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LiDAR Based Sensor Verification

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Overview

- Motivation
- Annotating Point Cloud Data
- Automating Object Detection with Deep Learning
- Results
- Workflow Benefits
- Future Work
- Conclusion

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Motivation

- Verifying accuracy of sensors in vehicles can be a very tedious
- We use alternative sources of ground truth, equip test vehicles with
  - Video (cameras mounted at different locations)
  - LiDAR (Velodyne HDL 32E, mounted at different locations)
  - GPS
- We look for True positives and False negatives

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Verifying Critical Events for Sensor accuracy

True Positive events

- True positive events occur when an object is present and the sensor correctly detects it
- We simply look at the logs of the recorded events when the radar detected an object
- Confirm validity with video and accuracy with LiDAR

False Negative events

- False negatives occur when an object is present but the sensor does not detect it
- Involves a human analyzing hours of recorded drive data to analyze all events.
- This is a tedious and labor intensive

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Motivation for LiDAR based Ground Truth

- Can we automatically detect and track objects from other sensors?

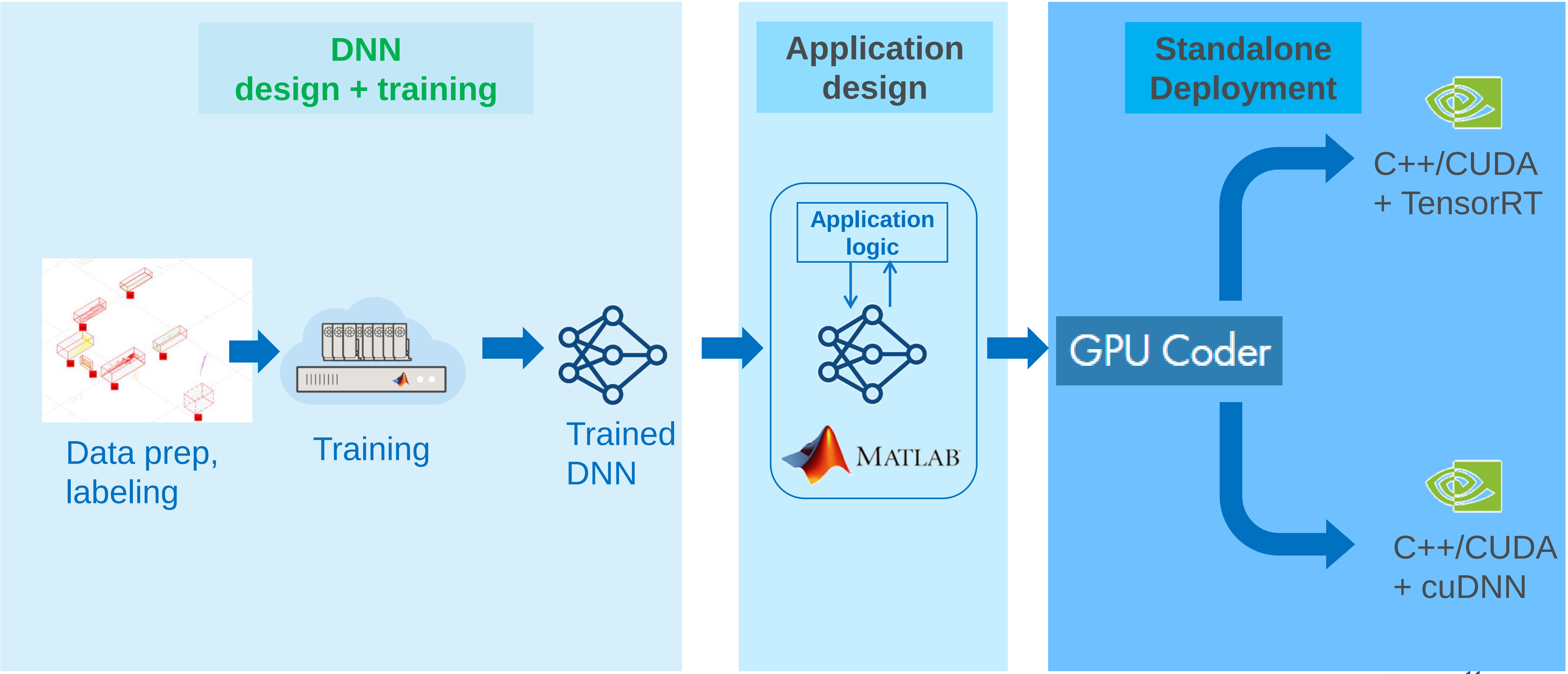
- For verifying blind spot events, distance metrics are critical
  - LiDAR provides accurate distance measurements

- Can we use LiDAR Sensors to detect objects in the blind spot zone?
  - Generate all events of interest
  - Next step, is can we automate this process?

Workflow for Automating Object Detection from LiDAR

- A MATLAB based tool to assist users to visualize, navigate, annotate and track objects with Point Clouds
- We present a workflow to automate the labeling of objects using LiDAR point cloud data
- We will look at some results
- Future work

Lidar processing application design in MATLAB



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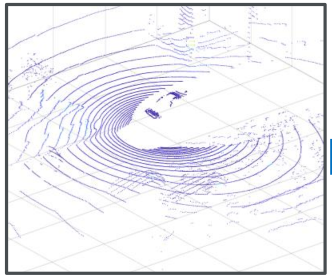
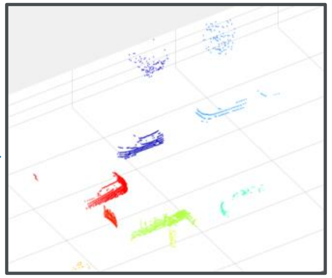
Data preparation and labeling of Lidar is a challenge

