High-quality Point Cloud Oriented Normal Estimation via Hybrid Angular and Euclidean Distance Encoding

Supplementary Material

In this material, we provide more qualitative comparison examples, and ablation study on ScanNet dataset as supplements to our main paper. Besides, we also evaluate the robustness of our method on different distances between virtual scanners and objects.

1. Additional comparisons

We compare our method with state-of-the-art normal estimation methods for point clouds, including PCA [3], N-jet [1], Graphfit [5], Du *et al.* [2], SHS-Net [6], and CMG-Net [7]. For the unoriented normal estimation methods (PCA, N-jet, GraphFit, Du *et al.*, and CMG-Net), we orient the normal results for a fair comparison. Specifically, we compute the dot product between each point normal and the corresponding ray, inverting the normal if the dot product is positive.

Fig. 1 and Fig. 2 display the qualitative comparison results of oriented normal estimation. We show the angle error via a heatmap, transitioning from blue (0°) to red (60°) to highlight error magnitude. To show the comparison more clearly, red denotes all angles which larger than (60°). It can be seen that the competitors may not obtain accurate normals in complex regions (wings of the 'Gargoyle' in Fig. 1) and sharp features (edges of the sofa in Fig. 2). In particular, our method performs better than the state-of-the-art techniques on noisy data. To visualize the quality of normals, we also display Poisson reconstruction [4] results of these point clouds with predicted normals.

2. Ablation studies on ScanNet dataset

Table 3 lists the ablation studies on ScanNet dataset (Results on FamousShape dataset has been listed in the main paper), including the angular distance encoding module, the ray feature fusion module, the $\mathcal{L}_{sin}$, and the $\mathcal{L}_{mse}$. The results in Table 3 demonstrate the contributions of these modules in enhancing the overall performance of our method.

3. Robustness on scanning distances

To further evaluate the robustness of our method, we use different distances between virtual scanners and objects to generate data. The statistics are listed in Tables 1 and 2. Note that the ScanNet dataset is captured by real-scanning, so their dataset naturally contains various scanning distances. So we conduct this experiment on the FamousShape dataset. The Tables 1 and 2 show that nearer or further distances would not hinder the performance of our method.

	Unoriented normals				
	None	Low level	Mid level	High level	Average
2.5m	8.62	11.78	19.51	26.79	16.67
5m	8.80	11.99	19.69	26.84	16.83
10m	8.86	12.13	19.83	26.86	16.92

Table 1. Results of different scanning distances on the FamousShape dataset using the modified RMSE metric (Unoriented normals).

	Oriented normals				
	None	Low level	Mid level	High level	Average
2.5m	9.46	13.54	23.80	33.17	19.99
5m	9.69	13.71	24.23	33.29	20.23
10m	9.61	13.93	24.59	33.78	20.48

Table 2. Results of different scanning distances on the FamousShape dataset using the modified RMSE metric (Oriented normals).

