A Semi-trailer Truck Right-Hook Turn Blind Spot Alert System for Detecting Vulnerable Road Users with Transfer Learning

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Engineering Need

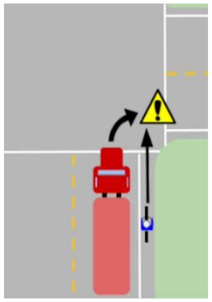
Semi-trailer truck drivers often have trouble identifying cyclists in their blind spots when making right-hand turns which can cause bicyclist-truck collisions.

Engineering Goal

The overall aim of this project is to engineer a device that can detect cyclists in a truck's right-rear blind spot and provide alerts for semi-trailer truck drivers.

Background

- When a truck makes a right-turn and collides with a cyclist
- Semi-trailer truck blind spots hinder visibility of approaching cyclists
- Are often fatal or cause severe injuries (Wang et al., 2022)



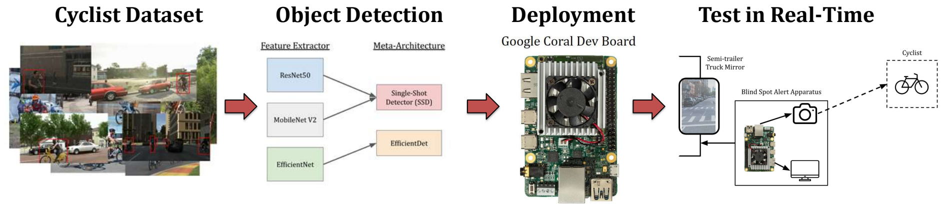
Project Objectives

- Actively detect and locate cyclists with greater than 80% Mean Average Precision (mAP)
- Be portable and installable onto most semi-trailer trucks
- Create visual warnings on cyclists in the right-rear blind spot within 2 seconds
- Be low-cost – less than $300.00

Blind Spot Systems

Blind Spot System	Accuracy	Portability	Speed	Cost	Total Score
Proposed system	9	10	8	7	34 / 40
Ultrasonic systems	4	8	10	9	31 / 40
LiDAR systems	9	3	8	5	25 / 40
Mechanical systems	-	2	-	6	8 / 40
Truck cab redesign	-	1	-	2	3 / 40

Design Process

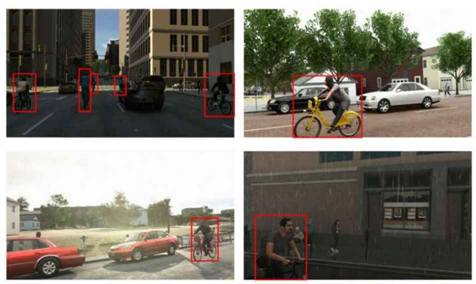


Proposed Cyclist Dataset

- 20,000 annotated cyclist images from web-scraped and synthetic cyclist images
- Contains edge case scenarios: rain, dark, fog, glare, etc.
- An average of 2.2 cyclist instances per image

Figure 2

Example Images From the Newly Proposed Cyclist Dataset



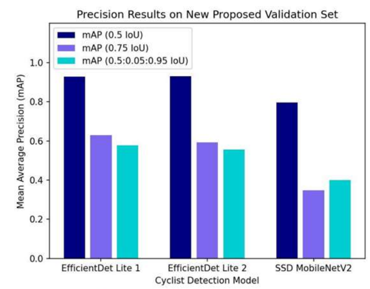
Note. Image annotations were drawn with Roboflow Computer Vision software. Images were used from Parallel Domain cyclist detection API (Thomas et al., 2021).

Cyclist Detection Models

- 3 cyclist detection models trained on CIMAT and newly proposed dataset
- Trained using TF Object Detection API and Model Maker API
- Highest accuracy: 95.6% mAP (IoU: 0.5)

Figure 3

mAP on the Newly Proposed Validation Set



Note. The mAP results were calculated at the 0.5, 0.75, and the 0.5:0.05:0.95 IoU intervals.

Experimental Testing

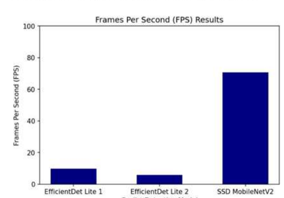
Figure 4

Aerial View of Real-Time Testing Environment.

Note. The cameras were positioned at the heights of 5 feet, 13 feet, and 13 feet, respectively. Each camera was pointed towards the blind spot on the right-hand side of the trailer body to detect cyclists. Oncoming cyclists were recorded and their identities are hidden due to privacy

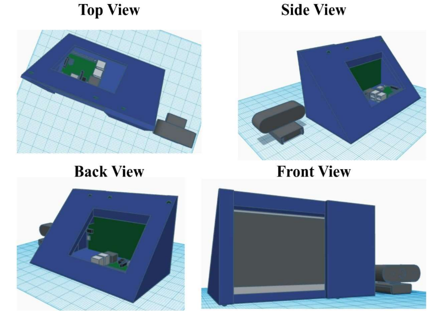
Figure 5

Frames Per Second Results From Experiments



Note. The frames per second were calculated using the average inference time per frame for each cyclist detection model.

Device Design



Discussion

- Able to make fast and accurate cyclist predictions in real-time
- Robust performance in adverse lighting conditions and with partial cyclist detection
- Camera placement #1 provides greater accuracy and ease of installation to cover right-hand blind spot (Figure 4)
- Matches accuracy with LiDAR with lower costs
- $200 per device suggests feasibility for use in trucking industry

Future Work

- Testing and feedback in trucking industry
- Deploy larger system: cameras, sensors, etc.
- Evaluate other hardware options
- Temporal-based object detection models

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