



# Active Learning for Semantic Segmentation in 3D Point Cloud Sequence

Faculty of Electrical Engineering

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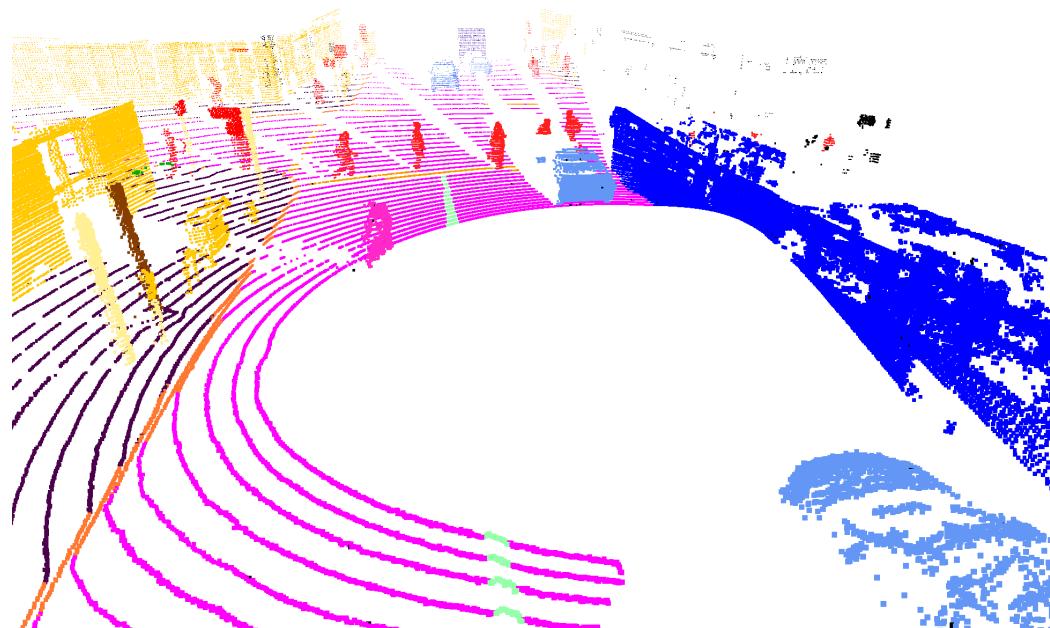
13.6.2023

# LiDAR data

- 3D point cloud
  - set of points in cartesian coordinates
- Unorganized / without structure



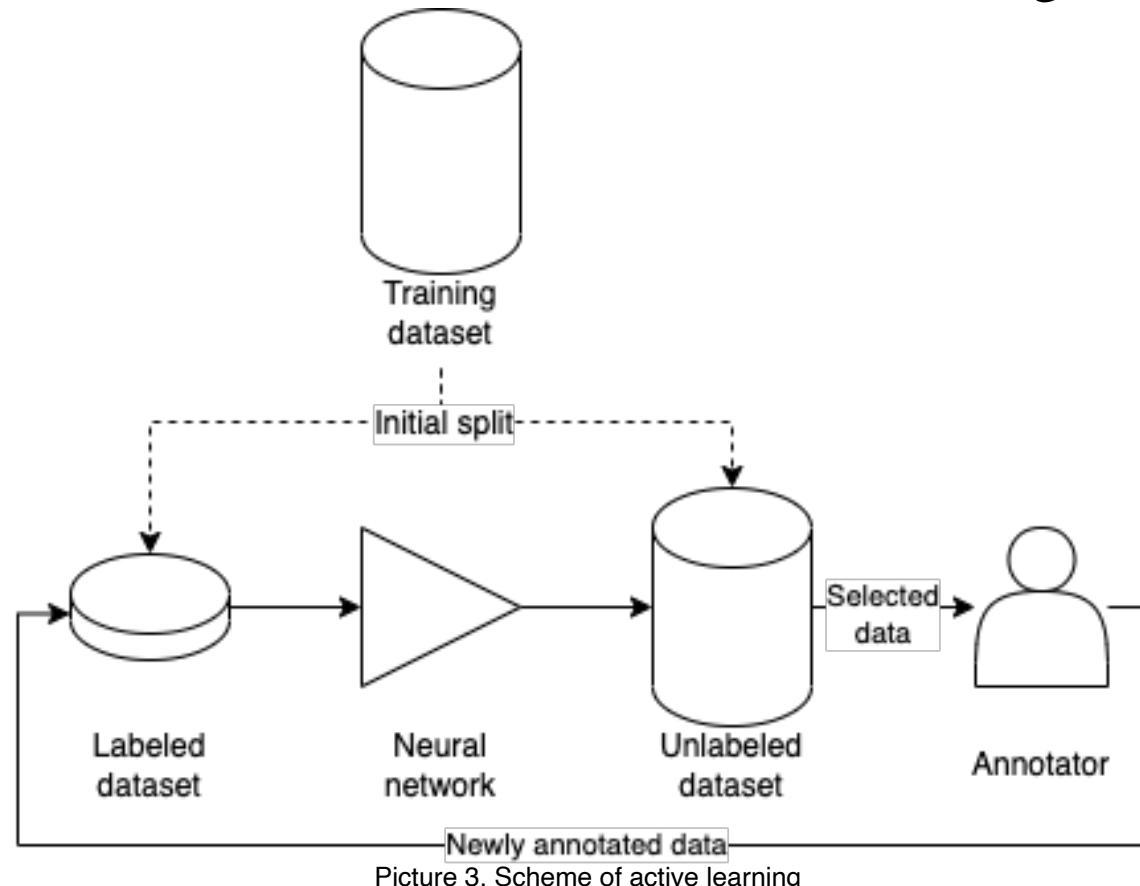
Picture 1. LiDAR sensor



Picture 2. 3D point cloud

# Active learning

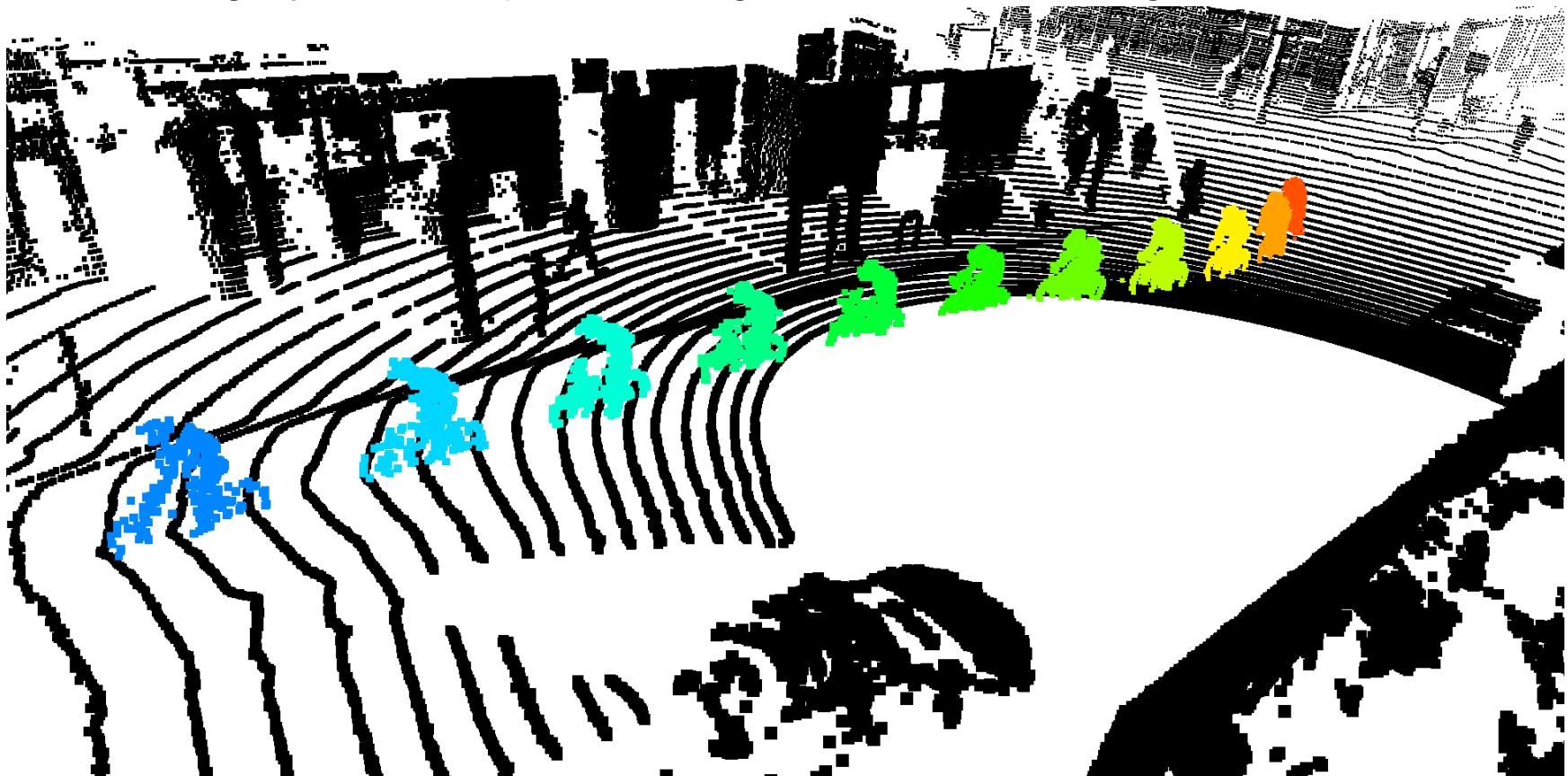
- Iterative method
- Annotating only “interesting” scenes
  - Estimated by e.g. softmax-entropy:  $H = -P \log(P)$



