KIDELTA LEARNING
Scalable AI for Automated Driving

Final Event | March 10, 2023

Simulation of a pulsed LiDAR

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Generation of synthetic data with Carla

3D Szenario
- Road Network
- Static Objects
- Dynamic Ojects
- Lightsources
- Weather

Traffic Simulation

Renderer/ Raytracer

RGB Image
Depth Image
Semantic Segmentation Image

Postprocessing
- Generate Range Images

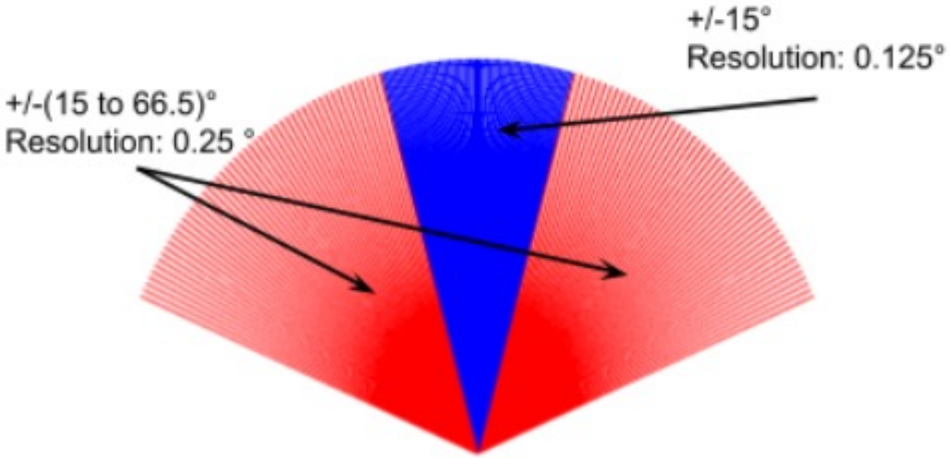
LiDAR Sensor model
- Simulate laser pulse
- Simulate beam divergence

Synthetic Pointcloud / Ground Truth

Applications/Algorithms
DNN Training
Object Tracking

The Valeo Mobility Kit LiDAR

- Rotating mirror
- Horizontal FoV 133°
- Vertically 16 APDs arranged in 4 groups
- Complex vertical scanpattern due to tilted mirror
- Wavelength 905nm

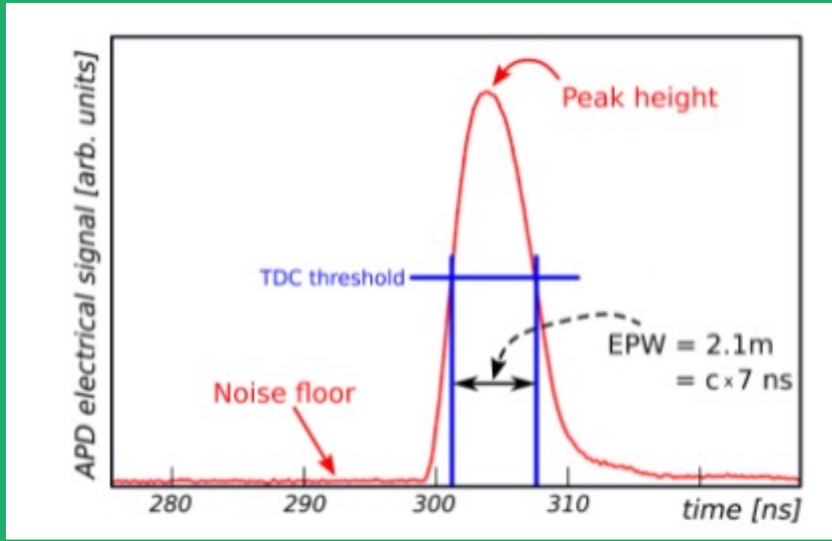


Region of Interest between -15° and 15°

The Valeo Mobility Kit LiDAR - Output

- Output
  - Range
  - Echo pulse width
  - Polar angle
  - Azimuthal angle

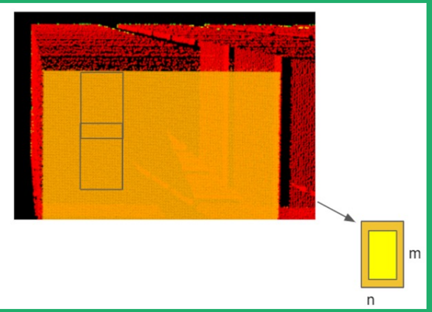
- Calculation of echo pulse width / Walk error compensation



