Physically-Grounded Turbulence Mitigation with Frame-Shared Degradation Parameters

Supplementary Material

6. Additional restoration results

Qualitative comparisons on the Open Turbulent Image Set (OTIS) [11] are provided in Figs. 10 and 11. Under weak turbulence conditions, TMFS achieves the best performance in most cases. These comparisons also reveal that supervised methods are observed to struggle under strong turbulence conditions. In contrast, the proposed TMFS maintains superior performance even in such challenging scenarios. Restoration results for full 1920×1080 images from [29] are shown in Fig. 12. These results further demonstrate that the results are completely free of splicing artifacts. The performance of TMFS remains effective and generalizes well to high-resolution images. Several methods are excluded from the high-resolution comparison due to the unavailability of their official code.

	Weak	Middle	Strong
D (m)	U(100,400)	U(400,800)	U(800,1500)
A (m)	U(0.001, 0.005)	U(0.04, 0.1)	U(0.1, 0.2)
D/r0	{0.5, 1, 1.5}	{1, 1.5, 2}	{1.5, 2, 3}

Table 3. This table summarizes the simulation parameters D(Distance), A(Apecture) and D/r0, used to generate turbulent data at different strength levels. U(a,b) denotes a uniform distribution over the interval (a,b), and {a,b,c} denotes a set from which a value is chosen uniformly at random.

7. Synthetic dataset

We synthesize turbulence data using the key parameters listed in Tab. 3. The turbulence strength is partitioned into three levels: weak, medium and strong following the convention in [33].

8. Additional performance comparison

The ablation study in paper submission demonstrates that with similar L0-sparse, our distortion mitigation module outperforms both CDSP and NDIR. Although methods without a deblurring module may yield poor visual results despite high metric scores, we compare their original blur outputs in the first section of Tab. 4. Two comparisons with similar SOTA blind deblurring methods, Restormer[31] and AdaIR[10], are presented in the second and third sections of Tab. 4. The results demonstrate that our distortion mitigation module achieves the best performance across all three cases.

Methods	Middle		Heat	
	PSNR↑	SSIM↑	PSNR↑	SSIM↑
w/o deblur NDIR	20.31	0.4642	20.29	0.6912
w/o deblur CDSP	18.91	0.4091	19.51	0.6116
w/o deblur TMFS	**22.01**	**0.5626**	**20.64**	**0.6974**
NDIR+Restormer	19.87	0.4564	20.05	0.6945
CDSP+Restormer	18.95	0.4128	19.47	0.6157
TMFS+Restormer	**22.22**	**0.5633**	**20.60**	**0.7033**
NDIR+AdaIR	19.26	0.4590	19.95	0.6893
CDSP+AdaIR	18.87	0.4132	19.52	0.6224
TMFS+AdaIR	**22.16**	**0.5662**	**20.26**	**0.6959**
w/o gradient loss	22.03	0.5444	20.06	0.7002
w/o lucky region	21.53	0.5262	19.58	0.6853
TMFS	**22.10**	**0.5786**	**20.17**	**0.7080**

Table 4. Additional performance comparison, structured from top to bottom as follows: (1) Comparison of the original method's output; (2) Comparison of outputs post-processed by Restormer; (3) Comparison of outputs post-processed by AdaIR; (4) Ablation study on the gradient loss and the lucky region loss.

To evaluate the contribution of the proposed regularization and loss terms, we conducted an ablation study, with the results detailed in the fourth section of Tab. 4. The performance degradation observed upon the removal of these components confirms their importance for the restoration effect.

