

Multi-Sensor Object Detection Data from Infrastructure Sensors Deployed at Traffic Intersections in the City of Colorado Springs, Colorado, USA

Authors

Rimple Sandhu, National Renewable Energy Laboratory

Faizan Mir, National Renewable Energy Laboratory

Stanley Young, National Renewable Energy Laboratory

Qichao Wang, National Renewable Energy Laboratory

Charles Tripp, National Renewable Energy Laboratory

Dan Sines, Olsson

Zoami Calles-Rios Sosa, Olsson

Funding

US Department of Transportation

National Renewable Energy Laboratory

Introduction

The dataset provided here was collected as a part of the US Department of Transportation (USDOT) Strengthening Mobility and Revolutionizing Transportation (SMART) project, where the City of Colorado Springs (Colorado, USA) and National Renewable Energy Laboratory (NREL) collaborated to collect object-level trajectory data from road users using multiple types of sensors deployed at different traffic intersections. The data was collected in 2024 across multiple days at various intersections in Colorado Springs. Each data folder contains all the data collected on the day. The goal of the data collection exercises was to learn various attributes about the sensor product and to build a repository of data that can be used for research and development (such as for developing multi-sensor data fusion algorithms).

Data presented here was collected from sensors either installed on the traffic poles or hoisted on top of NREL's Infrastructure Perception and Control (IPC) mobile laboratory. The state-of-the-art IPC trailer can deploy the latest generation of perception sensors at traffic intersections and capture real-time road user data. Sensors used for data collection include Econolite's EVO RADAR units, Ouster's OS1 LIDAR units and Axis Camera units. The object track data is sent to an edge compute device located inside the IPC mobile Lab.

General notes/caveats for using the data:

- Data is spread across multiple folders (names after the day it was collected) where each folder contains object-level sensor detection data in CSV format.
- Detections from EVO radar units are named EVO_RADAR_#.csv, the data from OS1 lidar units is named OS1_LIDAR_#.csv, and the data from camera units is named AXS_CAMERA_#.csv.
- The object list attributes provided in the CSV files are explained in the attached data_description.docx file
- The raw detections are transformed (rotation then translation) to ensure the data from all sensors is represented in the same cartesian coordinate system. The object list attributes impacted from the transformation are PositionX, PositionY, SpeedX, SpeedY and HeadingDeg. The rest of the data attribute remains untouched. Users should note that we do not claim that this transformation is perfect and there may be some misalignment among the different sensors.
- During the transformation we tried to ensure positive y-axis points towards the north direction through visual inspection of the plot containing the positional data from all sensors. However, we do not claim that this is numerically achieved in the published dataset. Some small rotational correction may be needed to ensure the positive y-axis exactly points towards the true north.
- For data contained within a particular day spread across multiple runs, the object ID's may be repeated in the data so proper care should be taken to merge all the data from a particular day or from multiple days.

Object List Attributes

Name	Description	Unit/Format
Standardized Object List Attributes (Raw Data from Sensors)		
Time	Local time	Year-Month-Day Hour-Min-Sec
ObjectId	Unique Identifier assigned by the sensor for the tracked object	Positive integer
PositionX/Y/Z	Position of the center of the object in the X/Y/Z direction (Cartesian coordinates)	Meters
SpeedX/Y/Z	Speed of the center of the object in the X/Y/Z direction	Meters per second
Speed	Magnitude of the speed	Meters per second
Width/Length/Height	Width/Length/Height of the object	Meters
Volume	Volume of the object	Cubic meters
TimeElapsed	Time measured from the start of the data collection	Seconds
HeadingDeg	Heading of the object in the horizontal (X-Y) plane measured anticlockwise from + X axis	Degrees
Class	Class of the object	String/Text
EVO RADAR Specific Attributes		
AgeCount	# of frames the object is alive since being released	Positive Integer
PredictionCount	# of steps predicted since last sensor detection	Positive Integer
TrackQuality	Quality of the track (min 50% required for detection)	Percentage
DistanceToBack	Distance from the center of the object (PositionX/Y) to the back of the object in the Length dimension	Meters
DistanceToFront	Distance from the center of the object (PositionX/Y) to the front of the object in the Length dimension	Meter
OS1 LIDAR Specific Attributes		
FrameNumber	Frame number of the point cloud data	Positive Integer
PredictionFlag	False=detection is obtained from the point cloud data, False= model-based prediction	True or False
Derived Attributes (Computed using sensor-supplied attributes)		
HeadingDeg	Tan inverse (SpeedY, SpeedX)	Degrees