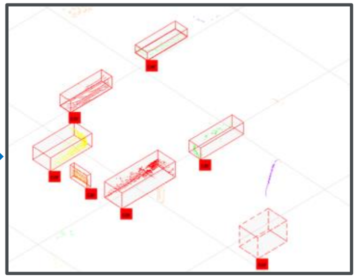
DNN design + training



Accessing lidar data

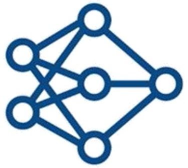


Lidar pre-processing



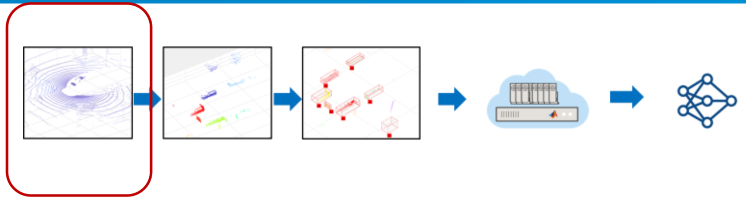
Labeling lidar data

Training



Trained DNN

Access and Visualize Lidar Data

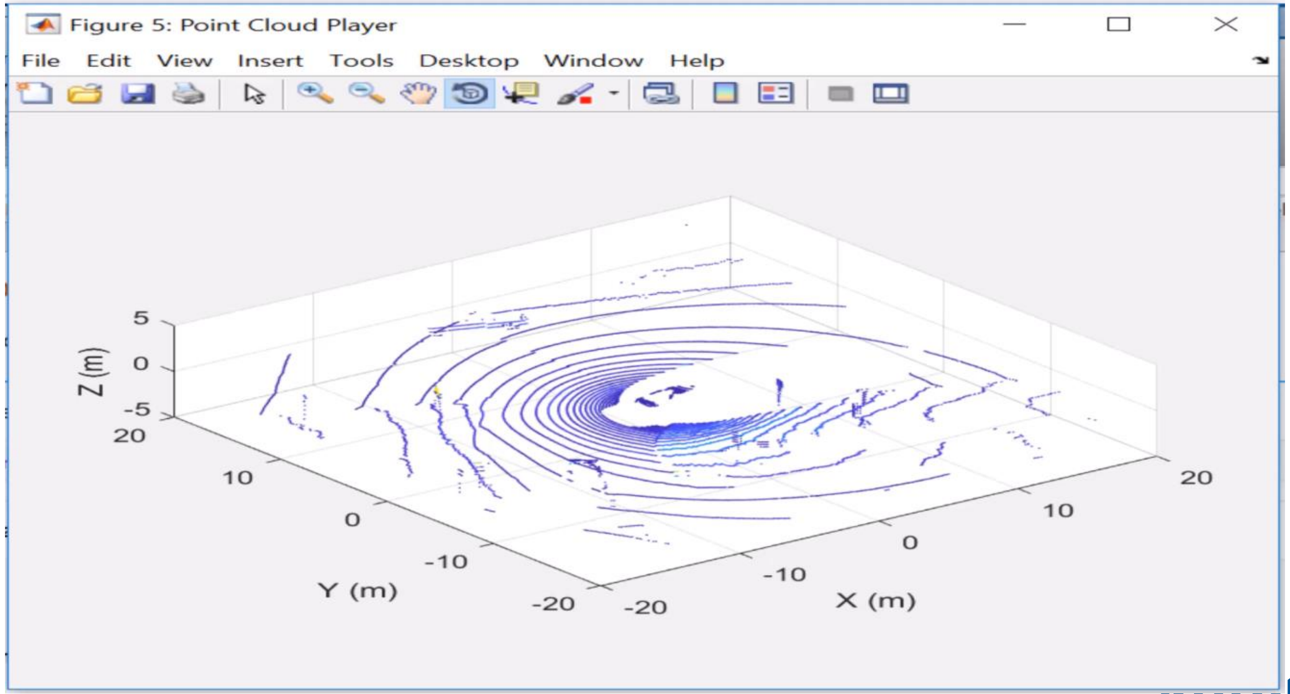


Access Stored Lidar Data

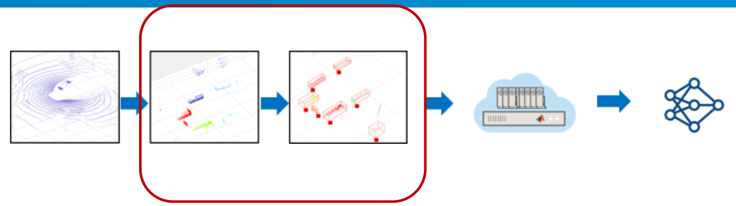
- Velodyne file I/O (pcap)
- Individual point clouds (.pcd,ply)
- Custom binary formats