Sensor Model

Beam expansion achieved through upsampling

Multiple channels per APD



Input:

- Range
- Intensity

for each channel

Blooming

Horizontal blooming profile

$$B_h(j) = A_h e^{-\frac{\left(\frac{j-c_h}{h_h}\right)^2}{2\sigma_h^2}}, \quad j = 1, \ldots, n,$$

where c_h center, h_h halfwidth, A_h amplitude and σ_h standard deviation.
Vertical blooming profile

$$B_v(i) = A_v e^{-\frac{\left(\frac{j-c_v}{h_v}\right)^2}{2\sigma_v^2}}, \quad j = 1, \ldots, n,$$

where c_v center, h_v halfwidth, A_v amplitude and σ_v standard deviation.
The blooming pofile is then modelled as

$$B(i,j) = B_v(i)B_h(j), j = 1, \ldots, n, i = 1, \ldots m.$$

Sensitivity

Horizontal sensitivity profile:

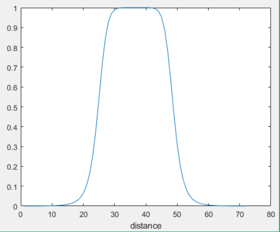
$$S_h(j) = \frac{1}{1 + \left(\frac{j-c_h}{h_h}\right)^{s_h}}, \quad j = 1, \ldots, n,$$

where c_h center, h_h halfwidt and s_h sharpness.
Vertical sensitivity profile:

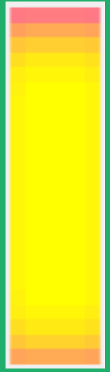
$$S_v(i) = \frac{1}{1 + \left(\frac{j-c_v}{h_v}\right)^{s_v}}, \quad i = 1, \ldots, m,$$

where c_v center, h_v halfwidt and s_v sharpness.
The sensitivity profile of the APD is than modelled as

$$S(i,j) = S_h(j)S_v(i), \quad i = 1, \ldots, n, j = 1, \ldots, m.$$

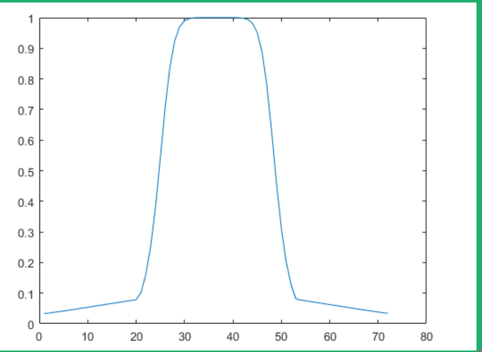


Vertical sensitivity profile



Sensitivity profile as heatmap

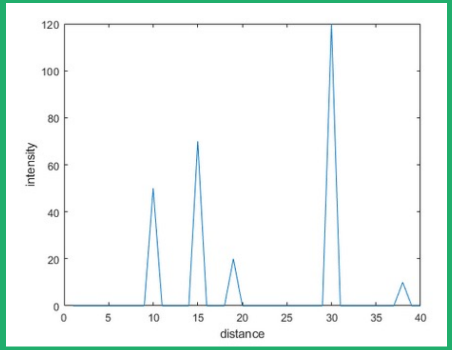
Multiplication yields full profile



Resulting intensity at channel is calculated as the product of the sensitivity profiles and the intensities

