



Fog Simulation on Real LiDAR Point Clouds for 3D Object Detection in Adverse Weather

Martin Hahner

Christos Sakaridis

Dengxin Dai

Luc van Gool

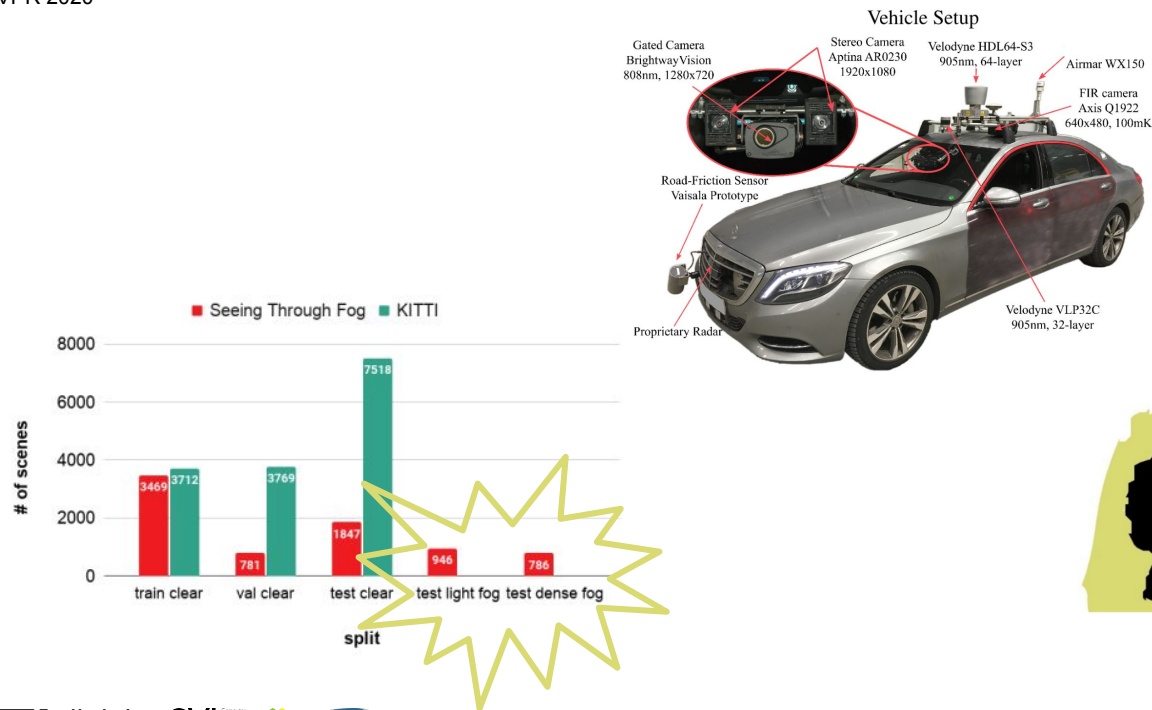


Challenges (1 / 2)