Picture 3. Scheme of active learning

# Task

- Extension of ReDALu\*
- Linking dynamic objects through time → propagation of annotations

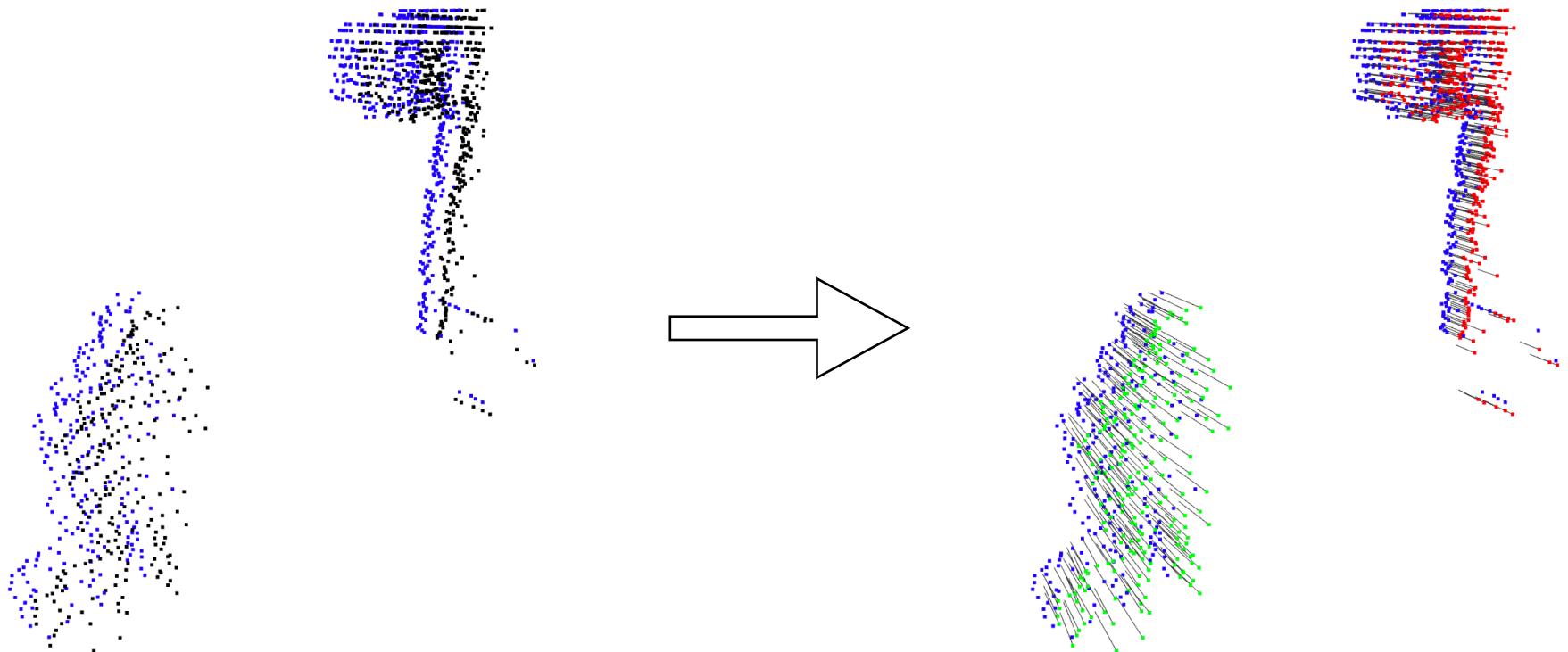


Picture 4. Dynamic object linked through time

# Approach

## Motion flow

- SLIM\*
  - Segmentation of dynamic vs. static points
  - Flow of each point to the next scene