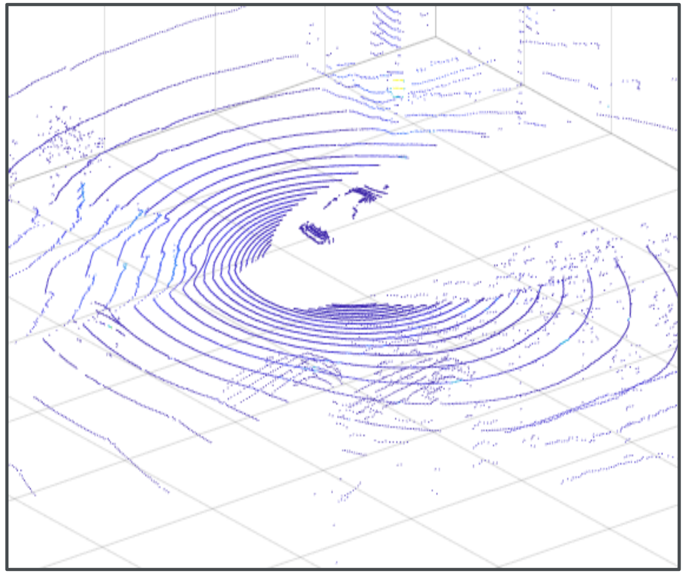
Visualize Lidar Data

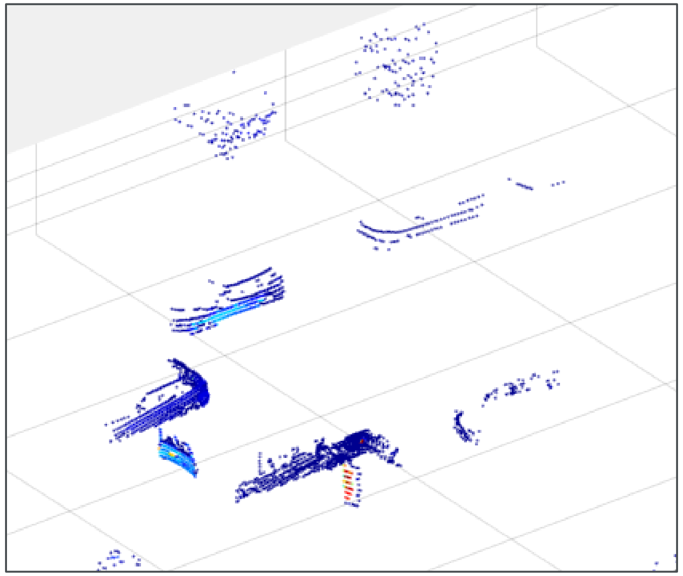
- Streaming Lidar player
- Static point cloud display
- Point cloud differences



