Adaptive Multi-Modal Cross-Entropy Loss for Stereo Matching

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Motivation

- Stereo matching networks poorly estimate clear edges due to the over-smoothing problem, causing **bleeding artifacts** in reconstructed point clouds.

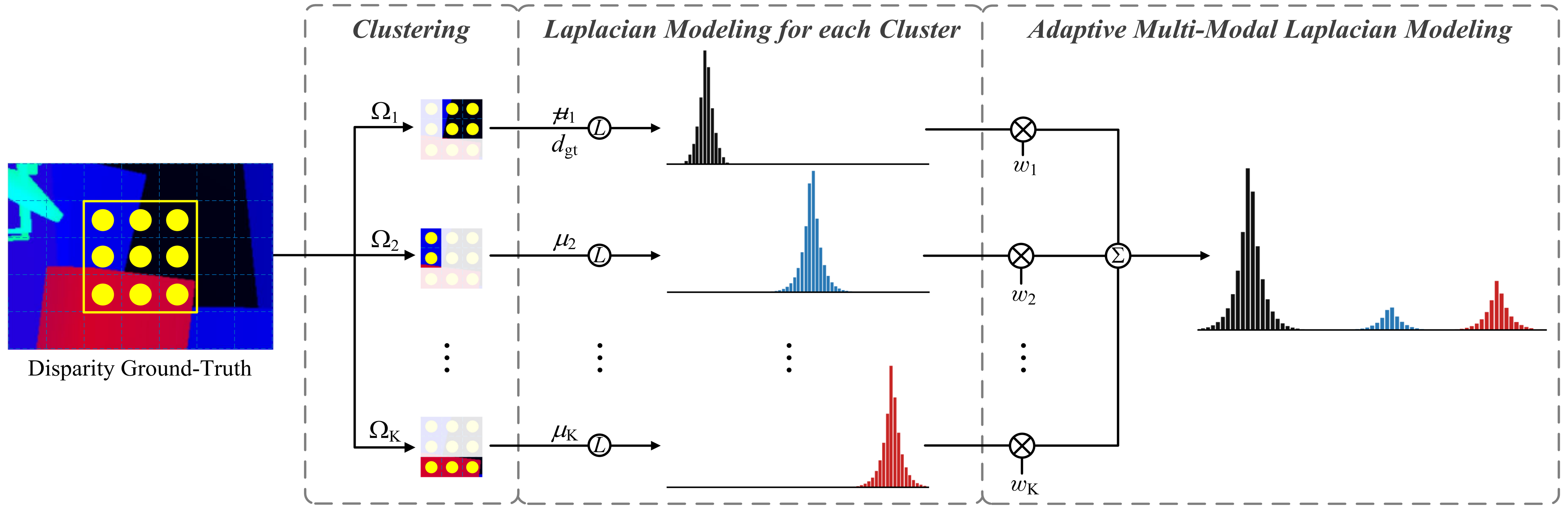
- Existing methods model the disparity ground-truth as the uni-modal distribution, but fail to suppress the multi-modal outputs at the edge. Meanwhile, the single-modal disparity estimator (SME) suffers from severe **misalignment artifacts**.

- Our work aims to explore a better modeling for the stereo ground-truth and improve the robustness of the disparity estimator.