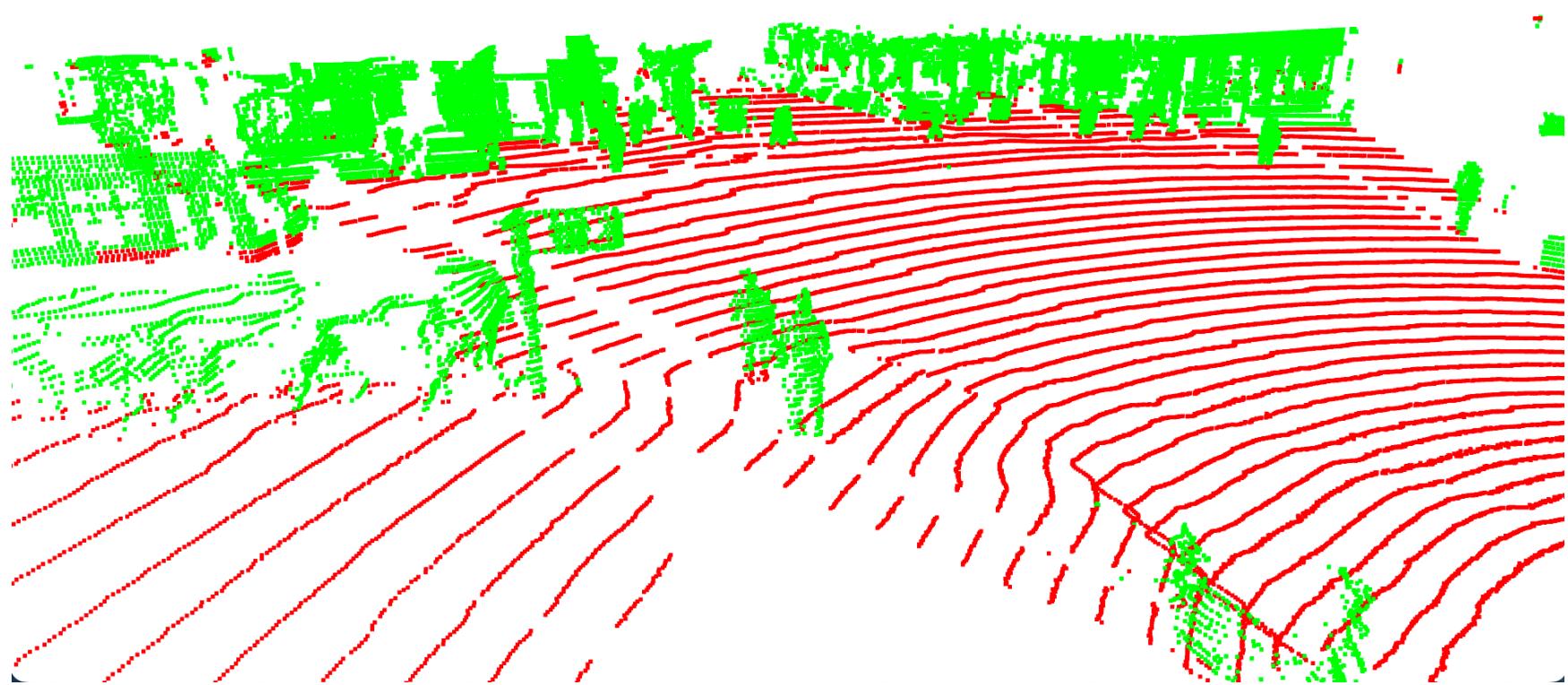


Picture 5. Prediction of SLIM

# Approach

## Ground masking

- Patchwork++\*

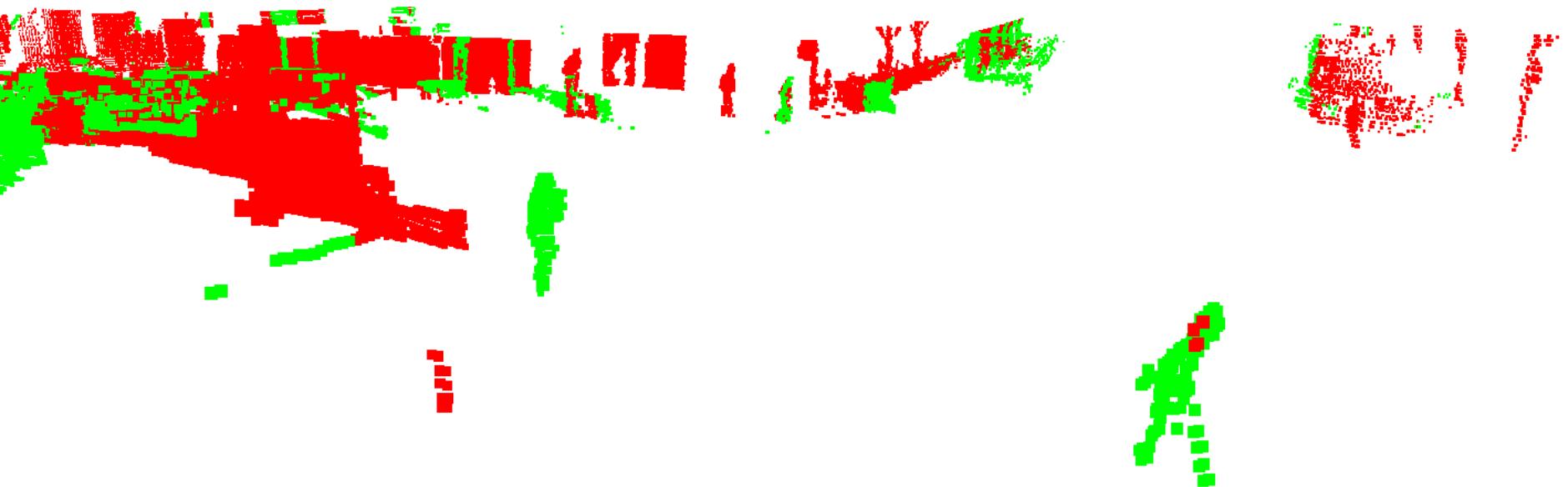


Picture 6. Ground segmentation

# Approach

## Motion flow

- Prediction of dynamic vs. static are noisy



Picture 7. SLIM prediction

# Approach

## DBSCAN\*

- Obtaining instances

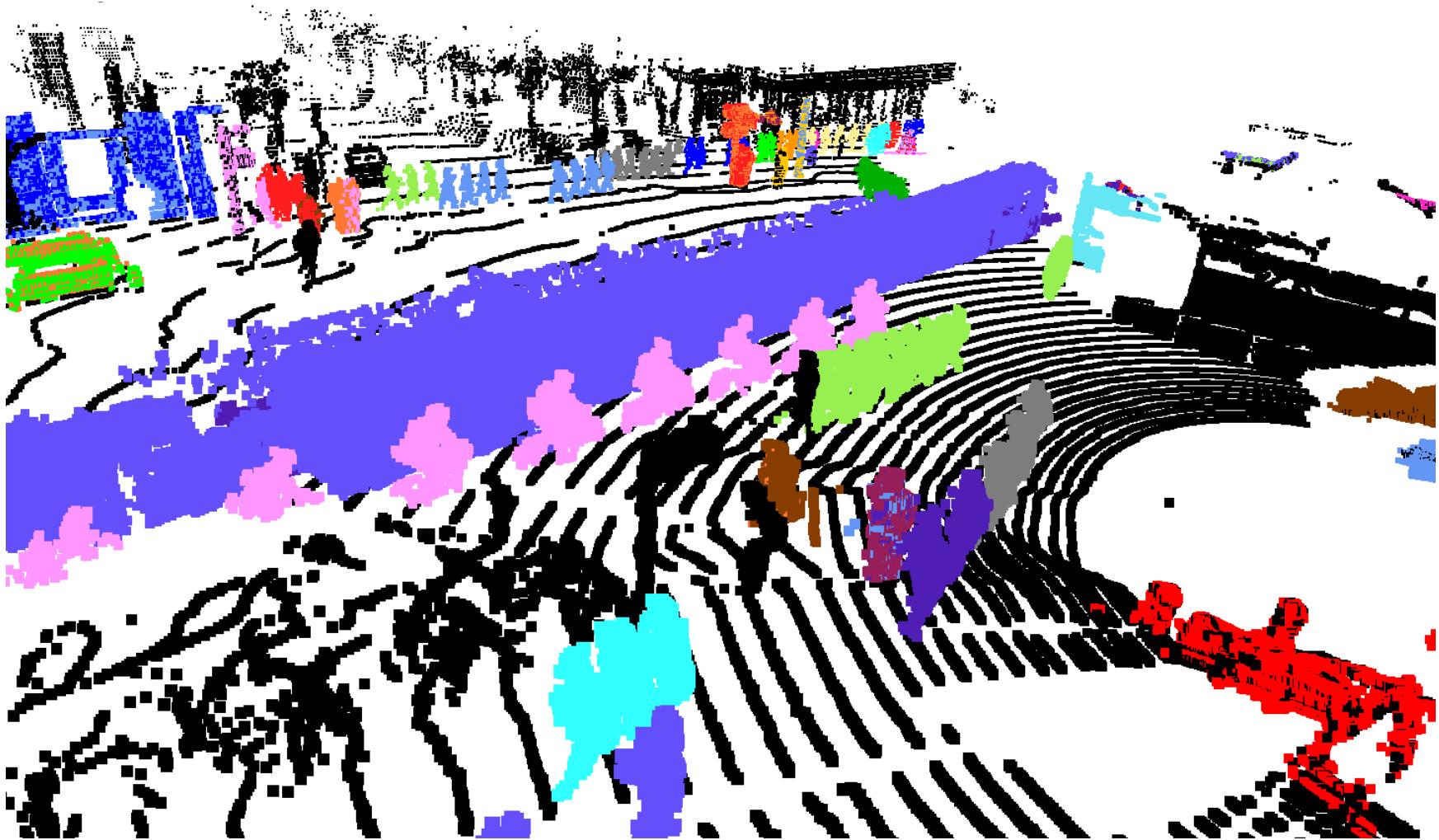


Picture 8. Clusters in scene obtain by DBSCAN

\*Martin Ester, Hans-Peter Kriegel, Jörg Sander, and Xiaowei Xu. A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise. In *Knowledge Discovery and Data Mining*, 1996

