator to estimate the Trajectory of each object. Since several objects may exist in each frame at a time (e.g., several pedestrians walking together in the same direction or different directions), it is essential to estimate the trajectory of each object individually. To this end, we use the Kalman Filter (Zarchan and Musoff, 2000) as an optimal state estimator to predict the next location of the object and estimate the trajectory of the object over time. Every time we detect a pedestrian whose location does not match any of the previously predicted locations (i.e., the pedestrian is not located on any of the existing estimated trajectories), we consider that person as a new pedestrian and, consequently, add to the pedestrian counter. This will allow us to monitor and count each pedestrian everywhere in the video, and avoid double counting them in sequential frames. Then, artificial neural networks and maximum likelihood estimation algorithms will be used to classify trajectories into incidents/non-incidents and identify accident risks. The algorithm detects near-miss collisions as situations where a slight shift in time or position of the person or vehicle could have caused an actual collision. The algorithm detects instants when a moving vehicle is about to collide with a pedestrian or bicyclist. It identifies and rates risks based on distance, velocity, direction, and the types of the motorized vehicles.

Findings

We evaluated our methods and the developed system on 14 hours of real videos captured by real traffic cameras. Despite the low quality of some of the videos, the results demonstrated the high accuracy and effectiveness of the developed system in automatically detecting, tracking and counting pedestrians/bicyclists, and detecting and reporting traffic risks and near misses. Our results demonstrate high accuracy of the proposed models in identifying traffic collision risks and detecting near-misses. This approach particularly enables us to recognize and monitor busy intersections that are prone to traffic accidents and allows us to identify risks in those intersections to protect vulnerable road users like pedestrians and bicyclists.

Policy Recommendations

The findings from this study indicate significant potential in the use of this method to improve road safety, especially for pedestrians and bicyclists. The high accuracy and effectiveness of the system demonstrate it can be implemented into traffic cameras to successfully identify and track road users and their trajectories and thus identify near-misses. This information can be used to identify and measure safety risks, especially in specific circumstances such as a "right turn on a red light" scenario. Policymakers can take advantage of this tool to better understand risk and take steps to improve safety for everyone.

About the Author

Dr. Mohammad Pourhomayoun is an Associate Professor of Computer Science at California State University Los Angeles (CSULA). He is the founder and director of the Artificial Intelligence & Data Science Research Lab at CSULA. Dr. Pourhomayoun's research interests focus on data science, artificial intelligence (AI), and machine learning for social good.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2350

MTI is a University Transportation Center sponsored by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology and by Caltrans. The Institute is located within San José State University's Lucas Graduate School of Business.