Not enough foggy LiDAR (training) data

Bijelic et al. - **Seeing Through Fog Without Seeing Fog (STF)**

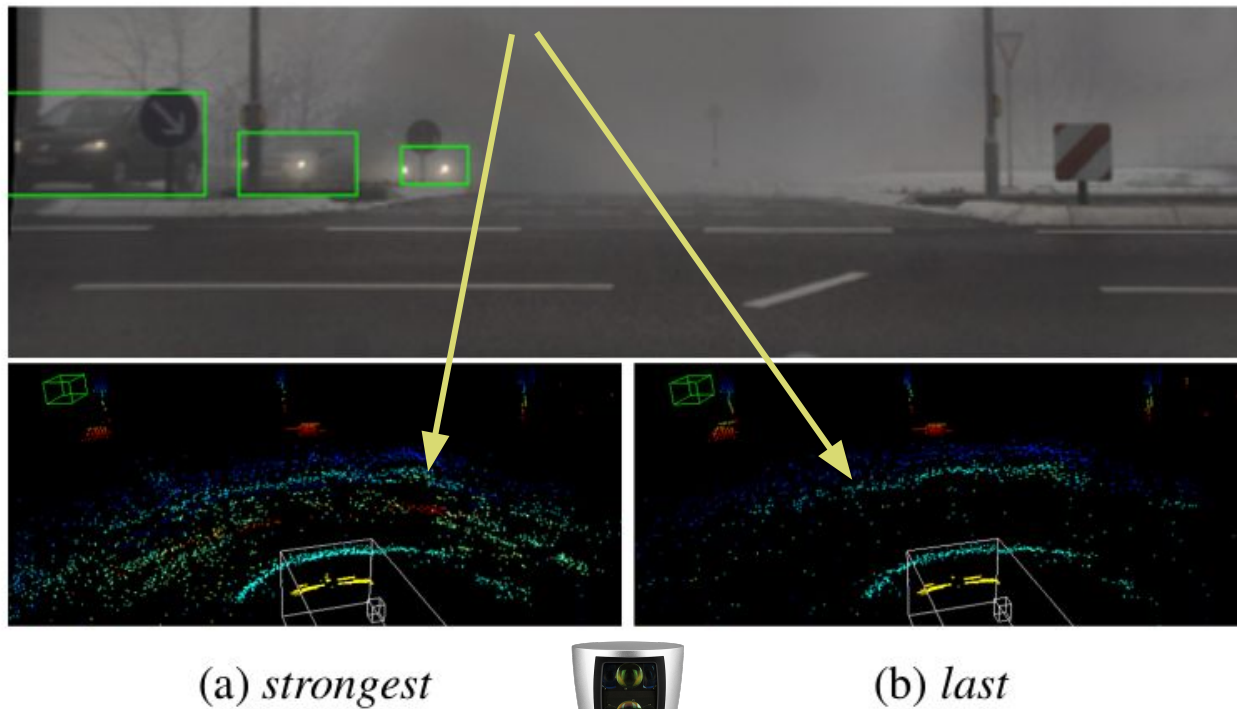
CVPR 2020



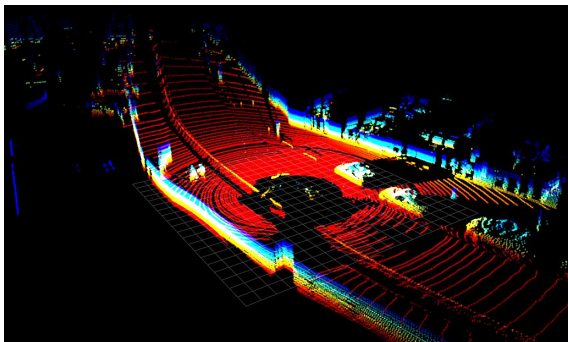
Geographical Sampling



Domain Shift: attenuation and backscatter in the LiDAR signal



Proposed Solution: Fog Simulation

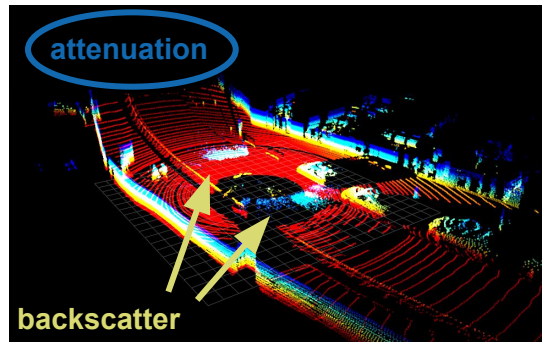


Algorithm 1 LiDAR fog simulation

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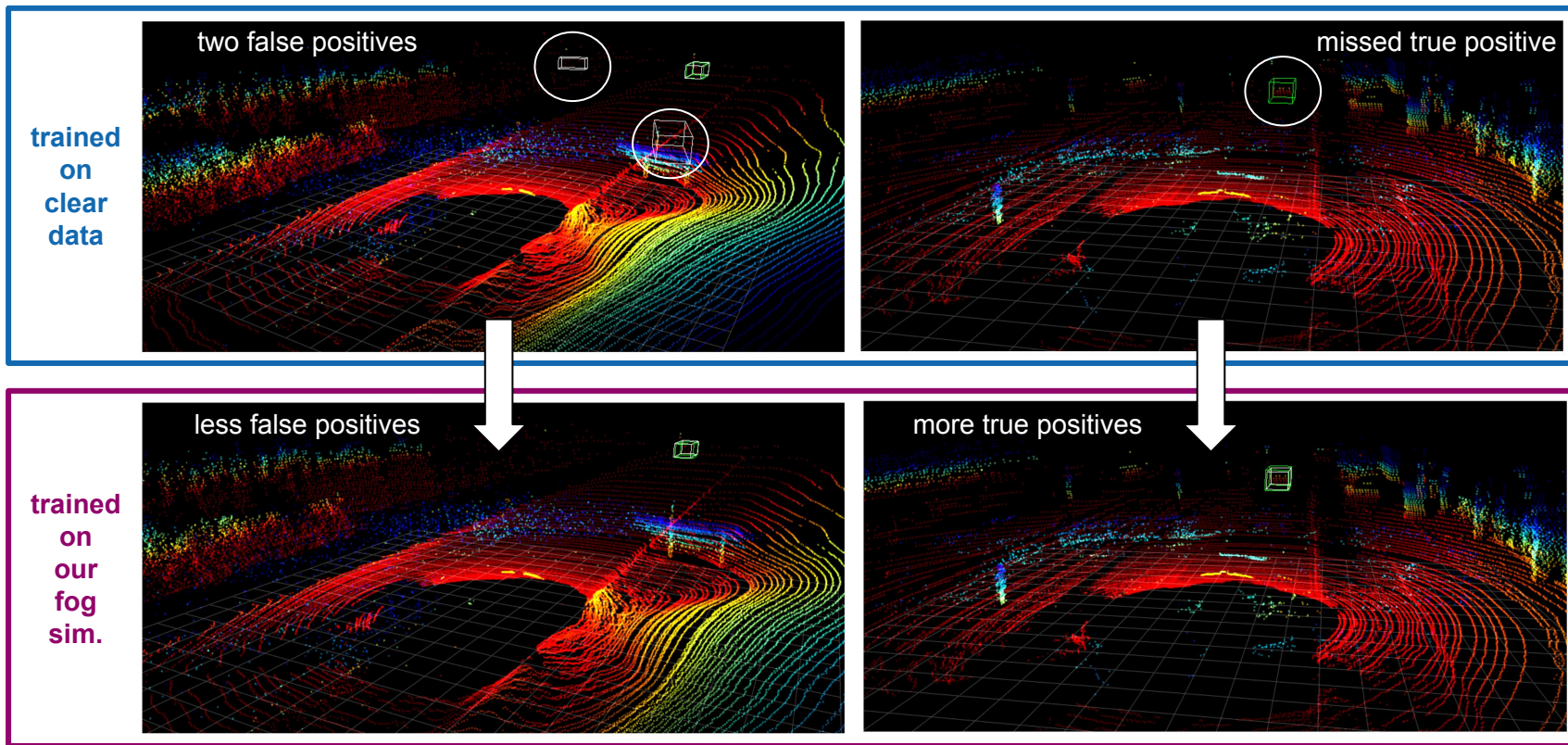
1: procedure FOGGIFY( $\mathbf{p}, i, \alpha, \beta, \beta_0, \tau_H$ )
2:    $R_0 \leftarrow \|\mathbf{p}\|$ 
3:    $x, y, z \leftarrow \mathbf{p}$   $\triangleright i = P_{R, \text{clear}}$ 
4:    $C_A P_0 \leftarrow i \frac{R_0^2}{\beta_0}$   $\triangleright$  follows from Eq. 12
5:    $i_{\text{hard}} \leftarrow i \times \exp(-2\alpha R_0)$   $\triangleright$  see Eq. 17
6:   for  $R$  in  $(0, 0.1, \dots, R_0)$  do  $\triangleright$  10cm accuracy
7:      $I_R \leftarrow \text{SIMPSON}(I(R, R_0, \alpha, \tau_H))$   $\triangleright$  see Eq. 18
8:   end for
9:    $i_{\text{imp}} \leftarrow \max(I_R)$ 
10:   $R_{\text{imp}} \leftarrow \arg \max(I_R)$ 
11:   $i_{\text{soft}} \leftarrow C_A P_0 \beta \times i_{\text{imp}}$   $\triangleright$  see again Eq. 18