# Approach

## Dynamic objects linked through time



Picture 9. Dynamic objects linked through time

# Dataset



## SemanticKITTI

- 19 130 training scenes
- 4 071 validation scenes

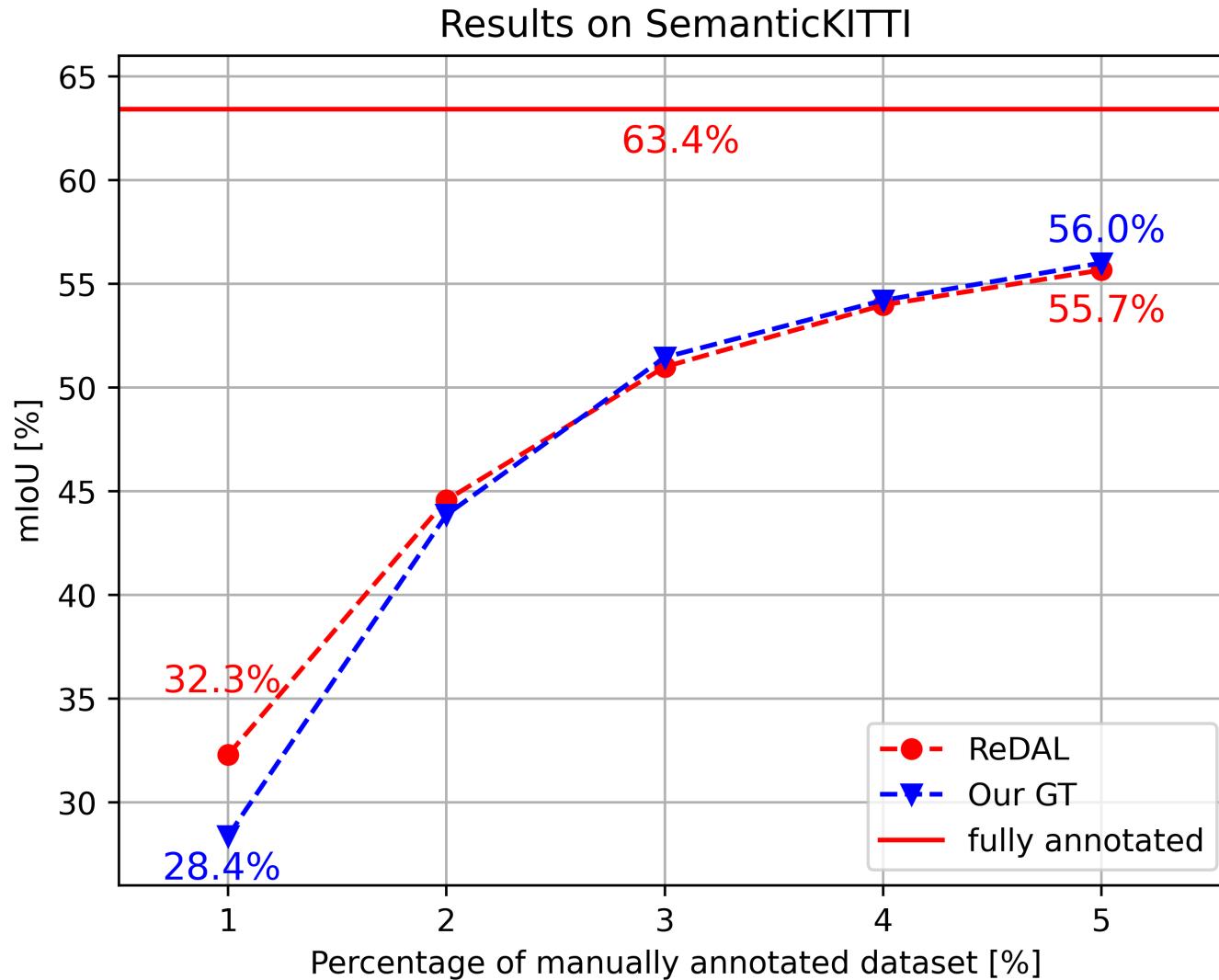
## Waymo Open Dataset (subset)

