# SEMANTIC UNDERSTANDING OF FOGGY SCENES WITH PURELY SYNTHETIC DATA

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## Abstract

This work addresses the problem of semantic scene understanding under foggy road conditions. We propose a novel method, which uses purely synthetic data to improve the performance on unseen real-world foggy scenes captured in the streets of Zurich and its surroundings. Our results highlight the potential and power of photorealistic synthetic images for training and especially fine-tuning deep neural nets.


## Contributions

- a purely synthetic, photorealistic, foggy dataset containing 25,000 unique outdoor scenes provided in five fog density levels => 125,000 images in total
- we show that with this data we outperform all previous methods on real-world, foggy data
- we show that a combination of purely synthetic and partially synthetic data can further improve the performance on real-world, foggy data


## References

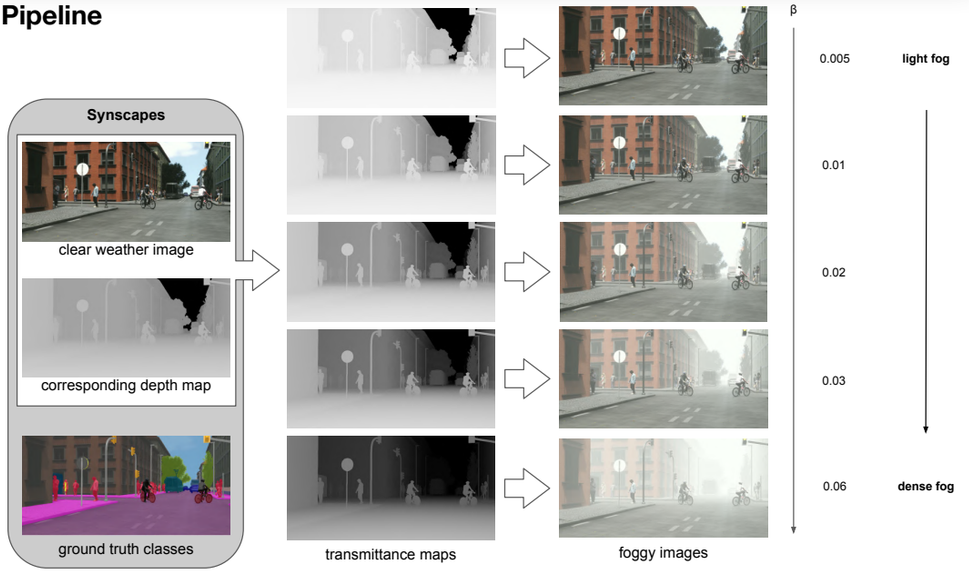
[1] M. Wrenninge and J. Unger, Synscapes: A photorealistic synthetic dataset for street scene parsing, in *CoRR*, 2018

[2] C. Sakaridis et al., Semantic Foggy Scene Understanding with Synthetic Data, in *IJCV*, 2018

[3] G. Lin et al., Refinenet: Multi-path refinement networks with identity mappings for high-resolution semantic segmentation, in *CVPR*, 2017

[4] C. Yu et al., BiSeNet: Bilateral Segmentation Network for Real-time Semantic Segmentation, in *ECCV*, 2018


## Pipeline




Our synthetic fog generation pipeline using the perfect depth information provided by *Synscapes* [1]