Lidar Preprocessing

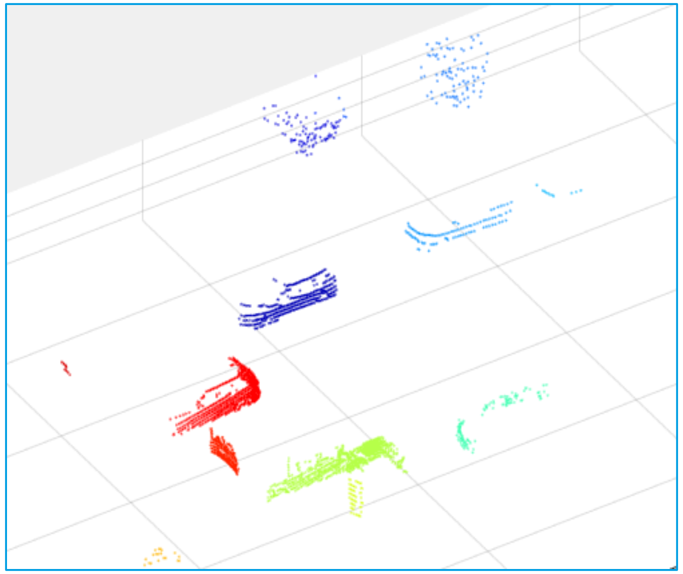






Remove Ground

- Fit plane using RANSAC



Cluster

- Segment clusters using Euclidean distance

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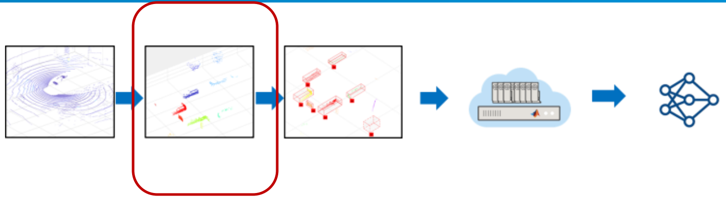
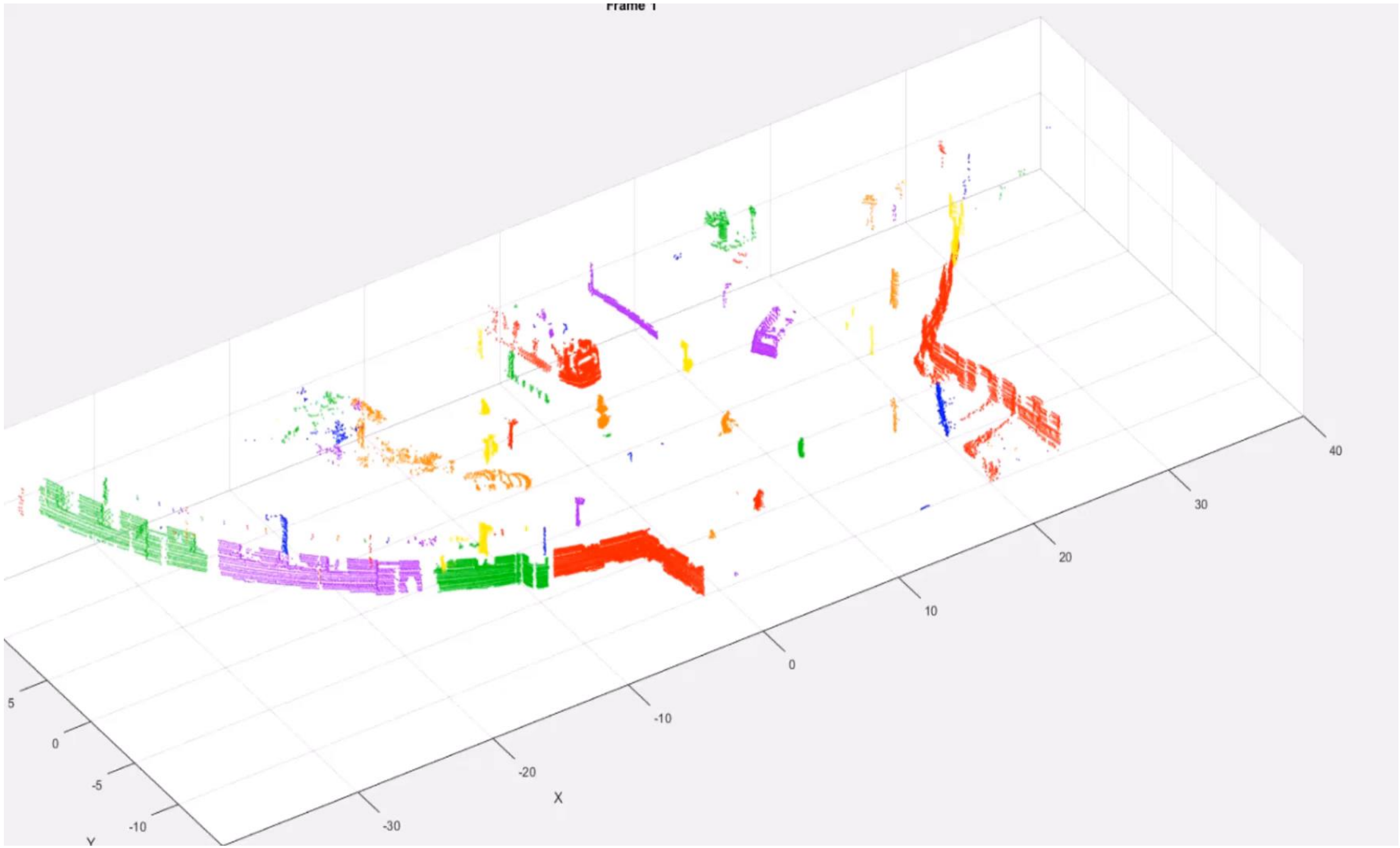
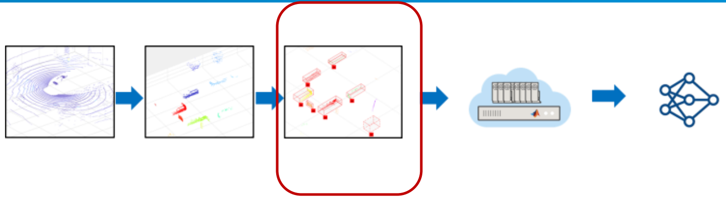
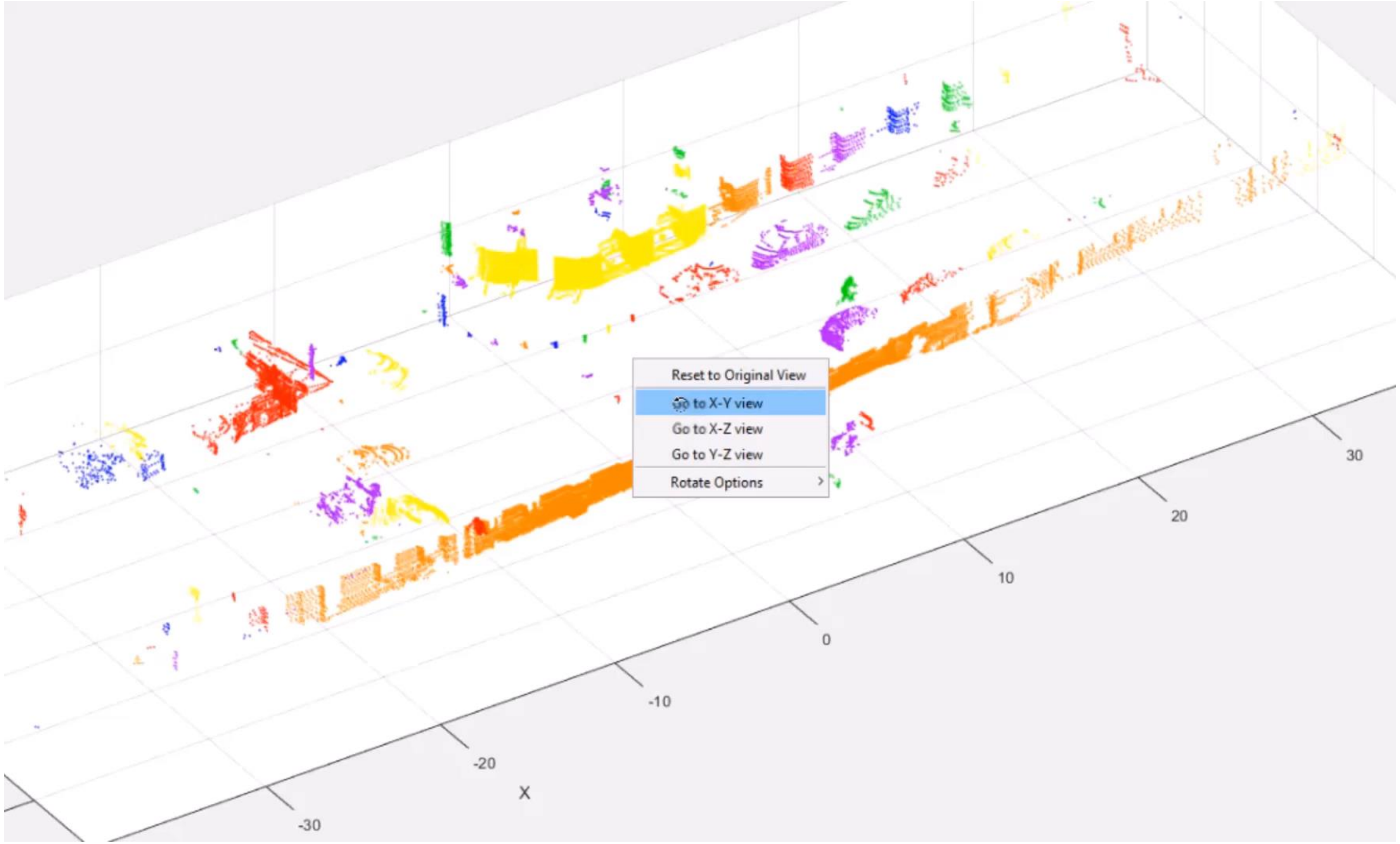
Ground Truth Labeling of Lidar Data