- 19 526 training scenes
- 4 165 validation scenes

# Experiments with instances based on ground truth

# Results

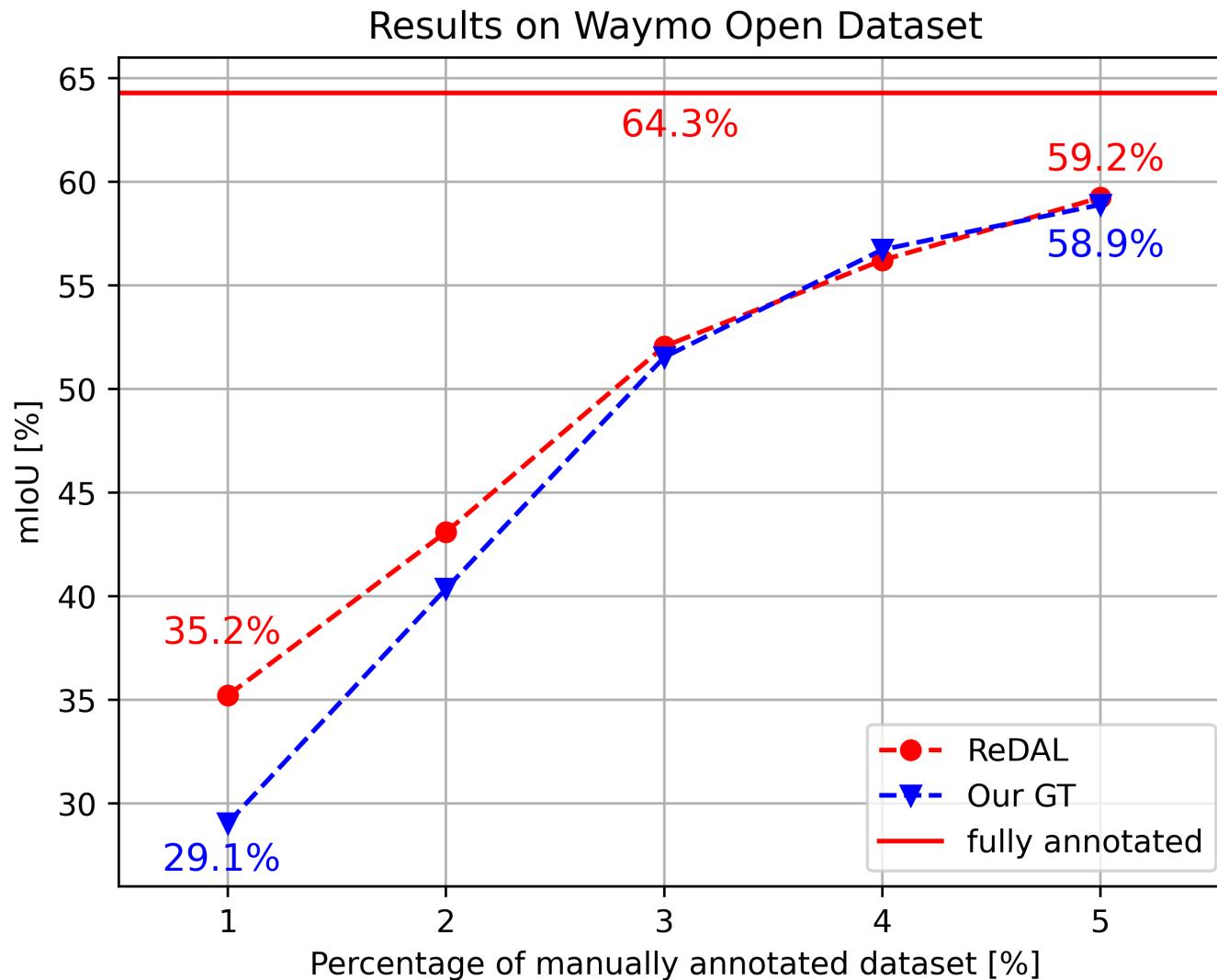
## SemanticKITTI



Graph 1. Results on SemanticKITTI

# Results

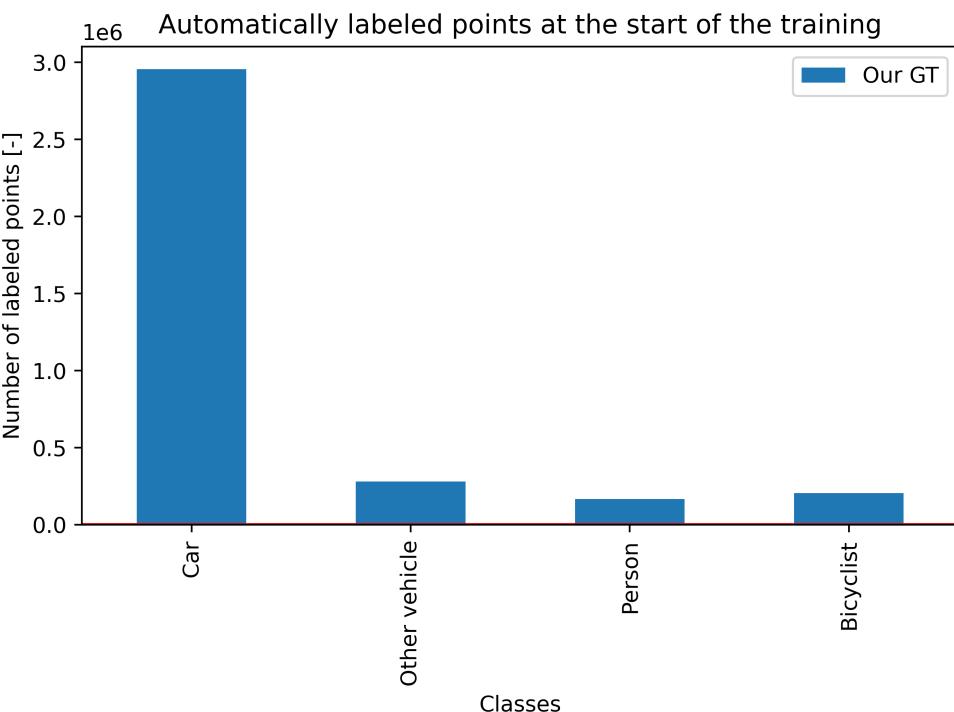
## Waymo Open Dataset



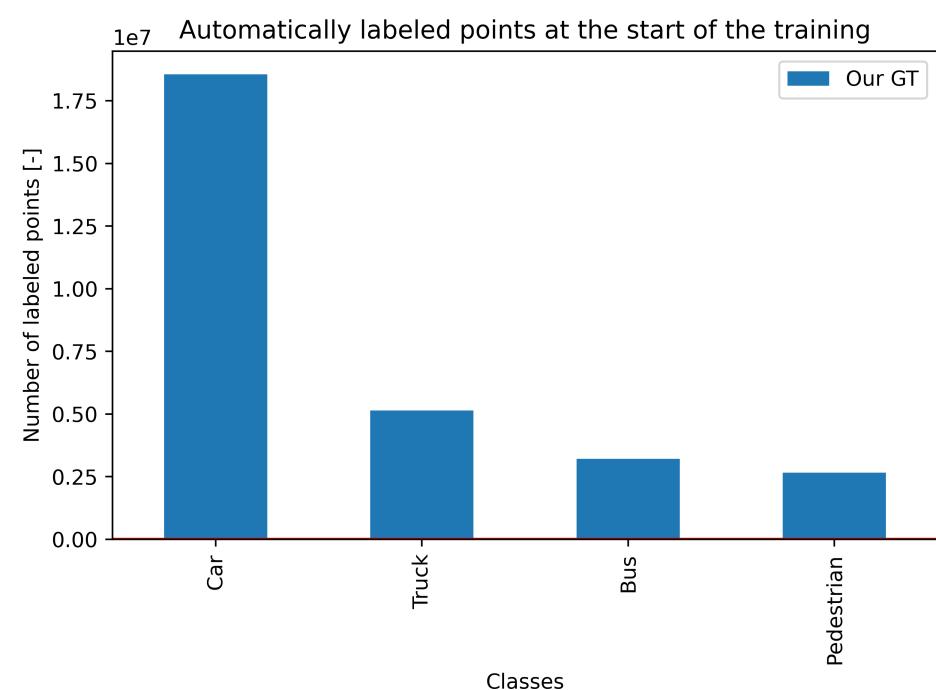
Graph 2. Results on Waymo Open Dataset

# Results

## Unbalanced dataset



Graph 3. Number of automatically labeled points at the start of the training on SemanticKITTI



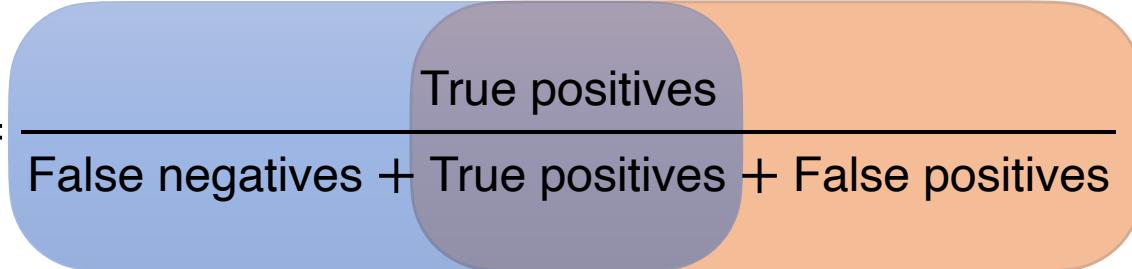
Graf 4. Number of automatically labeled points at the start of the training on Waymo Open Datasetu

# Results

## Unbalanced dataset

$$\text{IoU} = \frac{\text{True positives}}{\text{False negatives} + \text{True positives} + \text{False positives}}$$

Recall                      Precision



- Recall - percentage of detected objects
- Precision - reliability of detections

# Results

## Unbalanced dataset

### Precision

Classes	Our GT	ReDAL*
Car	0.73	0.90
Truck	0.13	0.21
Other vehicle	0.13	0.30
Person	0.07	1.00
Bicyclist	0.13	0.00
Motorcyclist	0.00	0.00

### Recall

Classes	Our GT	ReDAL*
Car	0.96	0.96
Truck	0.17	0.10
Other vehicle	0.22	0.02
Person	0.77	0.00
Bicyclist	0.96	0.00
Motorcyclist	0.01	0.00

Table 1. Precision (left) and recall (right) of dynamical classes on SemantiKITTI

Classes	Our GT	ReDAL*
Car	0.70	0.92
Truck	0.19	0.43
Bus	0.24	0.36
Pedestrian	0.28	0.82

Classes	Our GT	ReDAL*
Car	0.97	0.92
Truck	0.78	0.42
Bus	0.54	0.41
Pedestrian	0.93	0.55

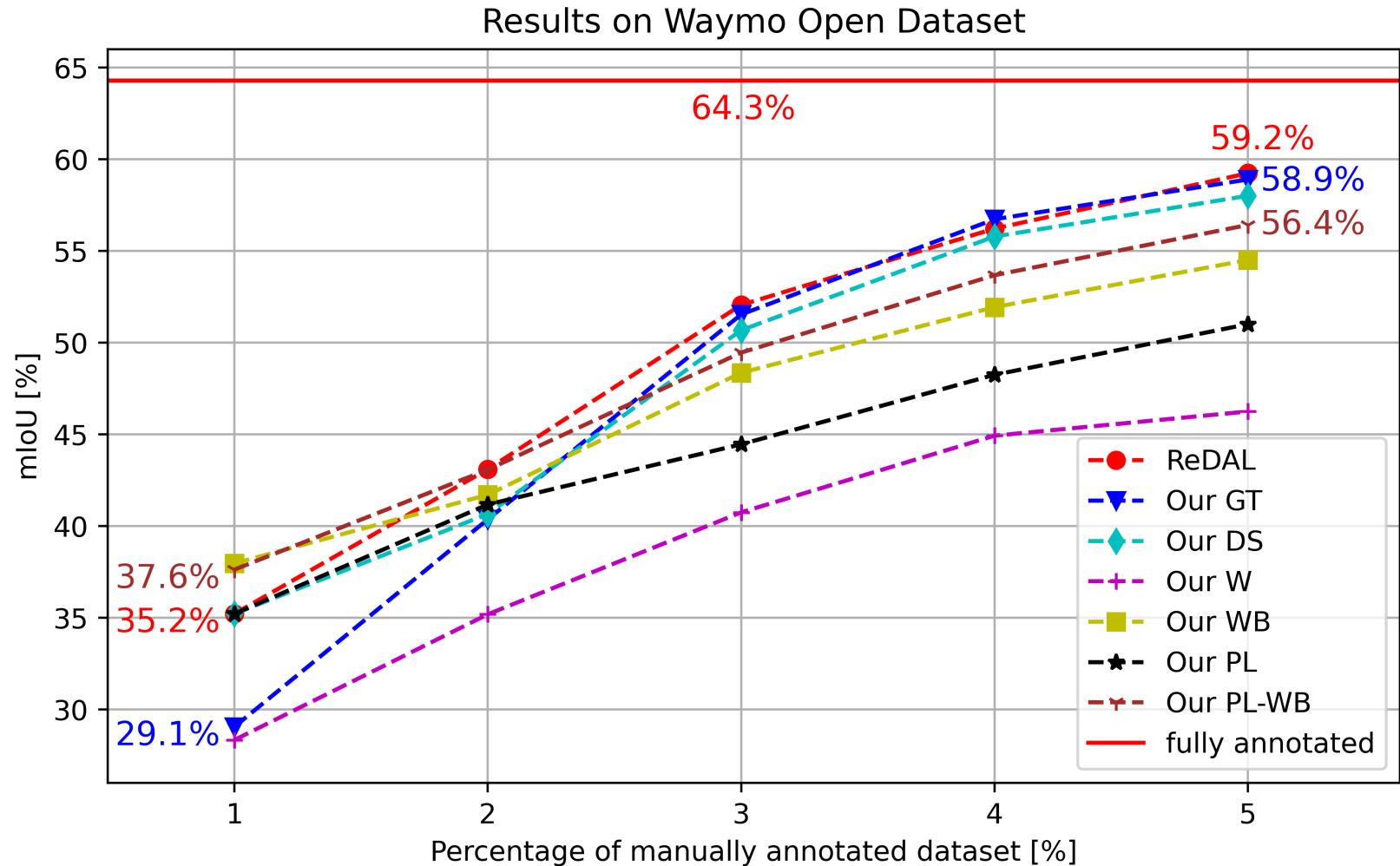
Table 2. Precision (left) a recall (right) of dynamical classes on Waymo Open Dataset