12:  if  $i_{\text{soft}} > i_{\text{hard}}$  then
13:     $s \leftarrow \frac{R_{\text{imp}}}{R_0}$   $\triangleright$  scaling factor  $s$ 
14:     $p \leftarrow \text{RANDOM.UNIFORM.FLOAT}(-1, 1)$ 
15:     $n \leftarrow 2^p$   $\triangleright$  noise factor  $n \in (\frac{1}{2}, 2)$ 
16:     $x \leftarrow s \times n \times x$ 
17:     $y \leftarrow s \times n \times y$ 
18:     $z \leftarrow s \times n \times z$ 
19:     $i \leftarrow i_{\text{soft}}$ 
20:  else  $\triangleright$  keep original location
21:     $i \leftarrow i_{\text{hard}}$   $\triangleright$  only modify intensity
22:  end if
23:  return  $x, y, z, i$ 
24: end procedure

```



3D Object Detection in real-world clear weather / dense fog					
mod. Car AP@.5IoU	PointPillars	Part-A ²	SECOND	PointRCNN	PV-RCNN
trained on clear scenes	74.64 35.23	73.79 38.15	75.20 42.99	76.52 45.03	77.05 46.00
trained on our simulation	74.56 39.14	73.86 42.75	75.95 44.01	76.58 47.99	76.75 47.38
Δ	-0.08 +3.91	+0.07 +4.60	+0.75 +1.02	+0.06 +2.96	-0.30 +1.38

Qualitative Results



Martin Hahner

PhD Candidate

martin.hahner@vision.ee.ethz.ch

ETH Zurich

Computer Vision Lab

ETF C 115

Sternwartstrasse 7

8092 Zurich, Switzerland

www.vision.ee.ethz.ch | www.trace.ethz.ch

Paper, Code, Slides, Video,
and Supplementary Materials