Ground Truth Labeling of Lidar Data





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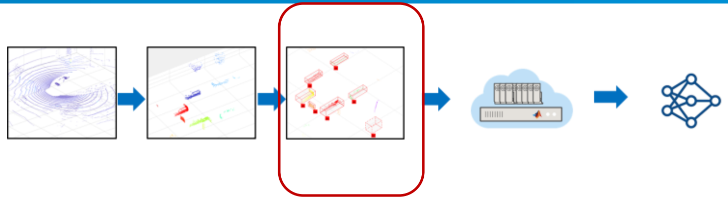
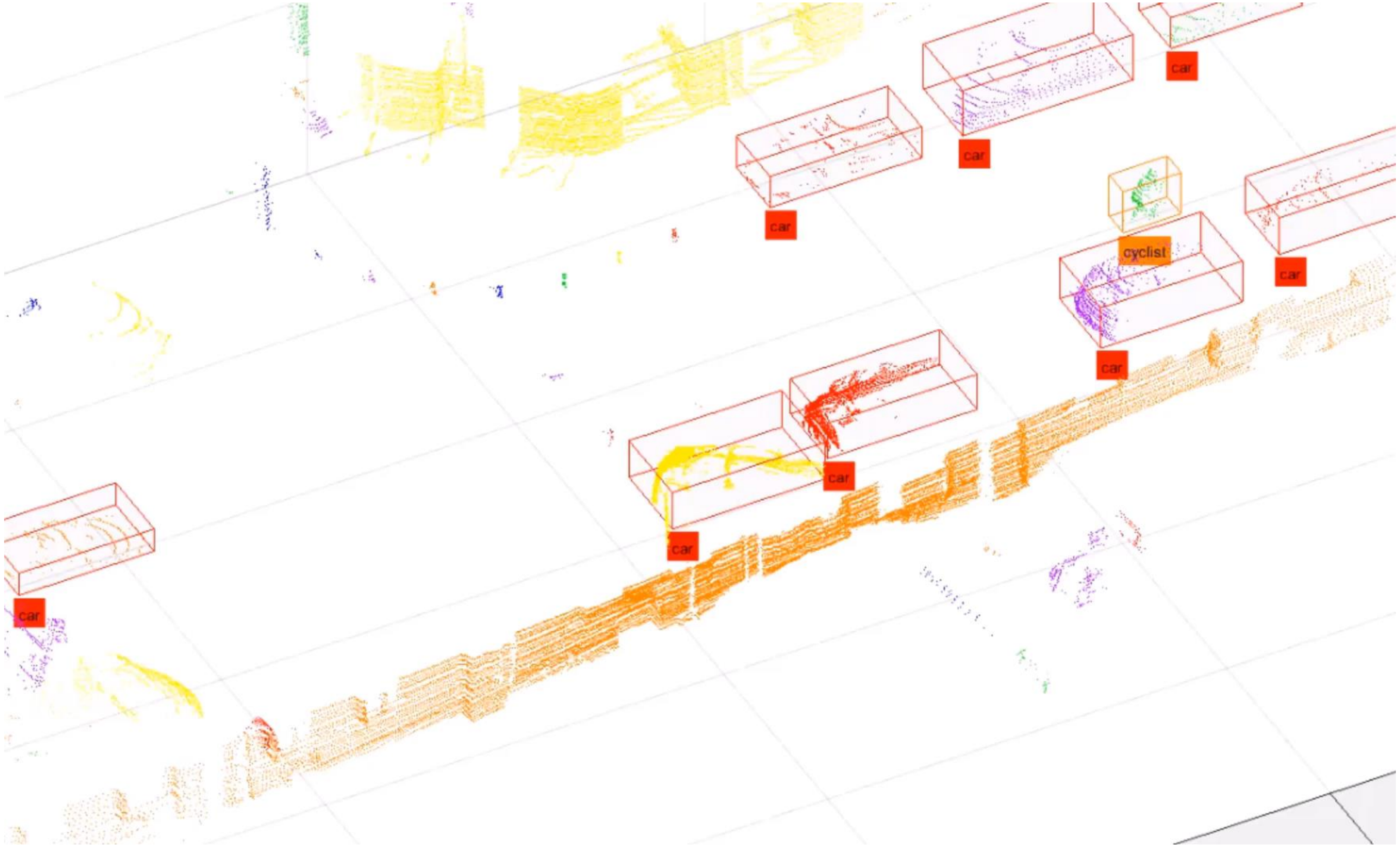
Ground Truth Labeling of Lidar Data





multiObjectTracker
(Automated Driving System Toolbox)