References

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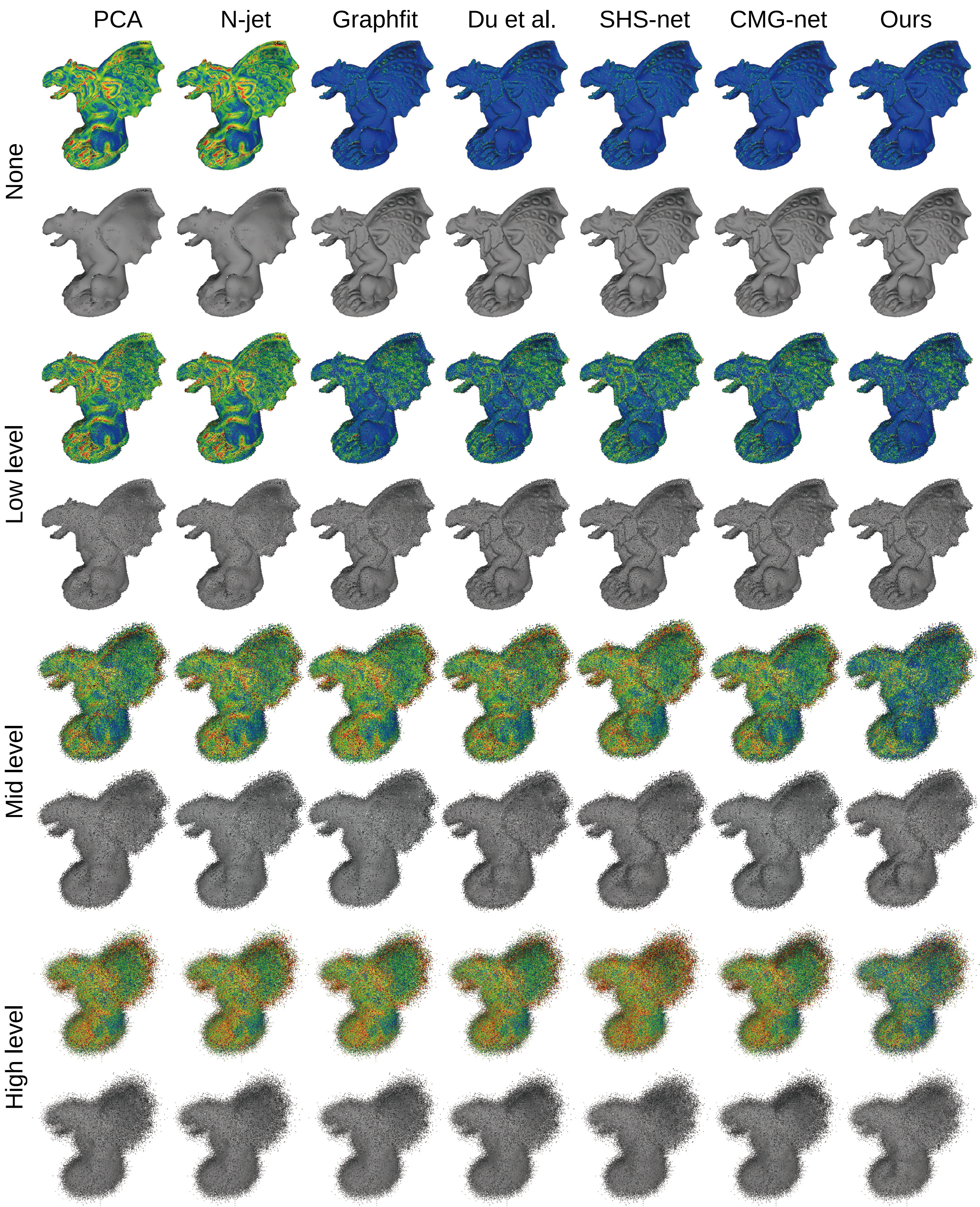

Figure 1. Qualitative comparison with SOTAs on the FamousShape dataset. Point-wise error and Poisson surface reconstruction are displayed. Angle error is visualized through a heatmap, transitioning from blue to red as errors increase from 0° to 60°.