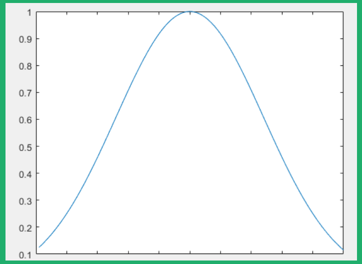
Sensor Model

- mxn distance/intensity pairs per cell resp. APD



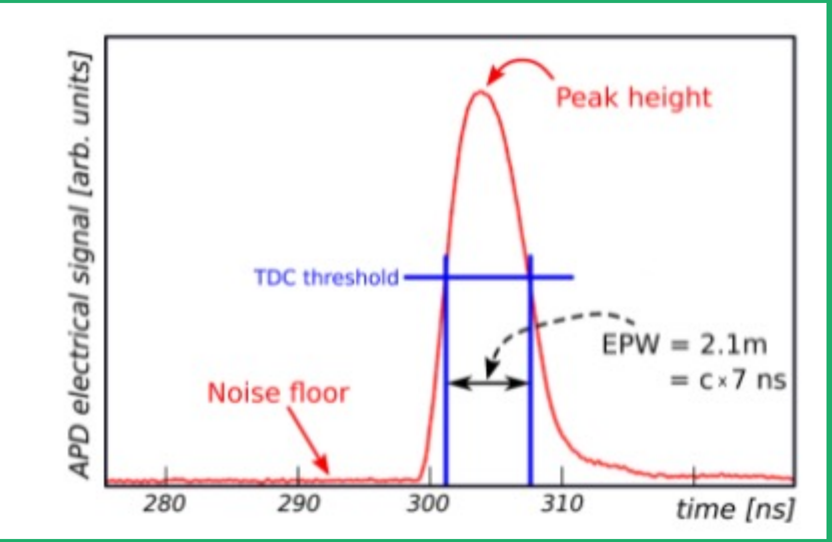
- The shape of the laser pulse is modelled as a superGaussian function of the type

$$f(x) = Ae^{\left(-\left(\frac{(x-x_0)^2}{2\sigma_x^2}\right)^P\right)}$$

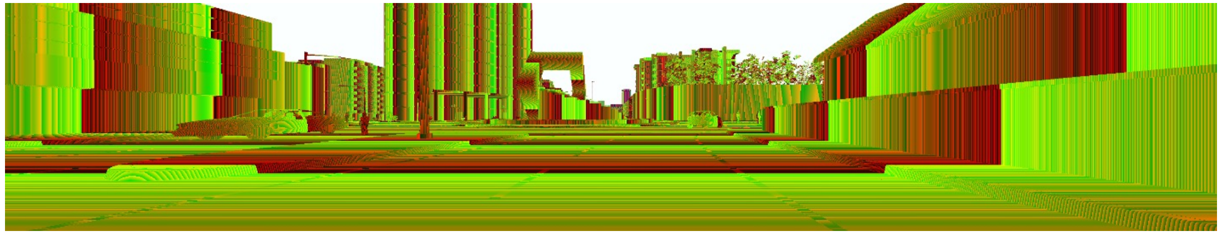


- Optical signal is convolution of distance/intensity-graph with pulse

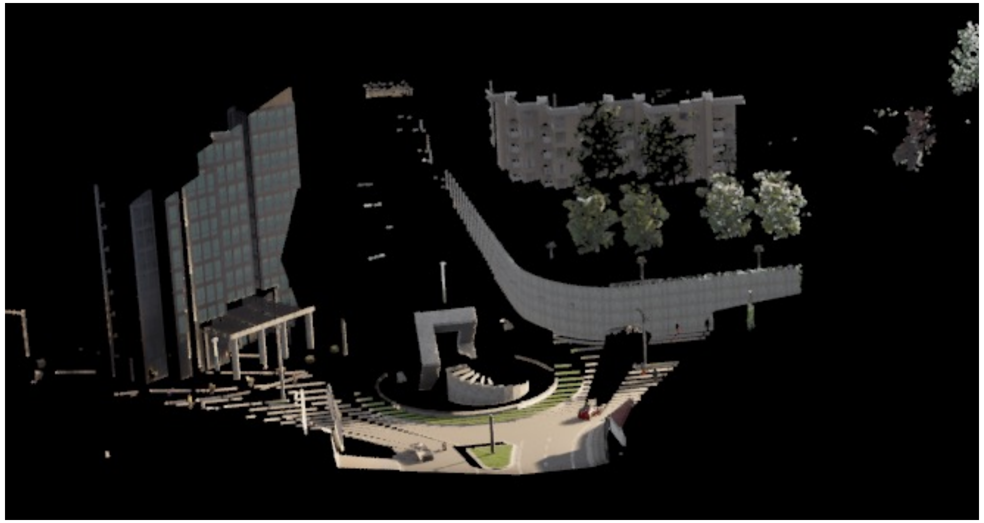
- Signal is thresholded to detect echoes
- Distance and echo pulse width are calculated as they are with the real sensor