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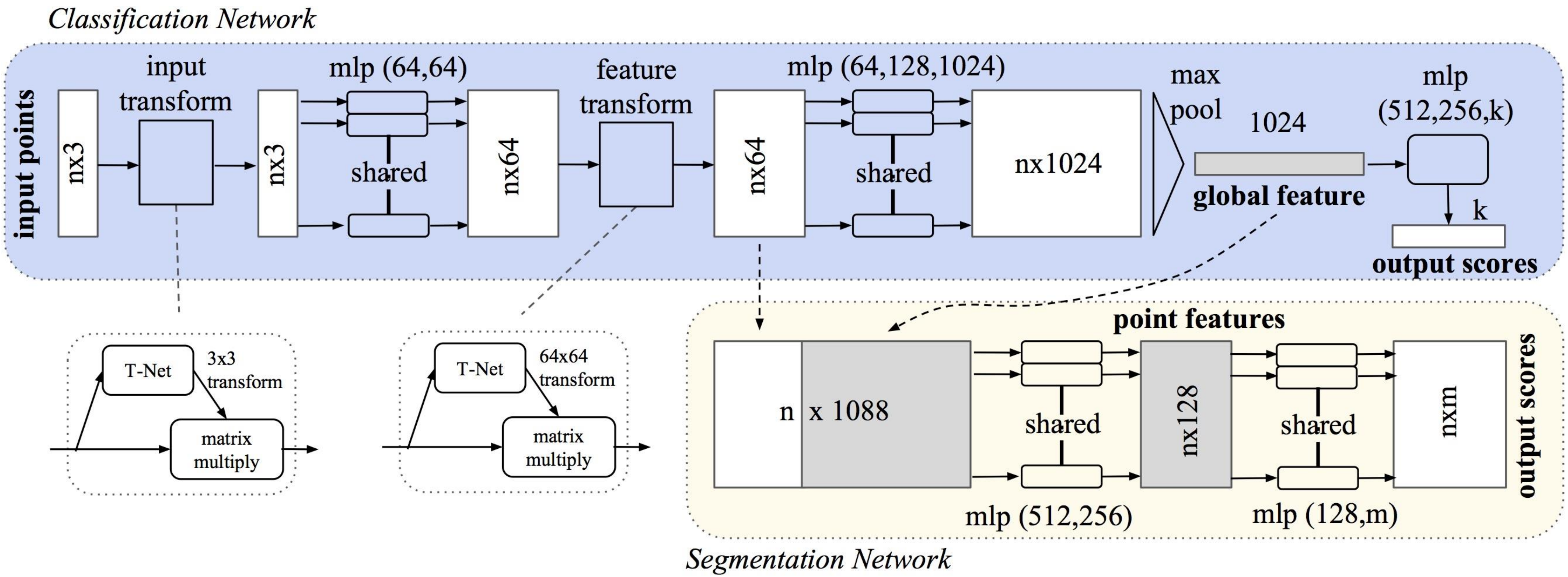
Automating Object Detection with Deep Learning

- We collected ground truth for LiDAR point clouds
- Now we look at methods to fully automate the LiDAR point cloud annotation
- Use Deep Learning for Point Cloud Object classification
- Use Kalman Filters for creating robust tracks

PointNet Network Structure



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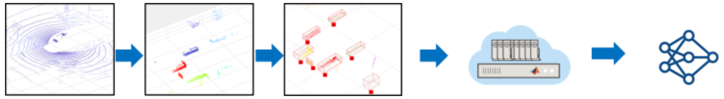
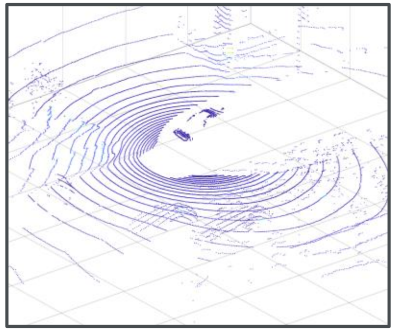
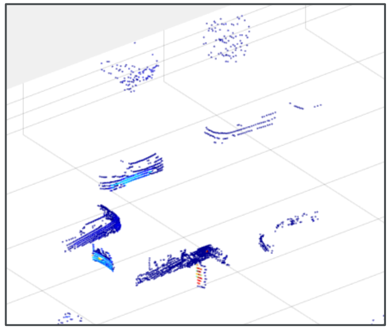
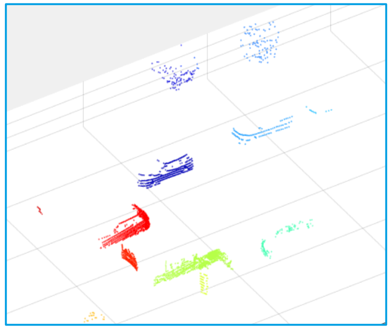
Lidar Processing Pipeline



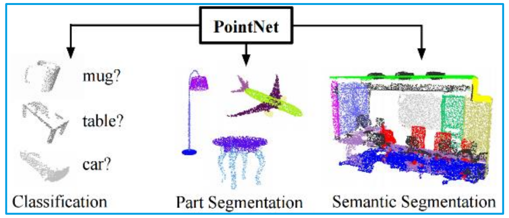




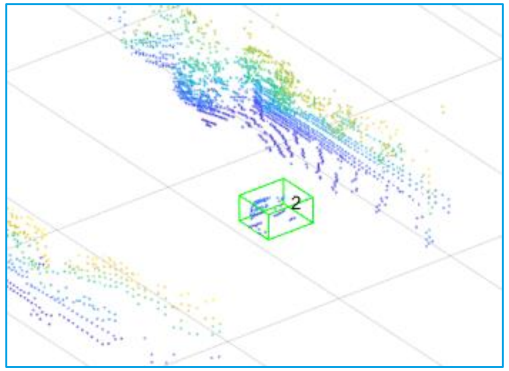
Remove Ground



Cluster



Classify



Track

multiObjectTracker

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Moving Object Detection

- Classifying objects as stationary or moving
- Uses host velocity to calculate target velocity in global coordinates.
- Classifying moving objects as potential False negatives
  - False negative is when Radar fails to recognizes valid objects.