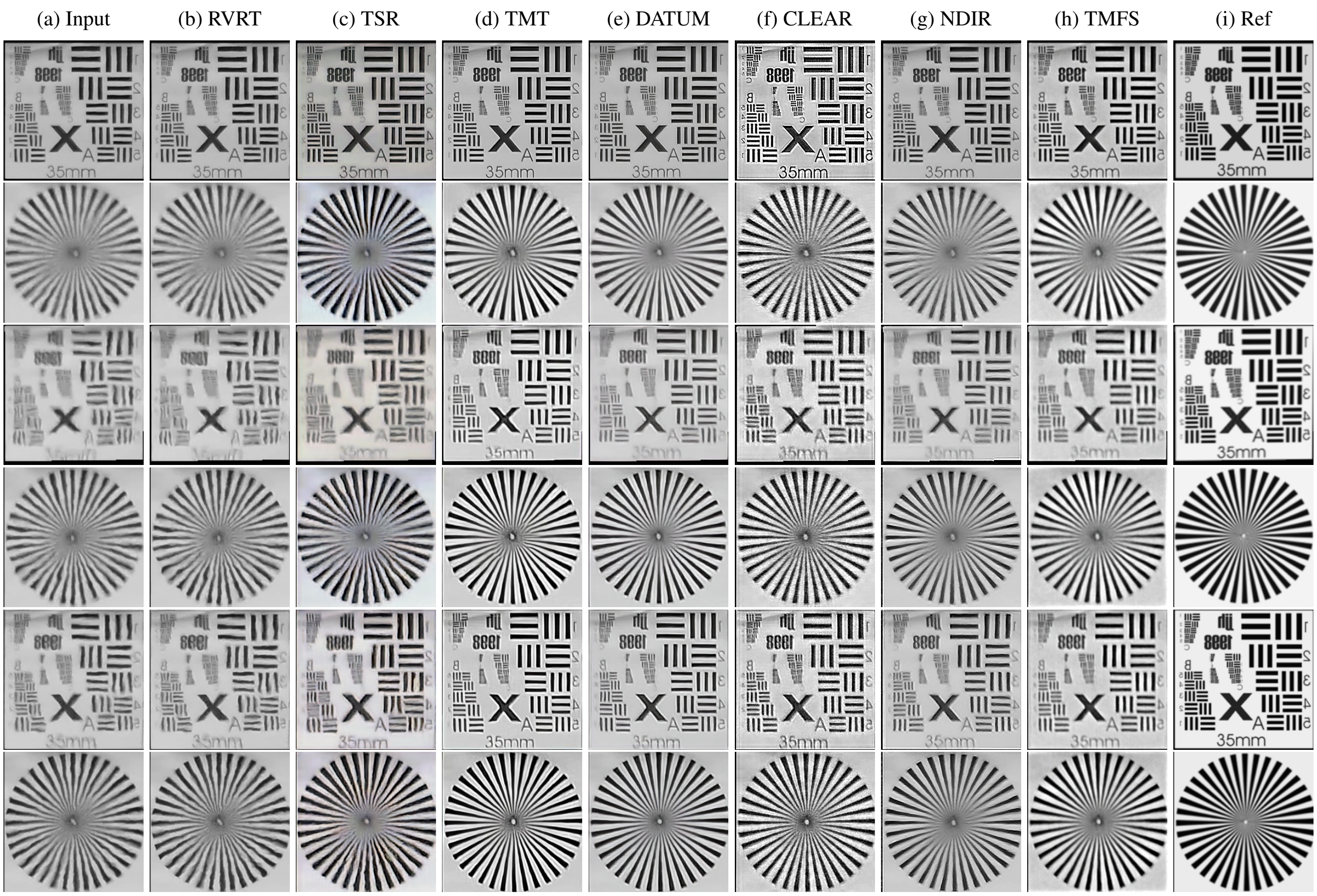

Figure 10. First part of all restoration results except strong level strength on dataset OTIS.

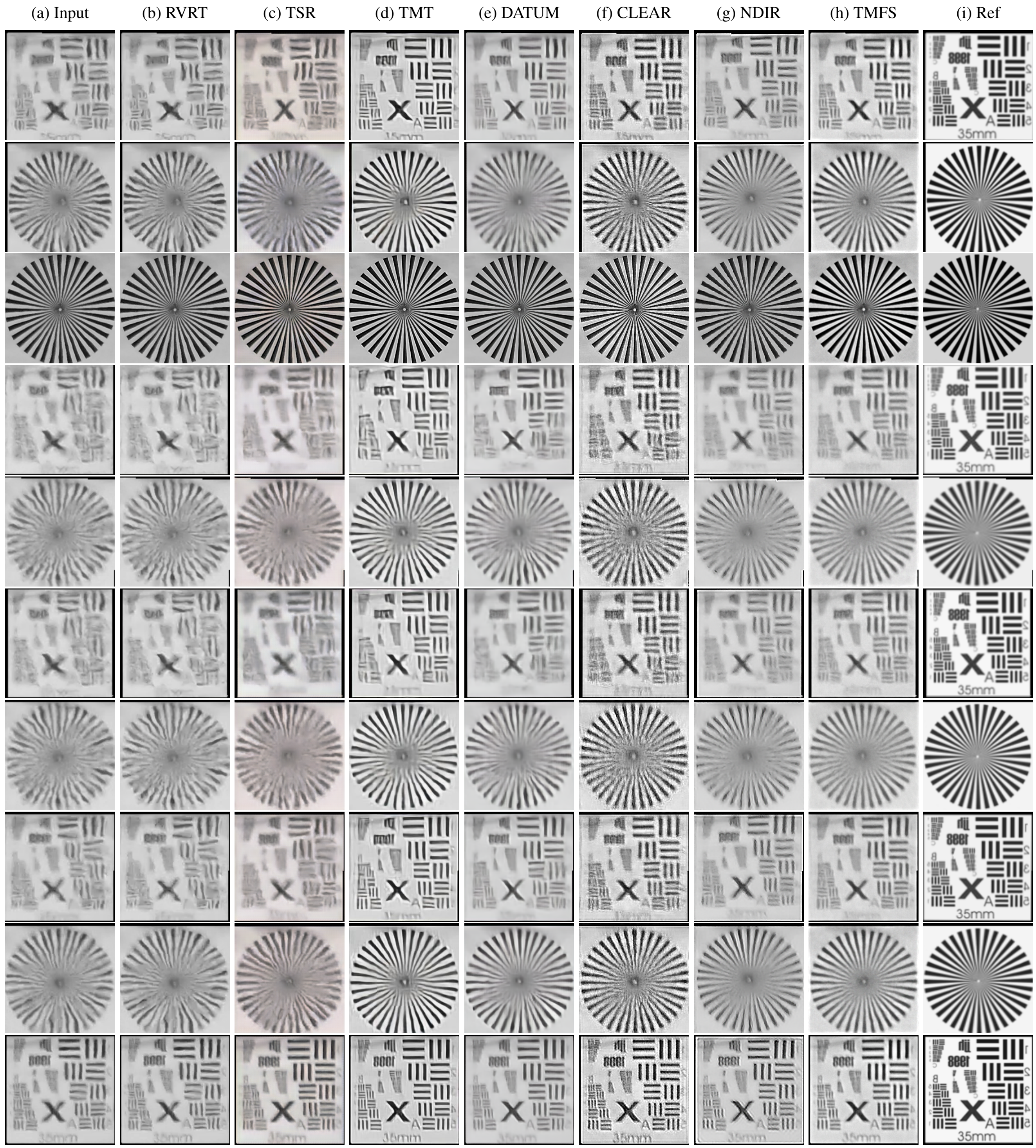

Figure 11. Second part of all restoration results except strong level strength on dataset OTIS.

Figure 12. The restoration results on static scenes from dataset RLR-AT [29].