Multi-Sensor Passenger Classification and Fare Evasion Detection

Centre for Mechatronics and Hybrid Technology
Mechanical Engineering McMaster University
Linnéa Campbell, Elliot (Yixin) Huangfu, Saeid Habibi

EECOMOBILITY (ORF) & HEVPD&D CREATE

BACKGROUND

Multi-object classification and tracking models are machine learning algorithms that allow the simultaneous detection, classification and tracking of multiple objects in real-time. These models are used in a wide range of applications such as computer vision, autonomous vehicles, traffic monitoring, security and more.

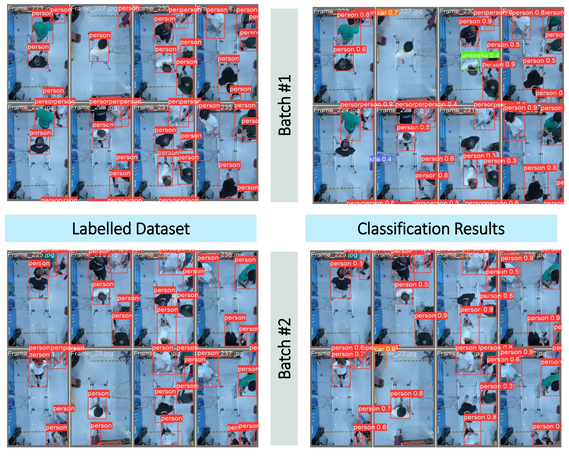

Fig. 1 Comparing Labelled Images to Pre-Trained YOLOv5 Detection Results on Experimental Footage

Millimetre wave (mmWave) radars are a special class of radar that transmit signals in the millimeter range wavelength (approximately 4mm) and typically function at frequencies between 76-81GHz. The mmWave radar class is considered to be in the short-wavelength spectrum making them advantageous for detecting slight movements with high accuracy.

With proper calibration, detections from a radar and camera can be merged and tracked – a method called sensor fusion . Since neither trajectory is a perfect estimate, there will always be a mismatch. Probability-based estimation algorithms, such as EKF and SVSF, can address such uncertainties and effectively perform decision-level sensor fusion.

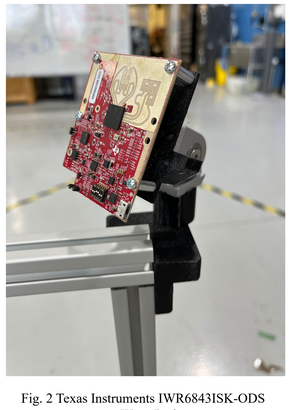

Fig. 2 Texas Instruments IWR6843ISK-ODS mmWave Radar

TRANSPORTATION INDUSTRY APPLICATION

This project assesses the capabilities of a multi-sensor system for detecting aisle occupancy in a metro style fare gate system that utilizes mmWave radar sensors in conjunction with computer-vision based classification for object tracking and fare evasion detection. The proposed method plans to employ decision level radar/camera fusion and tracking technique to classify and track objects and passengers in a designated area. Additionally, it implements a zone-based algorithm to recognize and categorize fare evasion and other unsafe behavior. The goals of this project are to apply zone based scenario identification to pedestrian management and improve multi-object tracking using sensor fusion from multiple sensors that face the target area from different locations.