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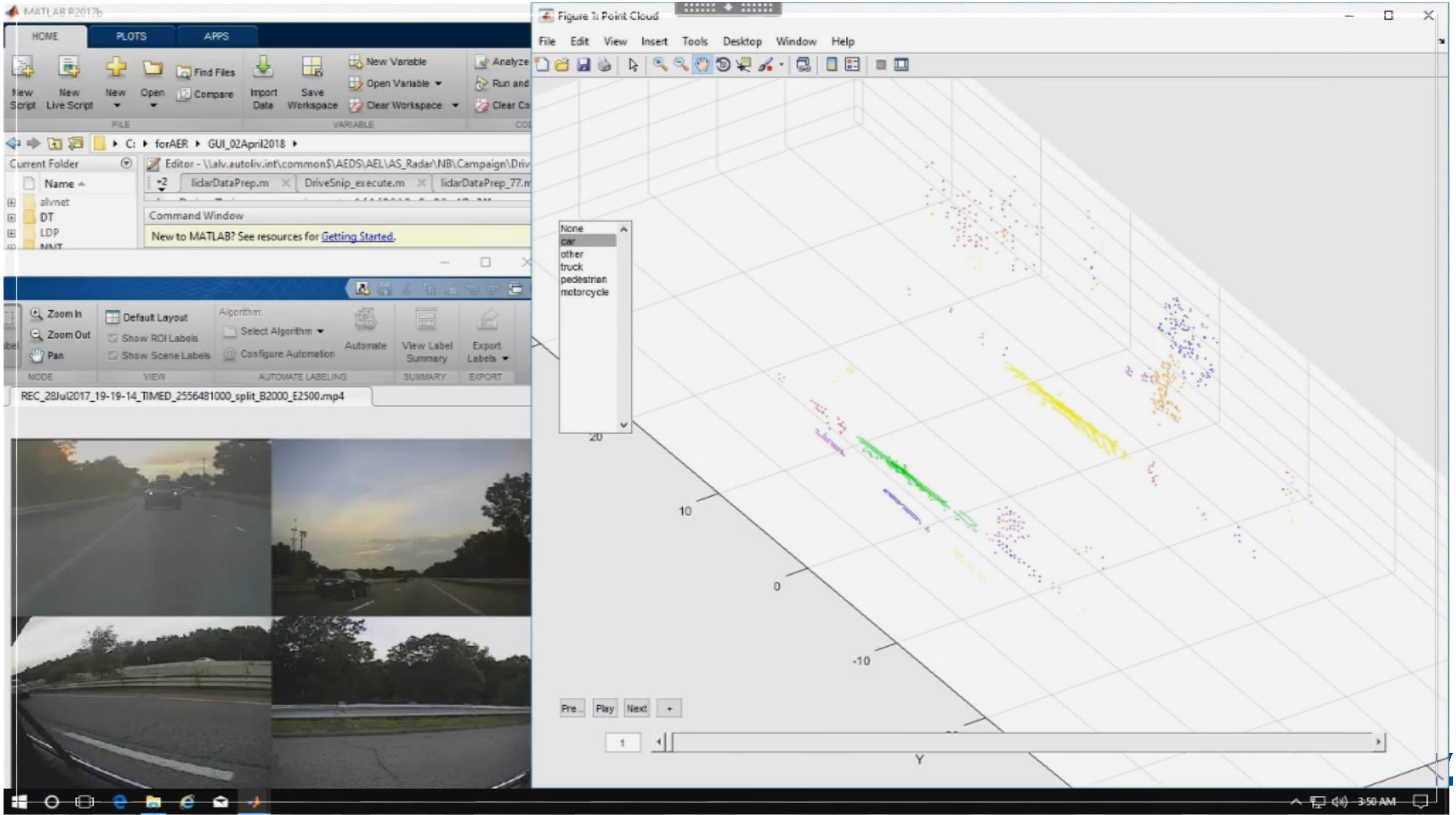
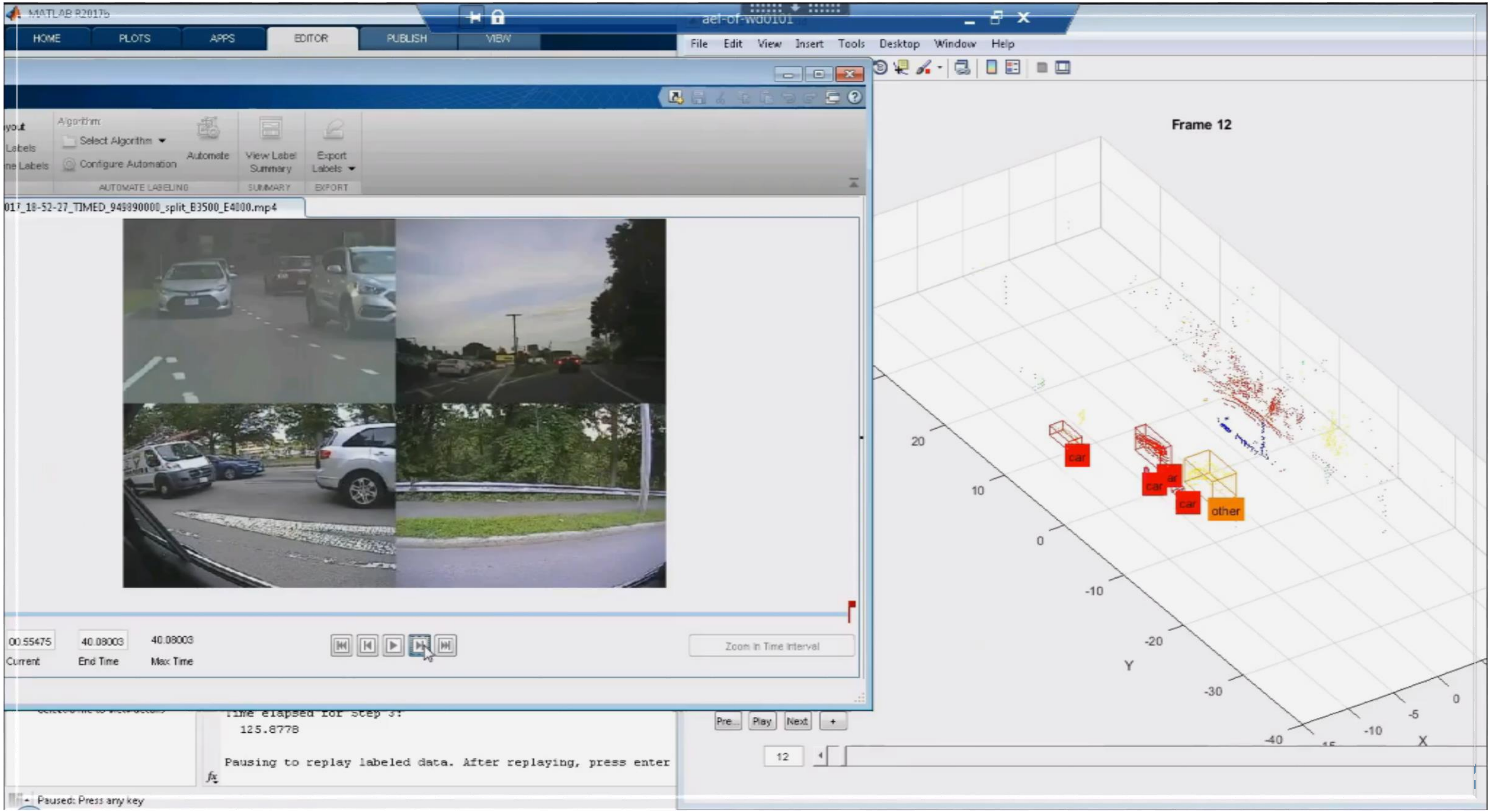
Results – Simple Scenario