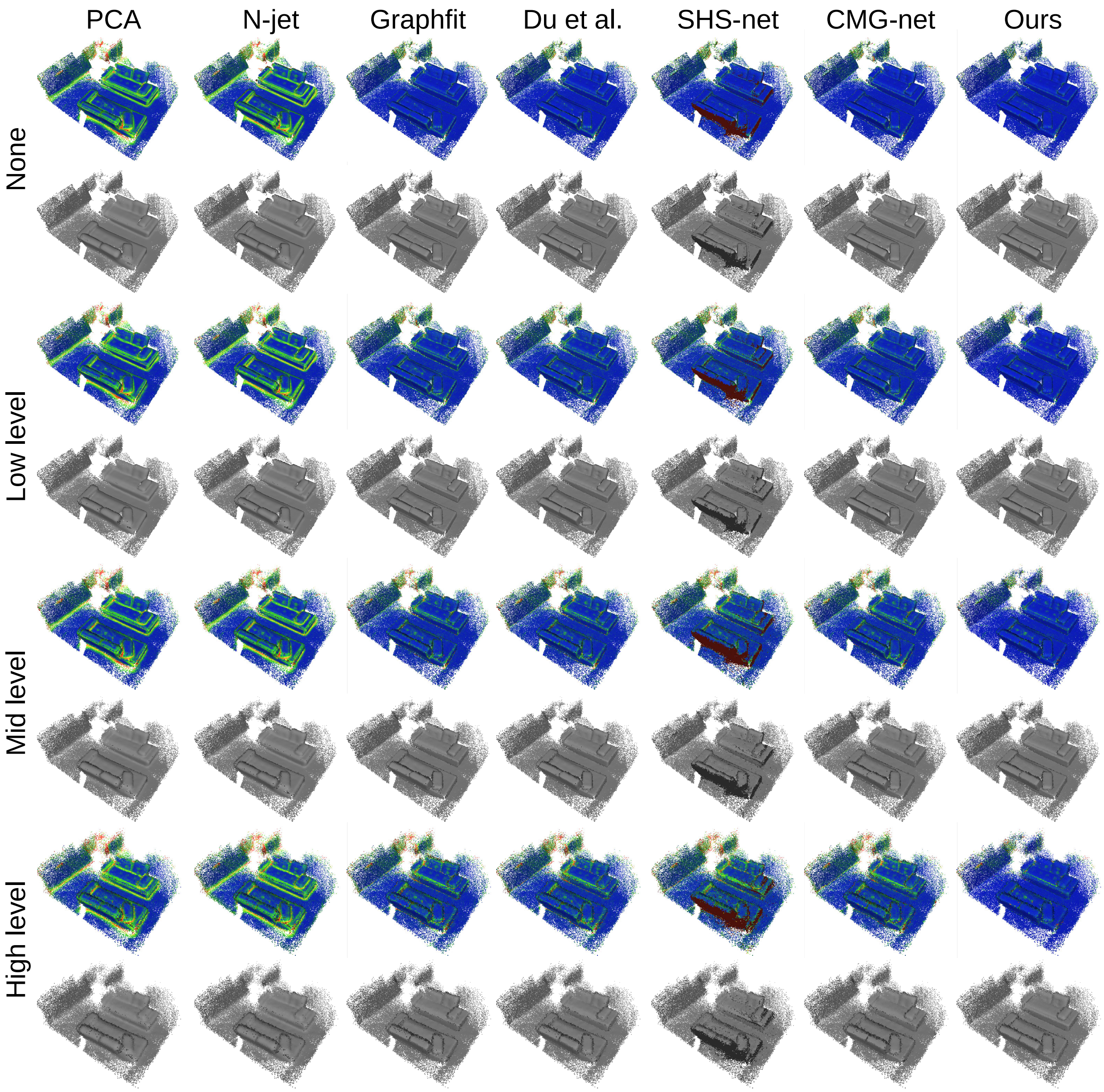

Figure 2. Qualitative comparison with SOTAs on the ScanNet dataset. Point-wise error and Poisson surface reconstruction are displayed. Angle error is visualized through a heatmap, transitioning from blue to red as errors increase from 0° to 60°.

	Unoriented normals					Oriented normals				
Noise level	None	Low level	Mid level	High level	Average	None	Low level	Mid level	High level	Average
w/o ang. dis. enc.	10.08	12.17	**15.04**	19.43	14.18	11.43	14.16	18.92	26.35	17.72
w/o ray feat. fus.	10.16	**12.07**	15.10	19.35	14.17	14.45	21.01	25.17	40.99	25.40
w/o $\mathcal{L}_{sin}$	10.65	12.61	15.75	19.71	14.68	11.80	14.47	19.59	26.04	17.98
w/o $\mathcal{L}_{mse}$	**10.07**	12.10	15.17	19.21	14.14	**11.40**	14.24	19.61	26.40	17.91
Ours	10.17	12.09	15.09	**19.15**	**14.12**	**11.40**	**13.89**	**18.60**	**25.41**	**17.32**

Table 3. Ablation study on ScanNet dataset using the modified RMSE metric. **Bold** values indicate the best estimator. Among them, "ang. dis. enc." denotes the angular distance encoding module, and "ray feat. fus." denotes the ray feature fusion module.