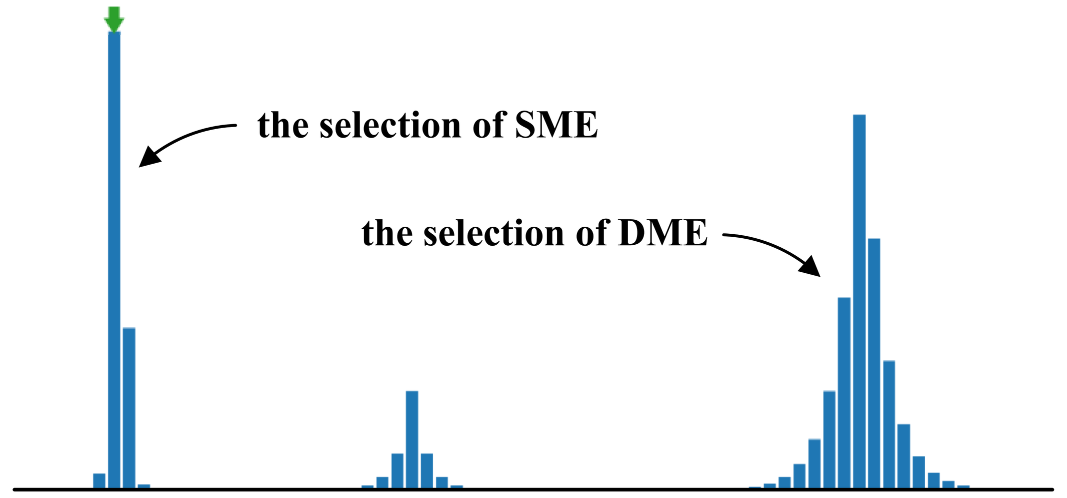
Contributions

- **An adaptive multi-modal probability modeling** for supervising stereo networks training, effectively guiding the networks to learn clear distribution patterns.
- **A dominant-modal disparity estimator** (DME) that can obtain accurate results upon multi-modal outputs.
- **State-of-the-art performance** on both the KITTI 2015 and KITTI 2012 benchmarks.
- **Excellent cross-domain generalization performance.**

Our Method



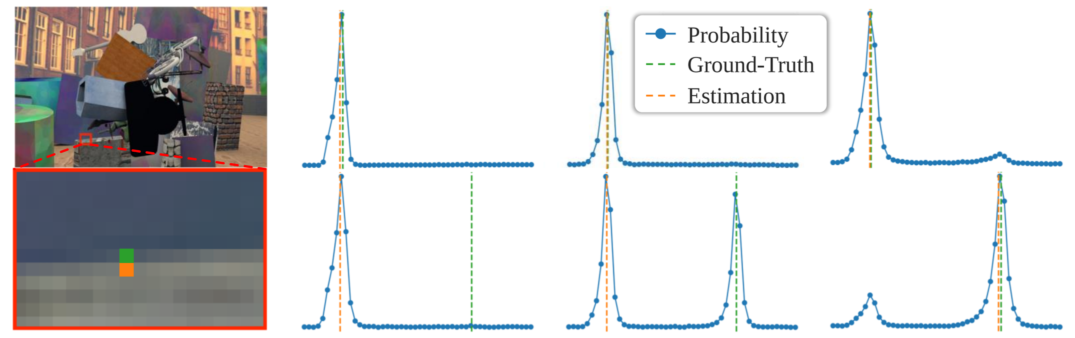
- Clustering is applied within the local window to separate different modals.
- Laplacian distribution is then employed for modeling each cluster.
- Local structural information is used to fuse the generated uni-modal distributions.



The output probability distribution

- we propose a dominant-modal disparity estimator (DME) to better tackle the difficulties brought by the multi-modal outputs from the network.