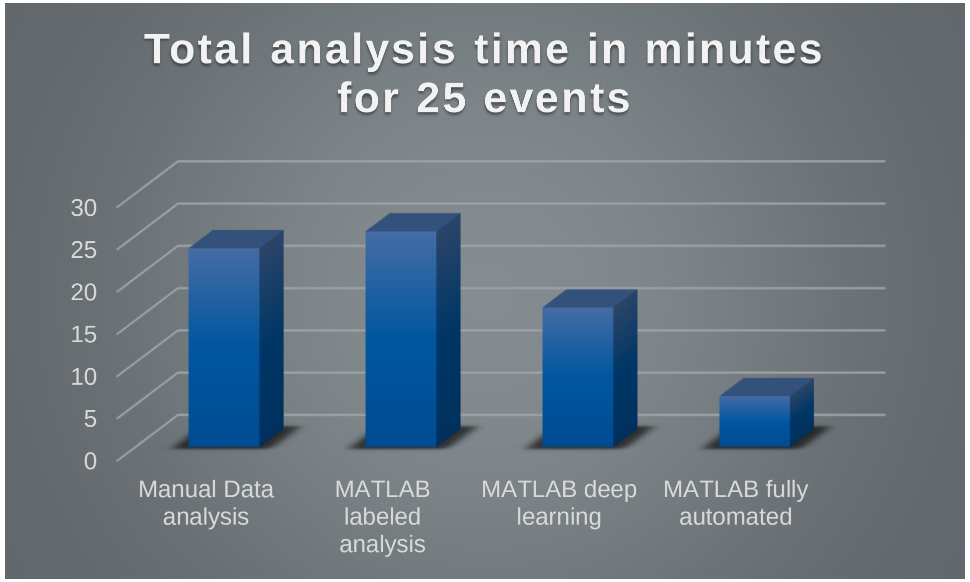


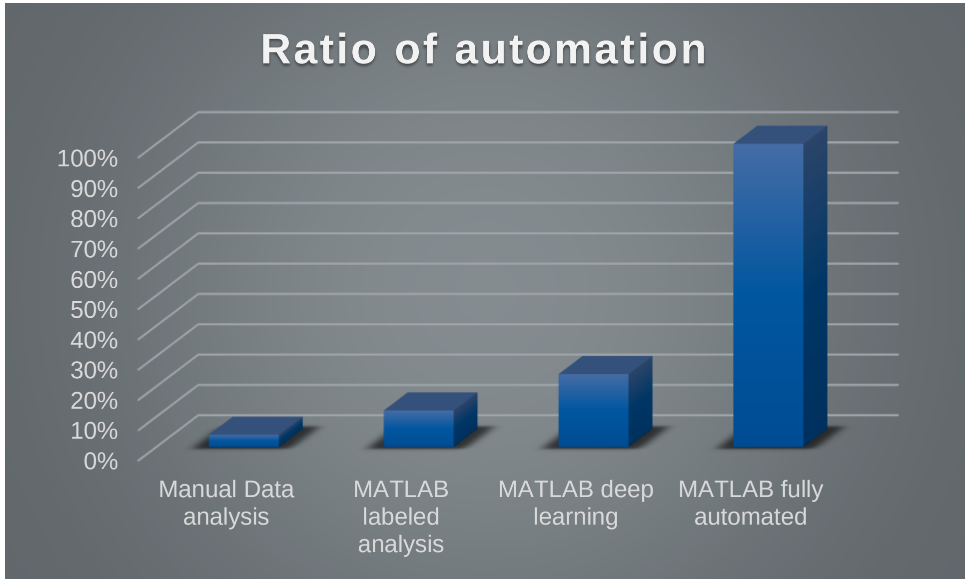
Results – Complex scenario



Workflow benefits

- Autoliv was manually analyzing LiDAR data to verify their Radar sensors.
- Using this MATLAB workflow, Autoliv is able reduce time needed to analyze LiDAR data
- As level of automation increases, the analysis time is further reduced
- A blind spot analysis is illustrated here.





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Future work

- Explore other Neural Net architectures which are more accurate
- Integrating video reference data along with LiDAR to provide easier annotation and also more accurate and automated classification of objects
- Extend results to categories other than just vehicles, also try to include pedestrians and general objects

Conclusion

- Manually labeling LiDAR point cloud is labor-intensive.
- We present an automated workflow that can cut down time and costs needed for sensor verification.
- Collaborative effort between Autoliv and MathWorks.