Equipment and Sensors

- NREL Mobile Lab: The state-of-the-art Infrastructure Perception and Control (IPC) mobile laboratory can deploy the latest generation of perception sensors at traffic intersections and capture real-time road user data.
- Econolite’s EVO RADAR: Econolite EVO radar uses a forward-fire Frequency Modulate Continuous Wave (FMCW) design to achieve detection range of 275 m and a 110-degrees of field-of-view. The Econolite EVO system uses iSYS-5220 radar model from InnoSenT GmbH along with their perception and classification software to process the radar raw point cloud data to generate object tracks which can be accesses using the InnoSenT API. The object track data is sent to an edge compute device located inside the IPC mobile Lab.
- Ouster OS1 LIDAR: An OS1 rev 6 LiDAR from Ouster Inc is 360 degrees rotating mechanical lidar capable of detection objects with 45m with a maximum sampling rate of 10 Hz. The Ouster LIDAR is mounted on the IPC mobile lab mast at a height of 18 ft from the ground. For processing the raw LiDAR point cloud data, Outsight SHIFT perception software was deployed to Detect, track and classify pedestrian and vehicles in real-time. The LiDAR point cloud data is sent to an edge compute located inside the IPC lab which tracks and classifies data to generate object track information.
- Axis Camera: An AXIS dome camera was also deployed to capture object tracks. An inbuilt deep learning-based object detection model was deployed to detection and track vehicles with the field of view of the camera in the image plane. AXIS analytics was used to generate object tracks from the image plane detection and stored on an edge compute inside the IPC lab.

Sensor Type	Radar	Lidar	Camera
Model	EVO RADAR	OS1 LIDAR	P3255-LVE
Vendor	Econolite	Ouster	Axis
Max Range	275 m	45 m	75 m
Field of view	110 Deg	360 Deg	
Max Sampling rate	10 Hz	10 Hz	10 Hz
Perception software	InnoSenT (ISYS-5220)	Outsight Shift	Axis Analytics

Dataset Summary:

Data Folder	Sensors Deployed	Intersection	Time Duration (Overlap)	Comments
Dec20_2024	EVO RADAR (4) – 2 Hz OS1 LIDAR (2) – 10Hz	Stapleton Dr & Meridian Rd, El Paso County, CO, USA	94 mins	<ul style="list-style-type: none"> • Rural intersection, not a lot of pedestrians • 2 EVO on IPC lab, 2 EVO on opposite traffic poles • Spurious detections from OS1
Nov22_2024	EVO RADAR (2) – 10 Hz OS1 LIDAR (2) – 10Hz AXIS Camera (1) – 10 Hz	N Nevada Ave & E Platte Ave, Colorado Springs, CO, USA	run1:38 mins run2:25 mins	<ul style="list-style-type: none"> • Urban intersection • All sensors on IPC lab • Elevation angle changed for OS1: run1=5°, run2=0°
Oct30_2024	EVO RADAR (4) – 10 Hz OS1 LIDAR (1) – 10Hz AXIS Camera (1) – 10 Hz	N Powers Blvd & Palmer Park Blvd, Colorado Springs, CO, USA	run1=85 mins run2=8 mins	<ul style="list-style-type: none"> • Urban intersection • 2 EVO on IPC lab, 2 EVO on opposite traffic poles • run1 has EVO at 1 Hz while run2 has EVO at 10 Hz
Aug21_2024	EVO RADAR (2) – 1 Hz EVO RADAR (2) – 2 Hz OS1 LIDAR (1) – 10Hz	N Powers Blvd & Palmer Park Blvd, Colorado Springs, CO, USA	84 mins	<ul style="list-style-type: none"> • 2 EVO on IPC lab at 2 Hz • 2 EVO on opposite traffic poles at 1 Hz • PredictionFlag attribute is inaccurate for OS1 data
Jun24_2024	EVO RADAR (2) – 1 Hz EVO RADAR (2) – 2 Hz	N Powers Blvd & Palmer Park Blvd, Colorado Springs, CO, USA	80 mins	<ul style="list-style-type: none"> • 2 EVO on IPC lab at 2 Hz • 2 EVO on opposite traffic poles at 1 Hz