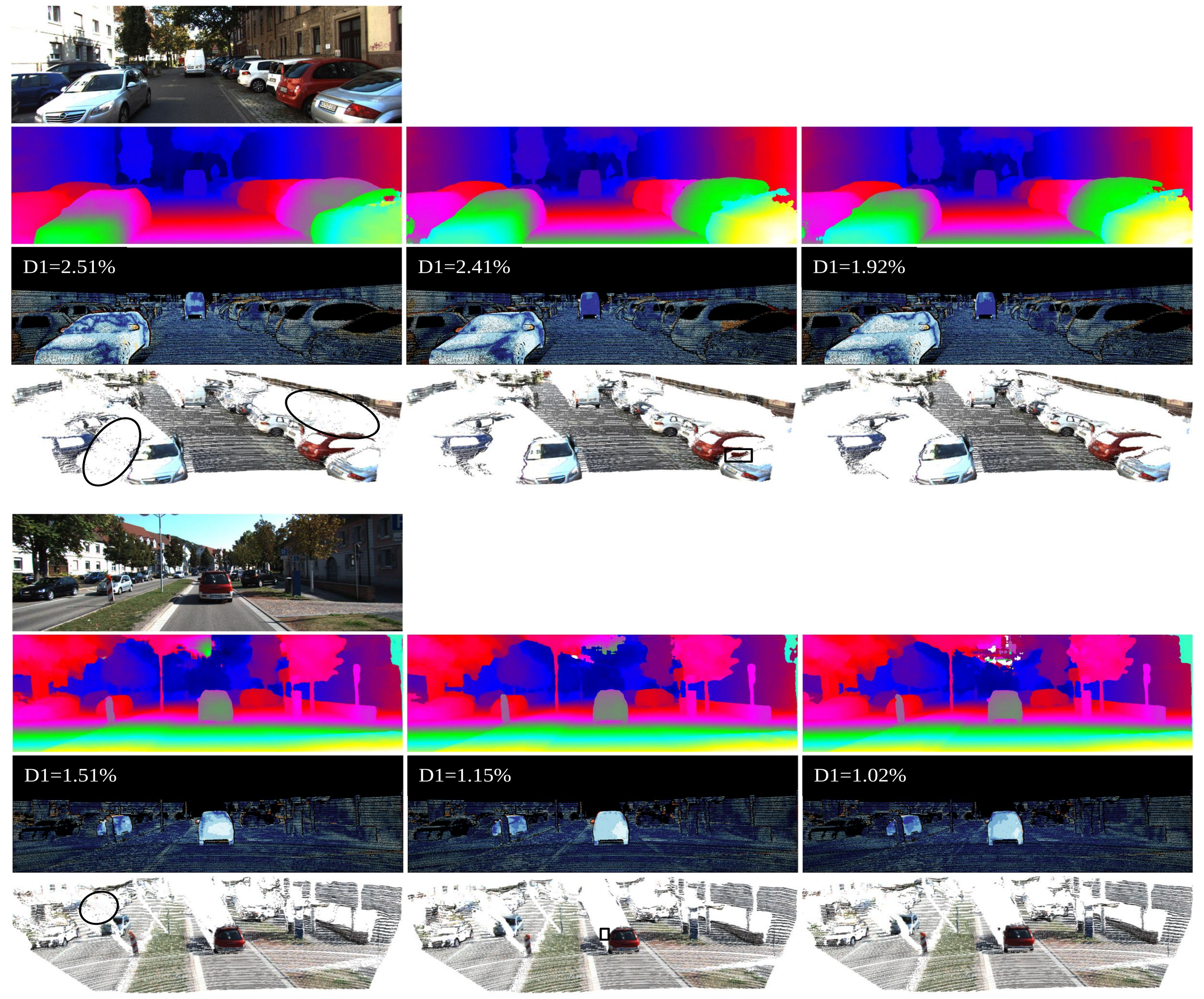
Vis. of Output Distributions



Left image PSMNet [1] PSMNet+[2] PSMNet+Ours

- Top row: background pixel
- Bottom row: foreground pixel

Qualitative Results



PSMNet [1] PSMNet+[2] PSMNet+Ours

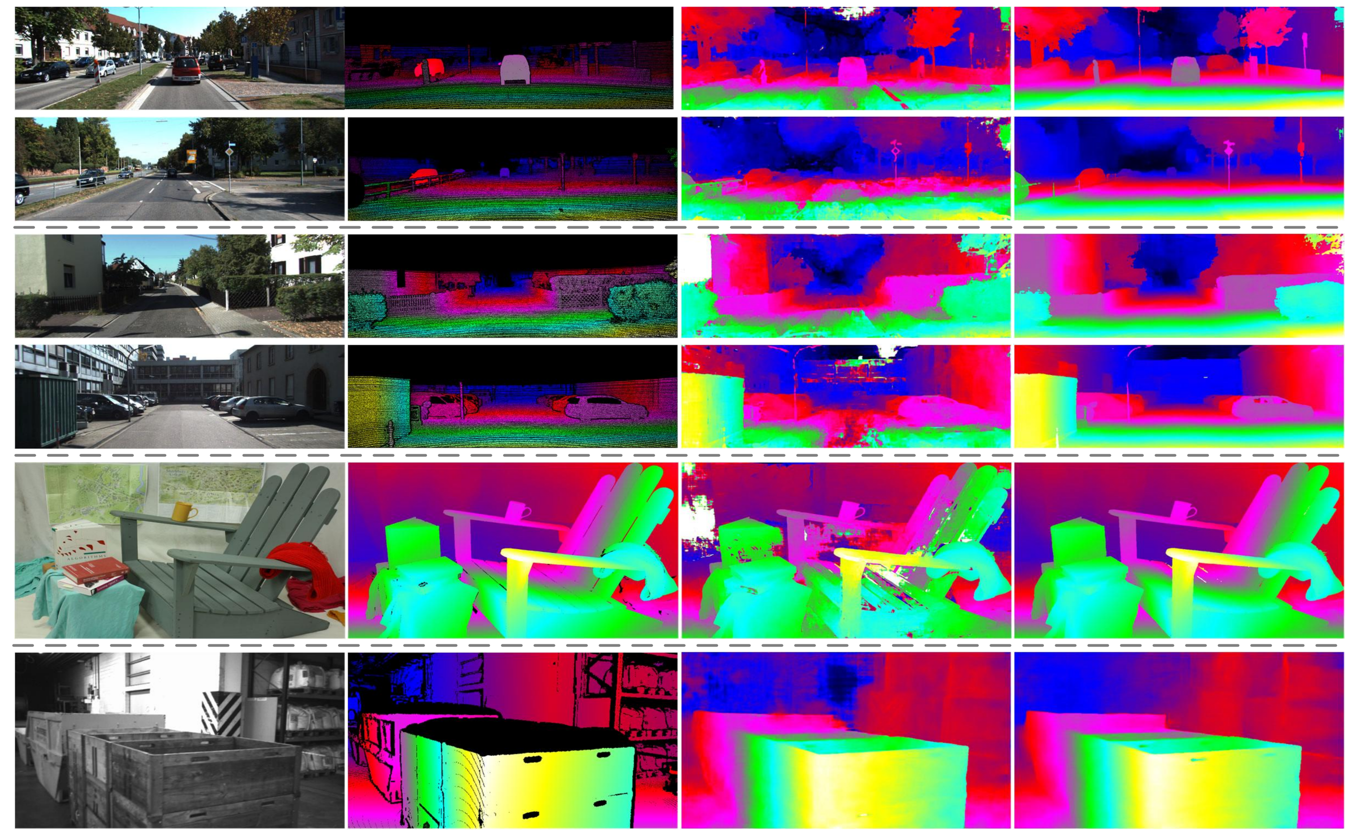
- From top to bottom: left images, disparity maps, error maps, and reconstructed point clouds.