# Different training approaches

- Delayed start (DS)
  - Method is used after 1. checkpoint
- Weighted loss function (W)
- Loss scaling by number of labeled points (WB)
  - $$\mathcal{L} = \frac{1}{|B|} \sum_{b \in B} \mathcal{L}_b \frac{|p_b^l|}{|p_b|}$$
- Pseudolabeling (PL)
- Pseudolabeling and loss scaling by number of labeled points (PL-WB)

# Results

## Waymo Open Dataset

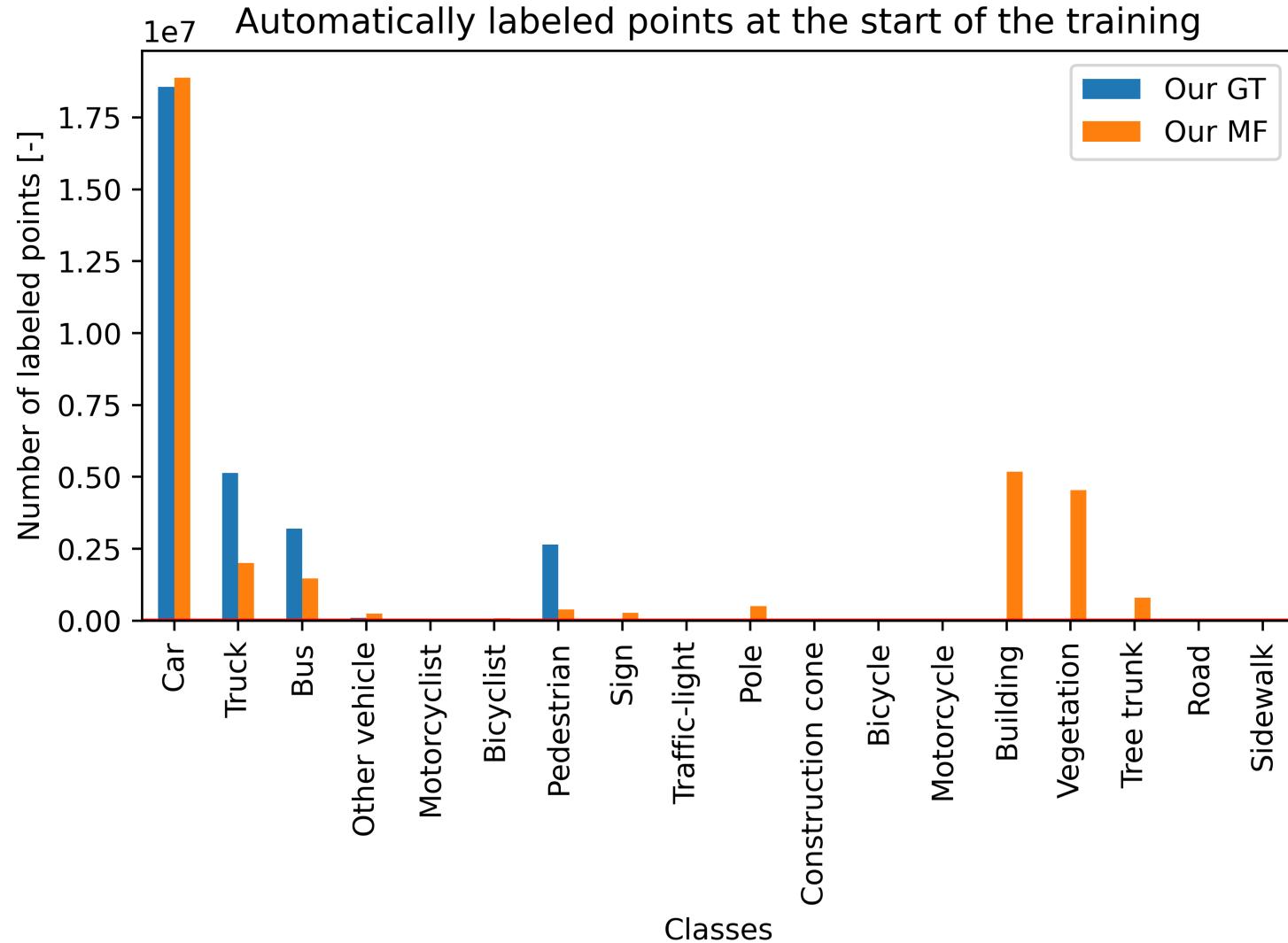


Graph 5. Results on Waymo Open Datasetu

# Experiments with instances created by our method

# Results

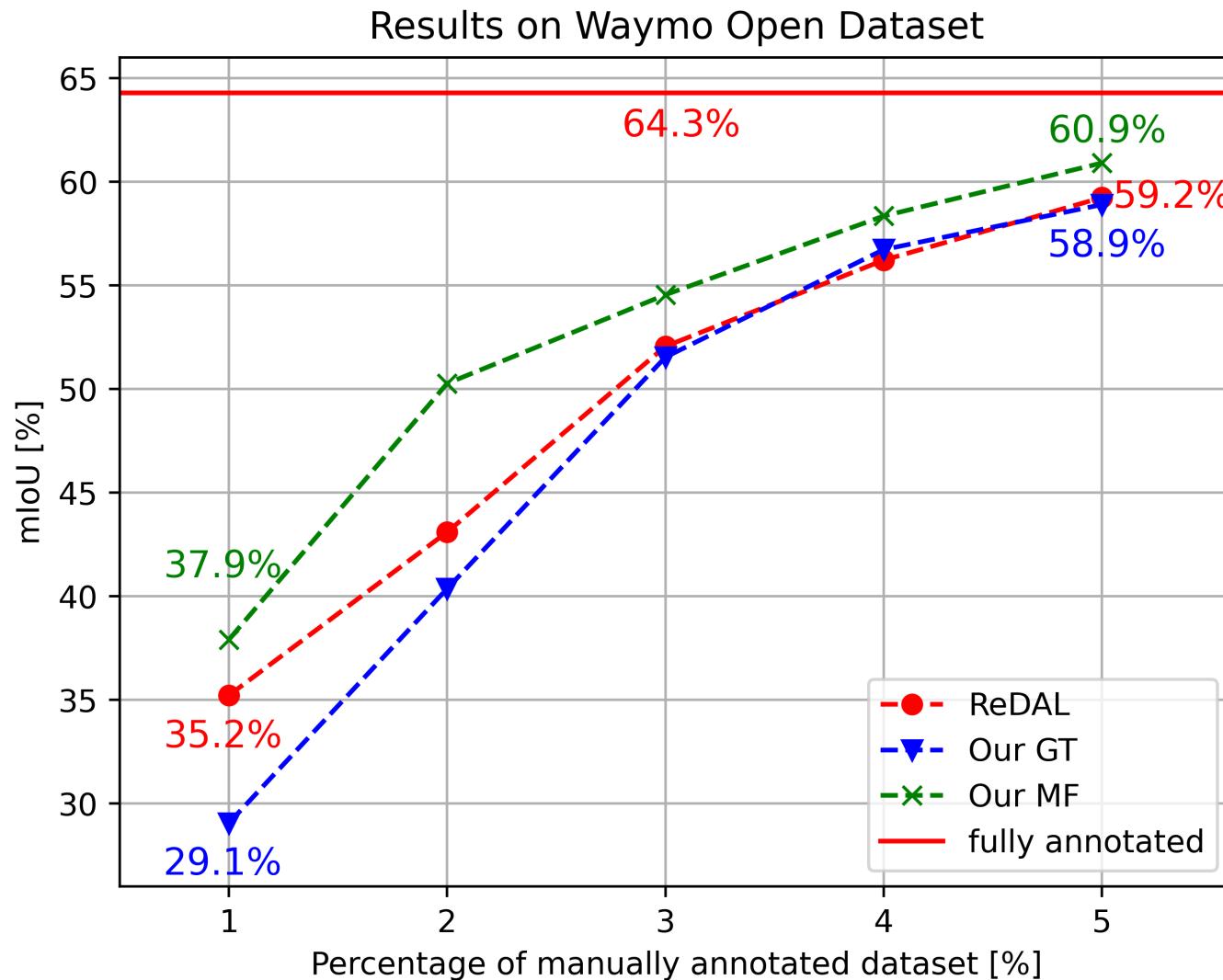
## Waymo Open Dataset



Graph 6. Number of automatically labeled points at the start of the training on Waymo Open Dataset