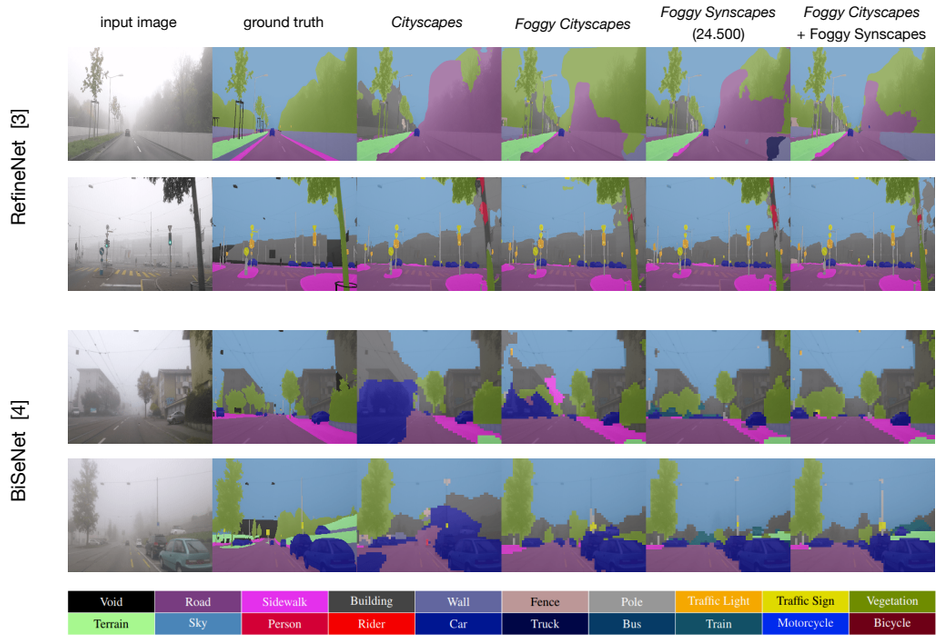
## Comparison



*Foggy Cityscapes* [2]



Our *Foggy Synscapes*




## Results

| Model | Training | Fine-Tuning (# of images) | road | sidewalk | building | wall | fence | pole | tr.light | tr.sign | vegetation | terrain | sky | person | rider | car | truck | bus | train | motorcycle | bicycle | **mean IoU** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RefineNet [3] | C | - | 90.1 | 29.3 | 68.3 | 27.3 | **16.7** | 41.3 | 54.2 | 59.6 | 68.0 | 6.8 | 88.7 | **60.9** | 45.4 | 66.4 | 5.5 | 9.6 | 45.4 | 9.8 | 48.4 | 44.3 |
| | C | FC (498) | 91.7 | 29.7 | 73.0 | **29.0** | 14.8 | 43.4 | 54.0 | **61.6** | 71.2 | 6.9 | 85.7 | 59.3 | 46.7 | 67.3 | 8.4 | 17.2 | 53.7 | 13.1 | 48.9 | 46.1 |
| | C | FS (24,500) | **92.4** | 32.9 | **76.1** | 16.8 | 14.6 | 43.3 | 55.0 | 60.8 | 74.0 | 9.3 | 90.8 | 49.8 | 36.0 | **72.2** | 17.5 | **51.3** | 65.0 | 11.1 | 50.3 | 48.4 |
| | C | FS (498) | 91.1 | **34.9** | 74.4 | 18.4 | 15.7 | 43.7 | **57.0** | 60.0 | 75.8 | 10.0 | **92.7** | 55.5 | **47.3** | 71.8 | **24.8** | 30.0 | 48.0 | **17.3** | **54.4** | 48.6 |
| | C | FC + FS (498) | **92.4** | 34.0 | **76.1** | 23.9 | 16.2 | **45.6** | 55.9 | **61.6** | **76.4** | **11.1** | 92.2 | 57.5 | 45.6 | 69.9 | 13.7 | 42.3 | **82.2** | 14.1 | 52.6 | **50.7** |
| BiSeNet [4] | C | - | 84.2 | 13.6 | **75.9** | 40.9 | **12.4** | 7.2 | 14.8 | 25.3 | 56.8 | 4.0 | 50.7 | 56.5 | 13.6 | 83.5 | 0.2 | 9.8 | 0.7 | 0.0 | 26.7 | 27.2 |
| | C | FC (498) | **90.4** | 18.1 | 67.3 | 36.3 | 6.4 | 10.2 | 26.9 | 23.2 | **72.1** | 1.4 | 66.9 | 47.4 | 11.4 | **84.4** | 0.1 | 13.2 | 4.5 | 0.0 | 11.8 | 30.3 |
| | C | FS (24,500) | 75.0 | 15.7 | 64.5 | 30.7 | 8.7 | 24.6 | 27.3 | 34.7 | 50.0 | 12.6 | 88.8 | 56.4 | 33.3 | 74.2 | 8.0 | 40.8 | **35.6** | 0.0 | 30.3 | 30.9 |
| | C | FS (498) | 76.5 | 14.9 | 62.4 | 30.1 | 10.2 | **28.8** | 34.4 | 40.6 | 57.0 | 4.4 | **92.6** | **61.7** | **48.6** | 77.0 | **9.3** | 58.6 | 13.2 | 0.0 | 29.0 | 31.8 |
| | C | FC + FS (498) | 79.0 | **19.0** | 67.0 | **55.9** | 12.3 | 27.1 | **36.6** | **41.1** | 59.9 | **18.4** | 83.9 | 60.4 | 33.8 | 83.6 | 6.1 | **73.3** | 16.1 | 0.0 | **40.0** | **35.2** |

Test results on *Foggy Driving* [2]


## Acknowledgements

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