ETH zürich

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PRS Photogrammetry Remote Sensing

Guided Depth Super-Resolution by Deep Anisotropic Diffusion

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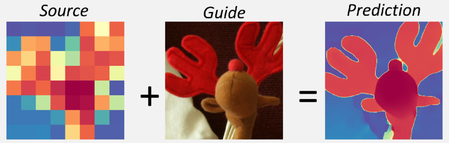
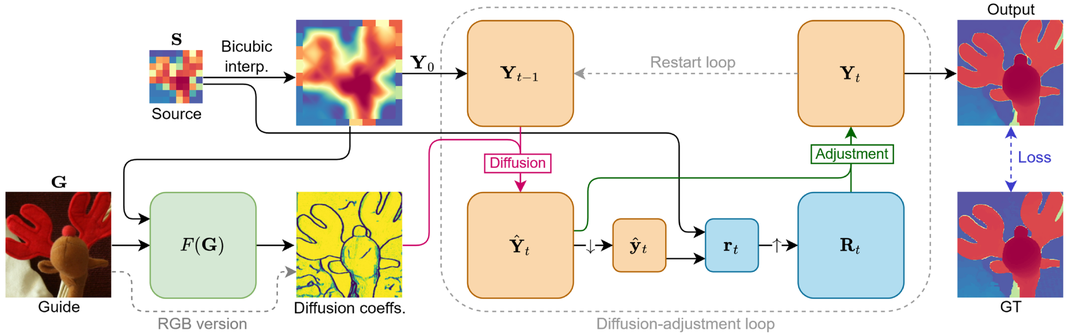
*Photogrammetry and Remote Sensing, ETH Zürich, *equal contribution*

Problem

Enhance low resolution **Depth Map** with **High Resolution** RGB guide.





DADA: Deep Anisotropic Diffusion and Adjustment

Mechanism

Diffusion → enhances edges

$$\hat{\mathbf{y}}_t^p = \mathbf{y}_{t-1}^p + \lambda \cdot \sum_{n \in \mathcal{N}_4^p} \underbrace{(\mathbf{y}_{t-1}^n - \mathbf{y}_{t-1}^p)}_{\text{Depth Gradient}} \cdot c(\mathbf{g}^p, \mathbf{g}^n)$$

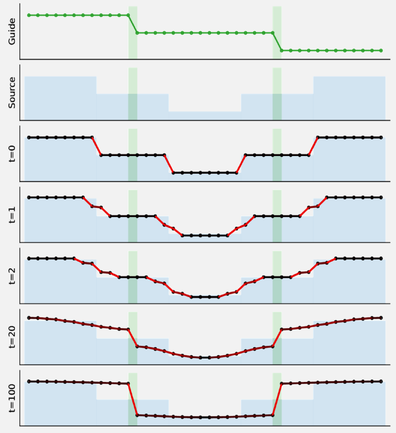
Diffusion Coefficient

$$c(\mathbf{g}^p, \mathbf{g}^n) = \frac{\kappa^2}{\kappa^2 + \|\mathbf{g}^p - \mathbf{g}^n\|_2^2} \qquad c(g^p, g^n) \in [0,1] \quad \begin{cases} 1 & \text{for } g^p = g^n \\ < 1 & \text{for } g^p \neq g^n \end{cases}$$

Adjustment → consistency with source

$$\mathbf{Y}_t = \hat{\mathbf{Y}}_t \cdot \underbrace{\text{up}\left(\overbrace{\frac{\mathbf{S}}{\text{down}(\hat{\mathbf{Y}}_t)}}^{\mathbf{r}_t}\right)}_{\mathbf{R}_t}$$

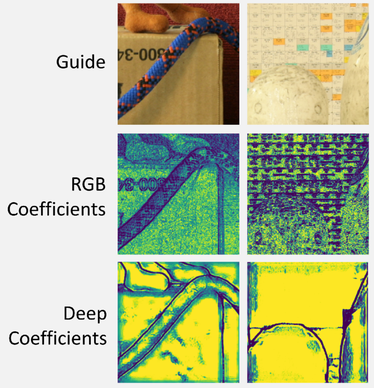
Intuition



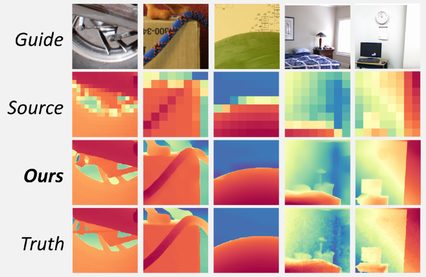
- Depth gradients (red) encourage diffusion
- Discontinuities in the guide signal (green) hinder diffusion and are transferred to the target
- The target is constrained to adhere to the low-resolution source (blue)

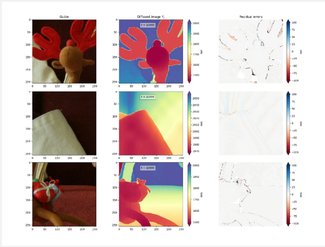
Coefficients

Deep feature extractor for image understanding



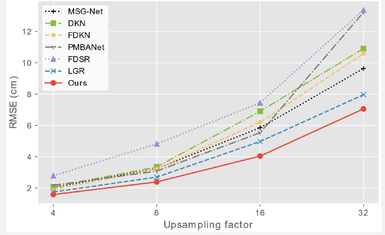
Visual Results



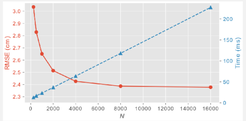


Performance

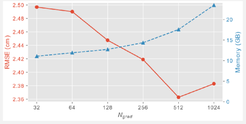
Learned



Accuracy/Speed trade-off



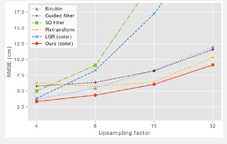
Accuracy/Memory trade-off



Cross Dataset

		DIML			Middlebury		
		MSE	MAE	MSE[1]	MSE	MAE	MSE[1]
×32	MSG	60.2	2.82	0.59	68.5	2.31	0.46
	FDKN	97.2	3.91	1.09	98.3	3.05	0.68
	PMBA	312	4.96	1.24	118	3.71	6.62
	FDSR	239	6.45	3.70	177	4.67	2.47
	LGR	64.5	2.83	0.001	70.7	2.28	0.008
	DADA	**56.9**	**2.35**	**0.0**	**52.3**	**1.67**	**0.0**

Learning Free



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Conclusion

→ DADA: simple & effective approach linking anisotropic diffusion and deep learning
→ Hybrid methods are better than learned and traditional methods
→ Computationally efficient: Constant memory & constant time w.r.t scaling
→ Speed vs. accuracy trade-off through number of iterations

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