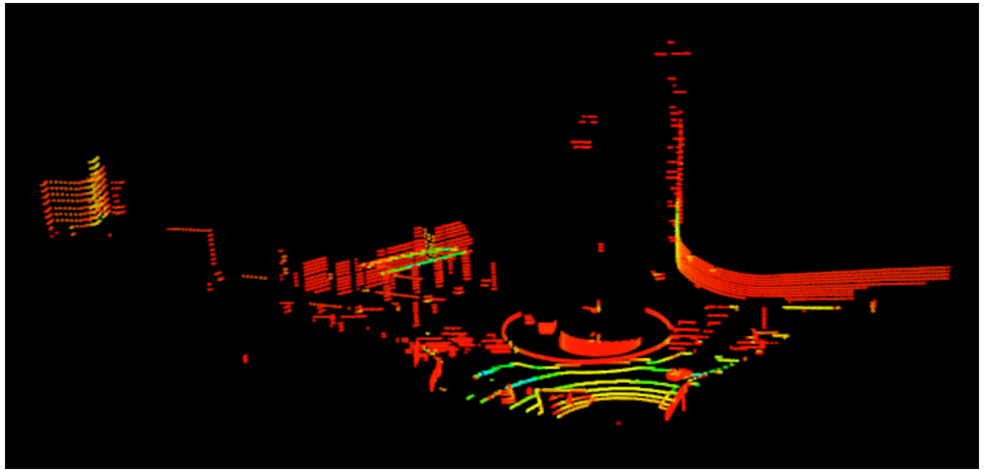


From Image to Pointcloud



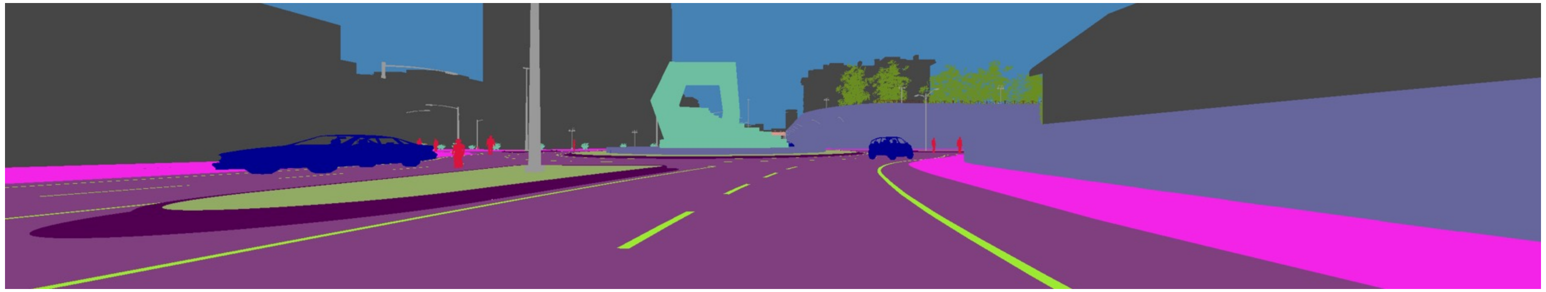
- From rgb and depth image calculate range image respectively pointcloud
- Use red channel as intensity
- Feed into sensor model