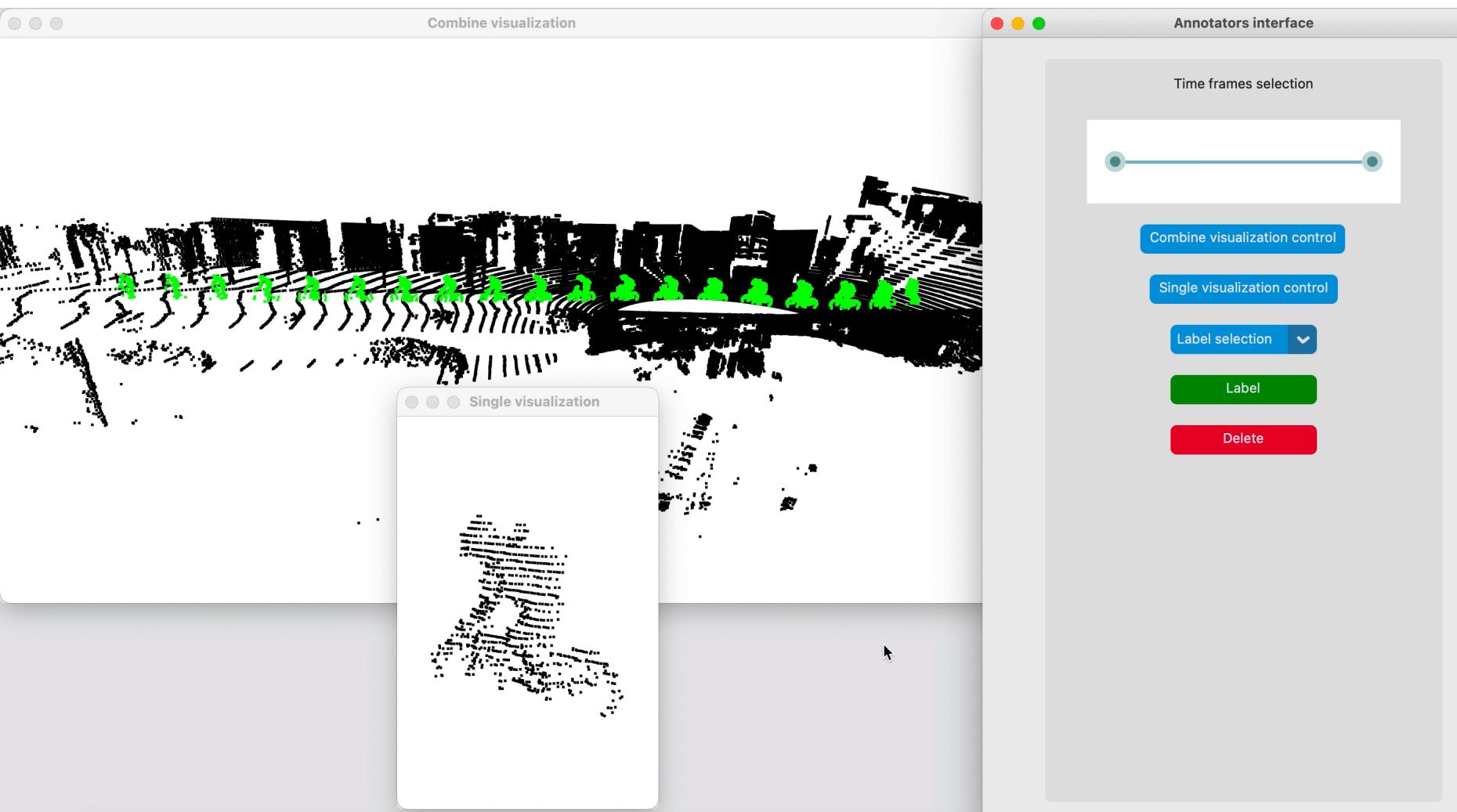
# Results

## Waymo Open Dataset

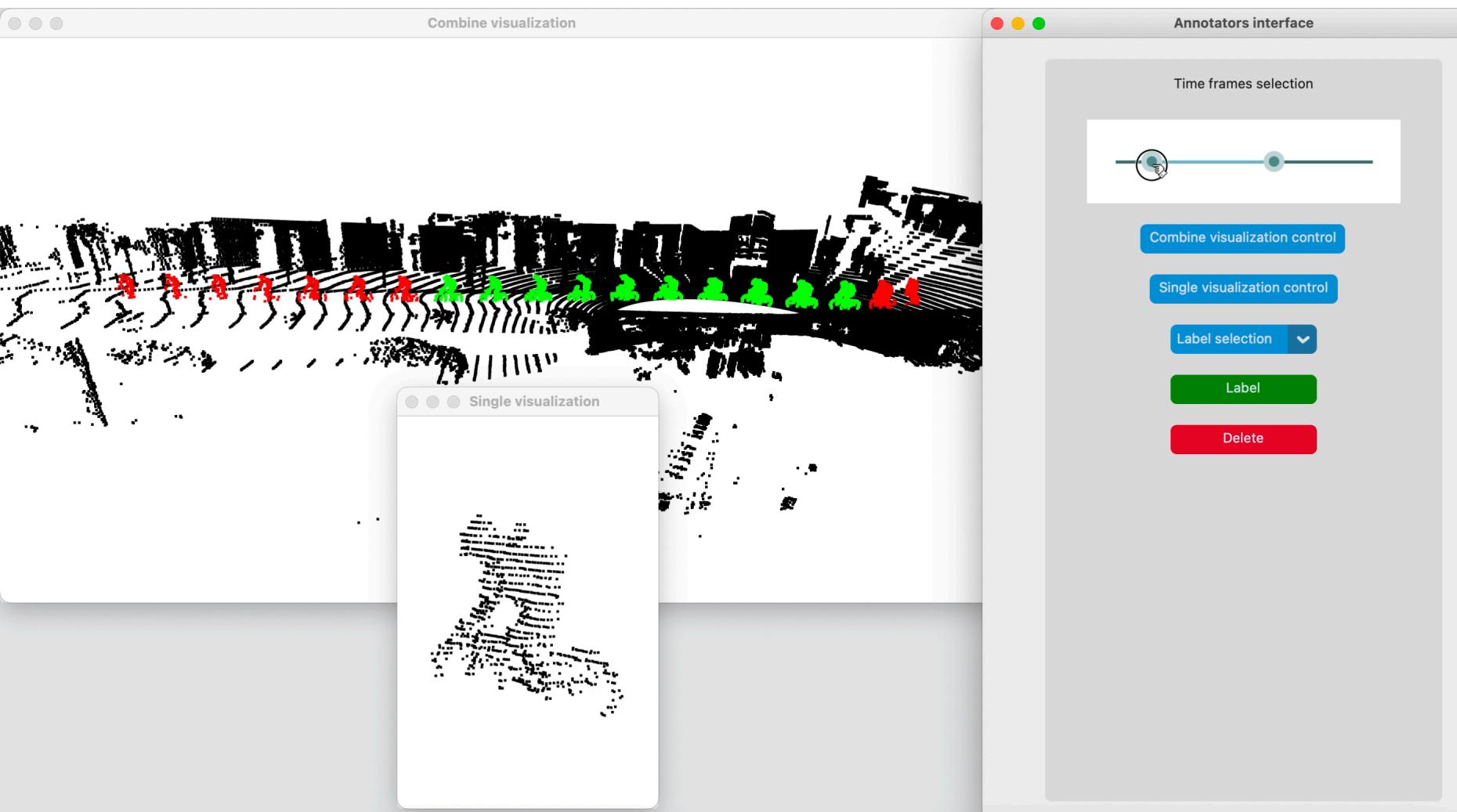


Graph 7. Results on Waymo Open Dataset

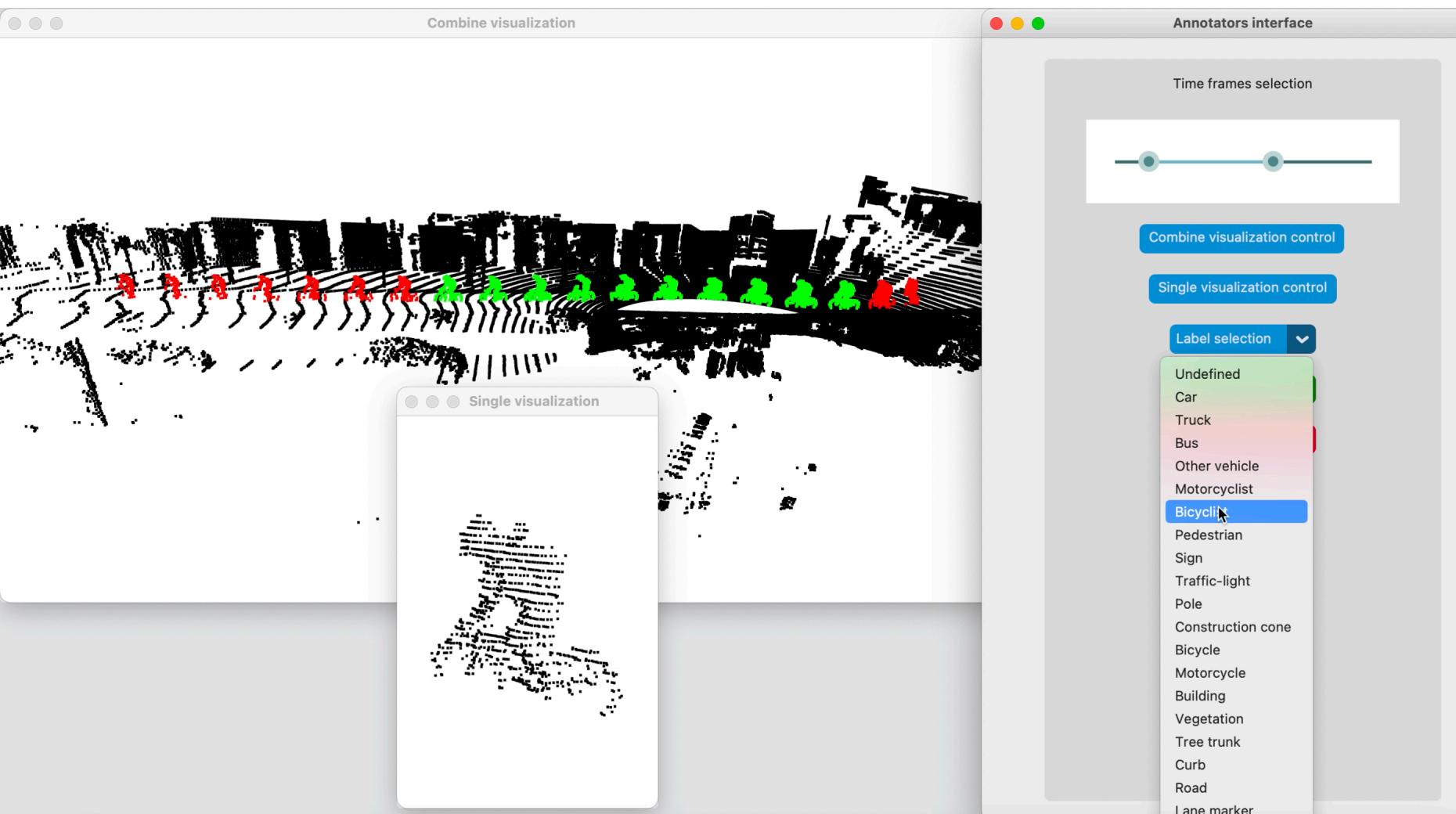