EXPERIMENTAL SET-UP

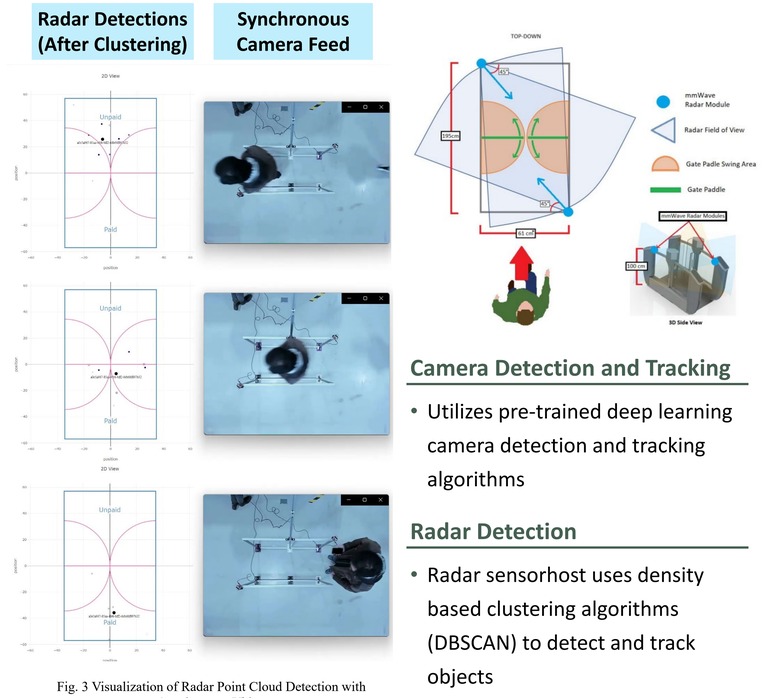

Fig. 3 Visualization of Radar Point Cloud Detection with Synchronous Video

Camera Detection and Tracking

- Utilizes pre-trained deep learning camera detection and tracking algorithms

Radar Detection

- Radar sensorhost uses density based clustering algorithms (DBSCAN) to detect and track objects

ZONE BASED SCENARIO IDENTIFICATION

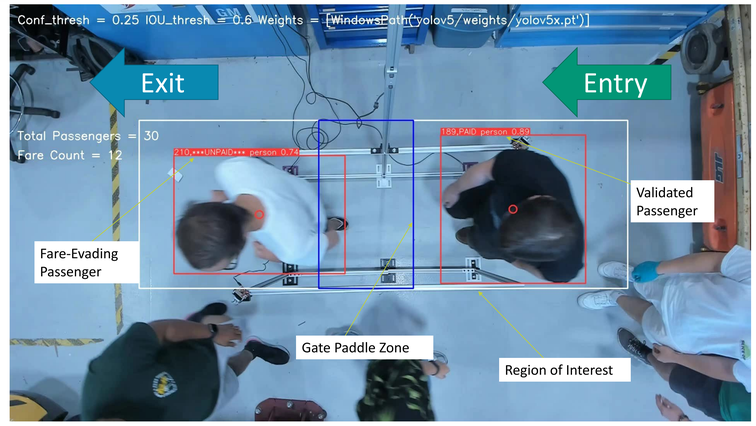

Fig. 4 Camera-Only Detection and Scenario Identification with Visual Overlay of Zones

Zone Definition

- 3 Zones: Entry, Gate Paddle, Exit
- Predefined zones combined with existing real-time gate feedback allow passenger movement to be classified as a “Paid” or “Unpaid”
- Can support up to 3 lanes (restricted by camera mounting height)

RESULTS AND ONGOING WORK

At present, the algorithm is capable of achieving an overall detection accuracy of 85% using solely a camera-based approach. However, the accuracy of identifying Paid and Unpaid passengers is currently being evaluated and tested through live lab trials. The results of these trials indicate promising outcomes. The project's next steps will involve integrating radar and camera data to observe the impact on detection and tracking performance. By combining these data sources, the algorithm can improve its ability to detect and track passengers accurately, which can potentially enhance overall system performance. Overall, the project aims to develop a robust and reliable system that can accurately detect and identify passengers to improve transportation efficiency and safety.

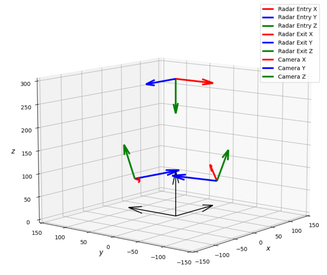

Fig. 5 Radar and Camera World Locations with Respect to Gate Center (Floor)

We acknowledge the support of the Ontario Research Fund: Research Excellence Program.

We acknowledge the support of the Natural Sciences and Engineering Council of Canada (NSERC), which invests annually over $1 billion in people, discovery and innovation.