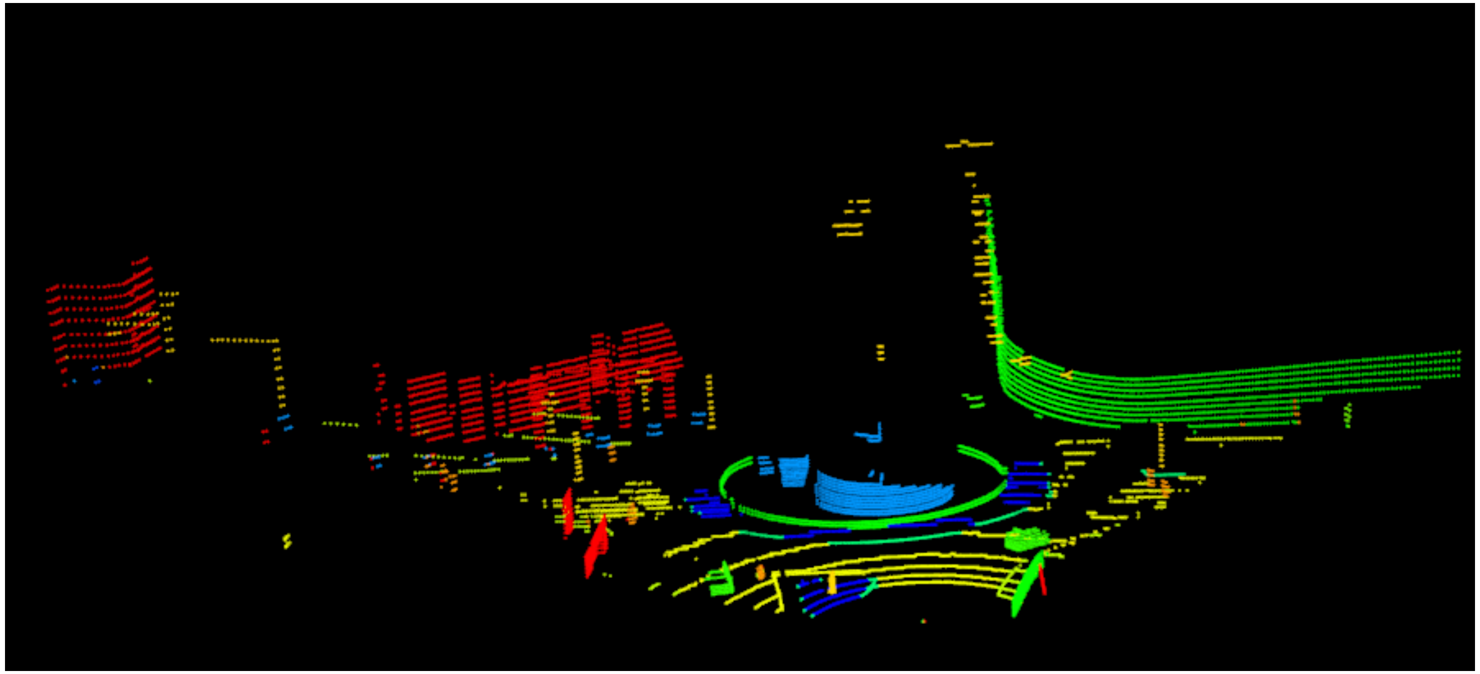




Semantic Segmentation

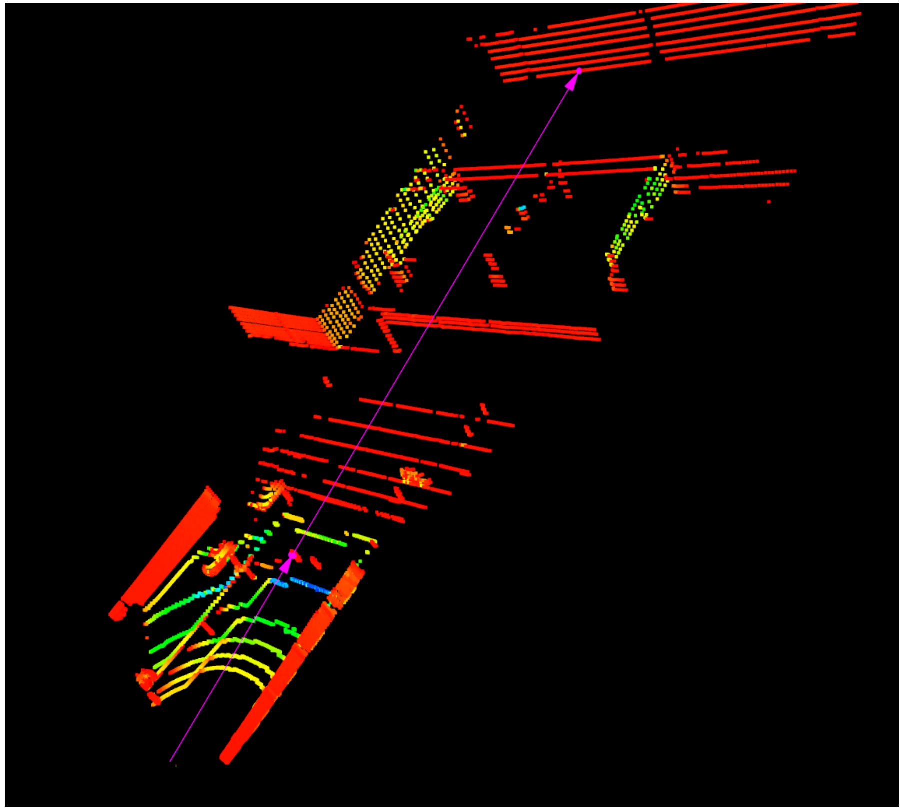
Also get semantic segmentation from Carla and feed it into the sensor model