Quantitative Results

Method	KITTI 2015						KITTI 2012			
	All			Noc			>2px		>3px	
	D1-bg	D1-fg	D1-all	D1-bg	D1-fg	D1-all	Out-Noc	Out-All	Out-Noc	Out-All
PDSNet	2.29	4.05	2.58	2.09	3.68	2.36	3.82	4.65	1.92	2.53
PSMNet	1.86	4.62	2.32	1.71	4.31	2.14	2.44	3.01	1.49	1.89
PSMNet + [2]	1.54	4.33	2.14	1.70	3.90	1.93	2.17	2.81	1.35	1.81
GwcNet	1.74	3.93	2.11	1.61	3.49	1.92	2.16	2.71	1.32	1.70
PSMNet+SMDNet	1.69	4.01	2.08	1.54	3.70	1.89	—	—	—	—
CDN	1.66	3.20	1.92	1.50	2.79	1.72	—	—	—	—
AcfNet	1.51	3.80	1.89	1.43	3.25	1.73	1.83	2.35	1.17	1.54
GANet	1.48	3.46	1.81	1.34	3.11	1.63	1.89	2.50	1.19	1.60
GANet + LaC	1.44	2.83	1.67	1.26	2.64	1.49	1.72	2.26	1.05	1.42
ACVNet	**1.37**	3.07	1.65	1.26	2.84	1.52	1.83	2.34	1.13	1.47
LEAStereo	1.40	2.91	1.65	1.29	2.65	1.51	1.90	2.39	1.13	1.45
IGEVStereo	1.38	2.67	1.59	1.27	2.62	1.49	1.71	2.17	1.12	1.44
CroCoStereo	1.38	2.65	1.59	1.30	2.56	1.51	—	—	—	—
PSMNet + Ours	1.44	3.25	1.74	1.30	3.04	1.59	1.80	2.32	1.14	1.50
GwcNet + Ours	1.42	3.01	1.68	1.30	2.76	1.54	1.65	2.17	1.05	1.42
GANet + Ours	1.38	**2.38**	**1.55**	**1.24**	**2.18**	**1.40**	**1.52**	**2.01**	**0.98**	**1.29**

- All of the three baselines are lifted to a highly competitive level by our method.
- GANet with our method achieves new state-of-the-art results on both KITTI 2015 and KITTI 2012 benchmarks.

Generalization Performance



Left images Ground-Truth PSMNet [1] PSMNet+Ours

- From top to bottom: KITTI 2015, KITTI 2012, Middlebury, and ETH3D.

Links

paper

demo

References

[1] Chang and Chen. Pyramid stereo matching network. CVPR 2018.
[2] Chen, Chen, and Cheng. On the over-smoothing problem of cnn based disparity estimation. ICCV 2019.