# Annotator user interface



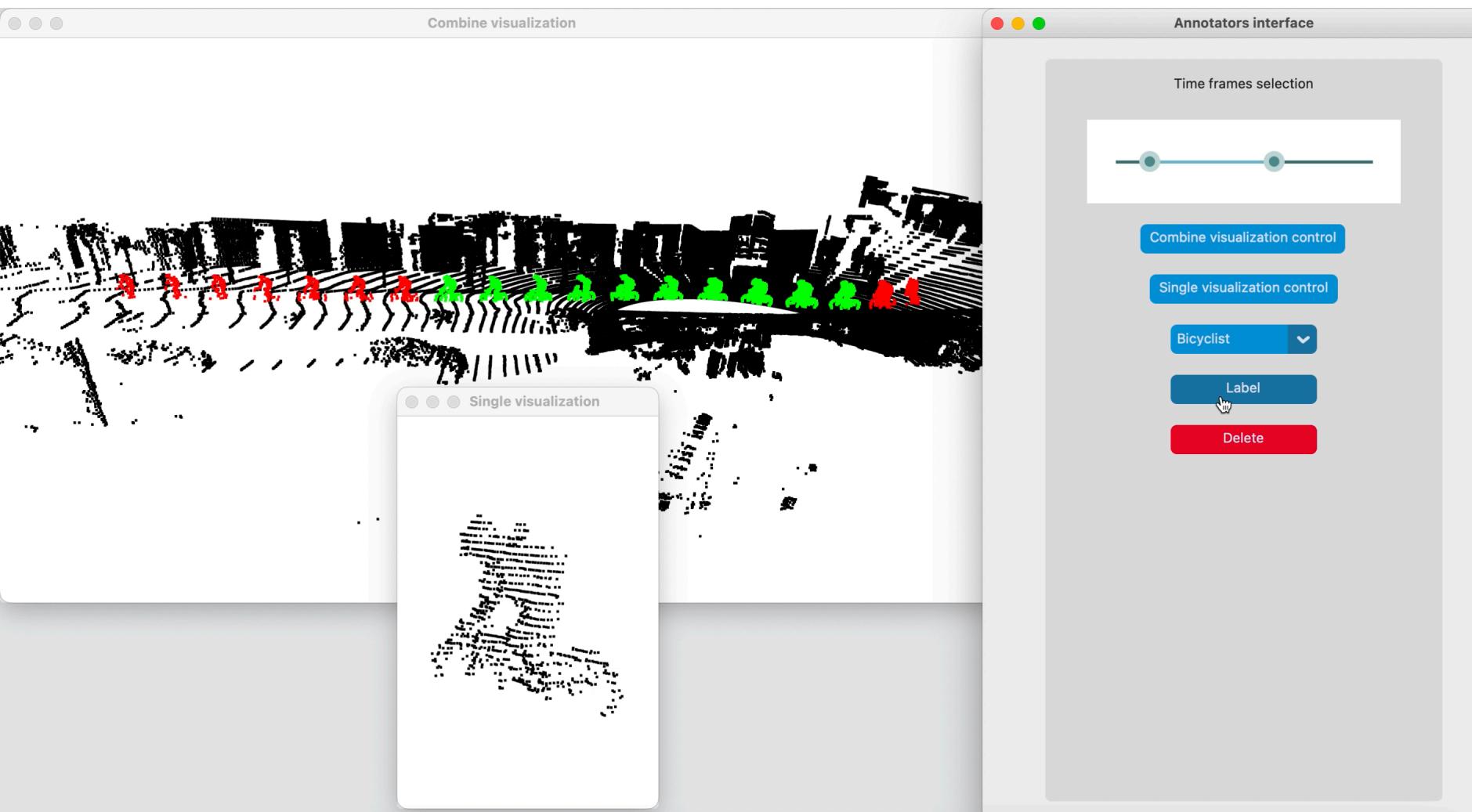
# Annotator user interface



# Annotator user interface



# Annotator user interface



# Thank you for your attention