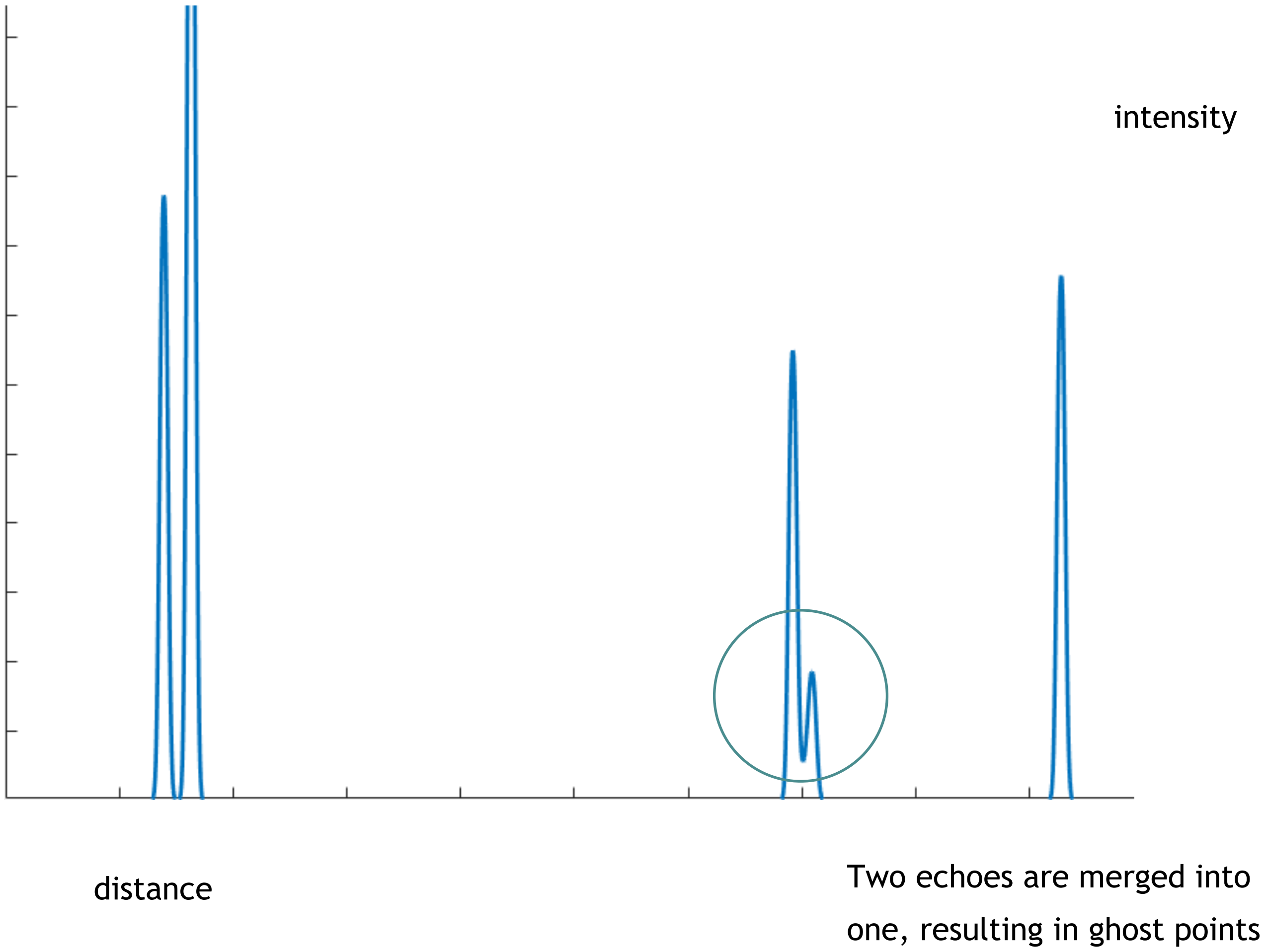


Evaluation - Multiple Echoes and ghost points

- Multiple echoes detectable

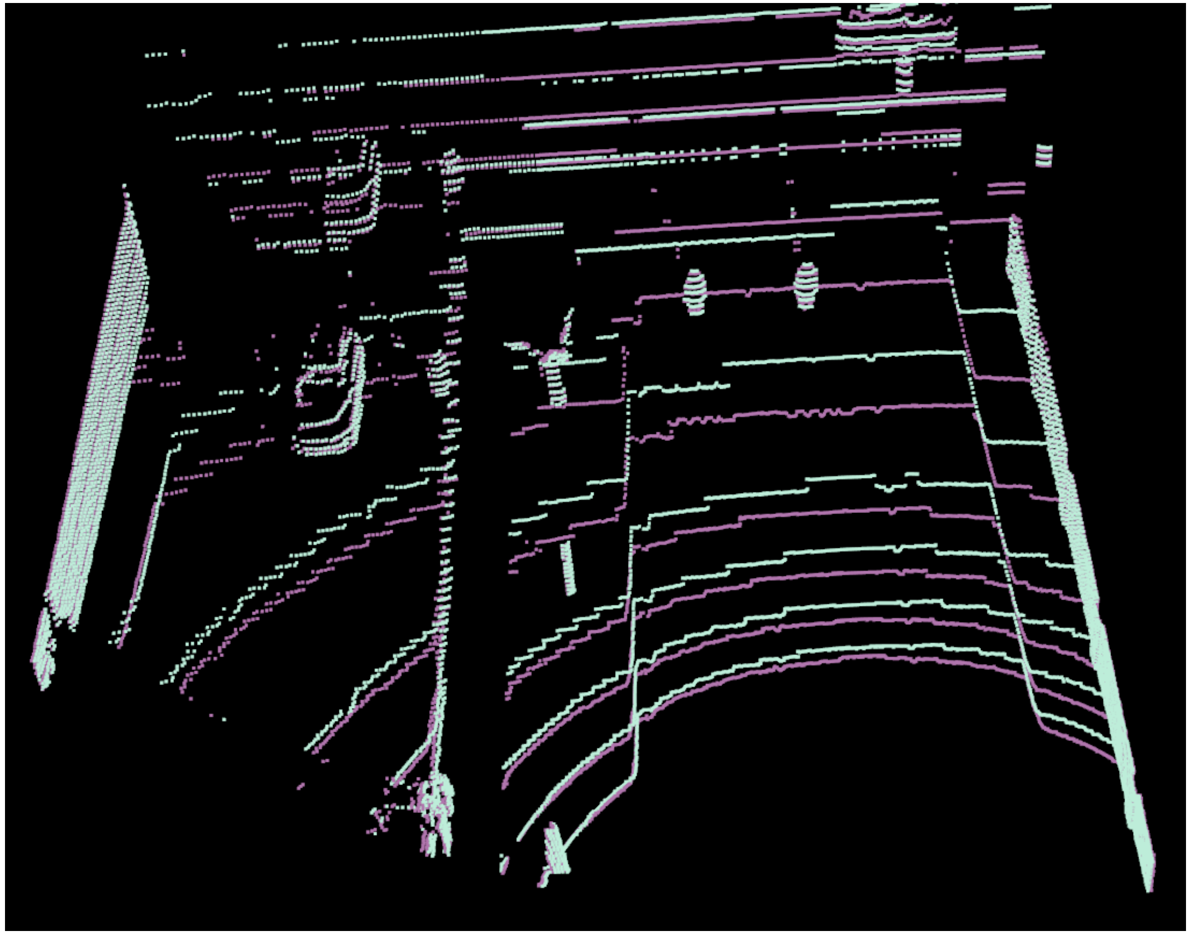


- Ghost points are simulated



Evaluation - Mirror Tilt

- Tilted Mirror



Pointcloud for two mirrorsides plotted in parallel

Dataset

- 7 Carla towns
- 200 frames per town
- Random spawnposition of ego vehicle
- Randomly spawned vehicles and pedestrians

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KI FAMILIE

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