Towards a Universal Image Degradation Model via Content-Degradation Disentanglement

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1. Introduction

1.1 Motivation

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Image degradation modeling and **synthesis** have wide range of applications:

- Image restoration,
- Data augmentation, and
- Simulating artistic effects

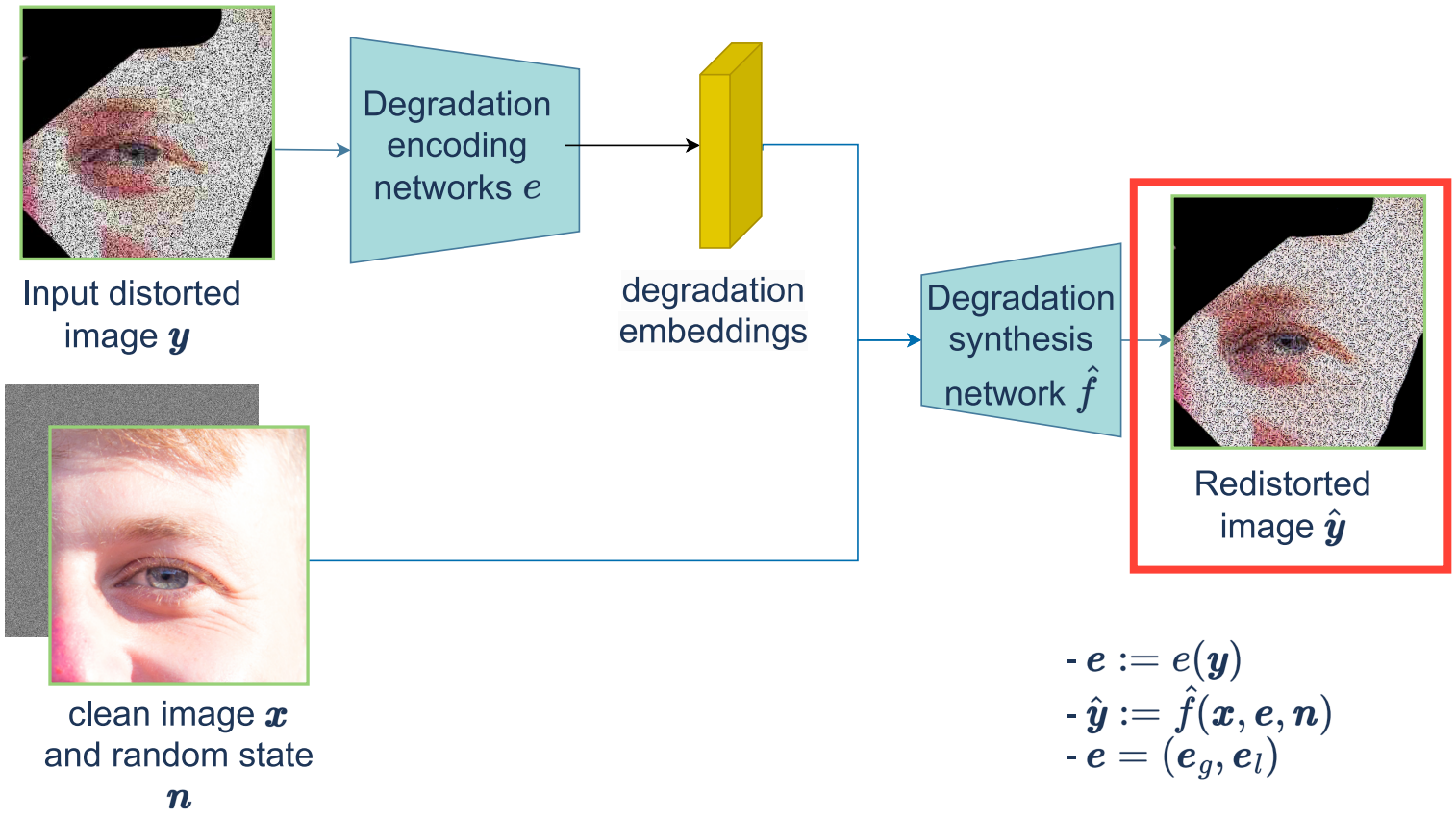
Existing methods –

- are **labor consuming**: each model is designed *for each downstream application*, which requires strong domain knowledge.
- have difficulties modeling **localized degradations**
- require **supervised degradation parameters**

1.2 Contributions

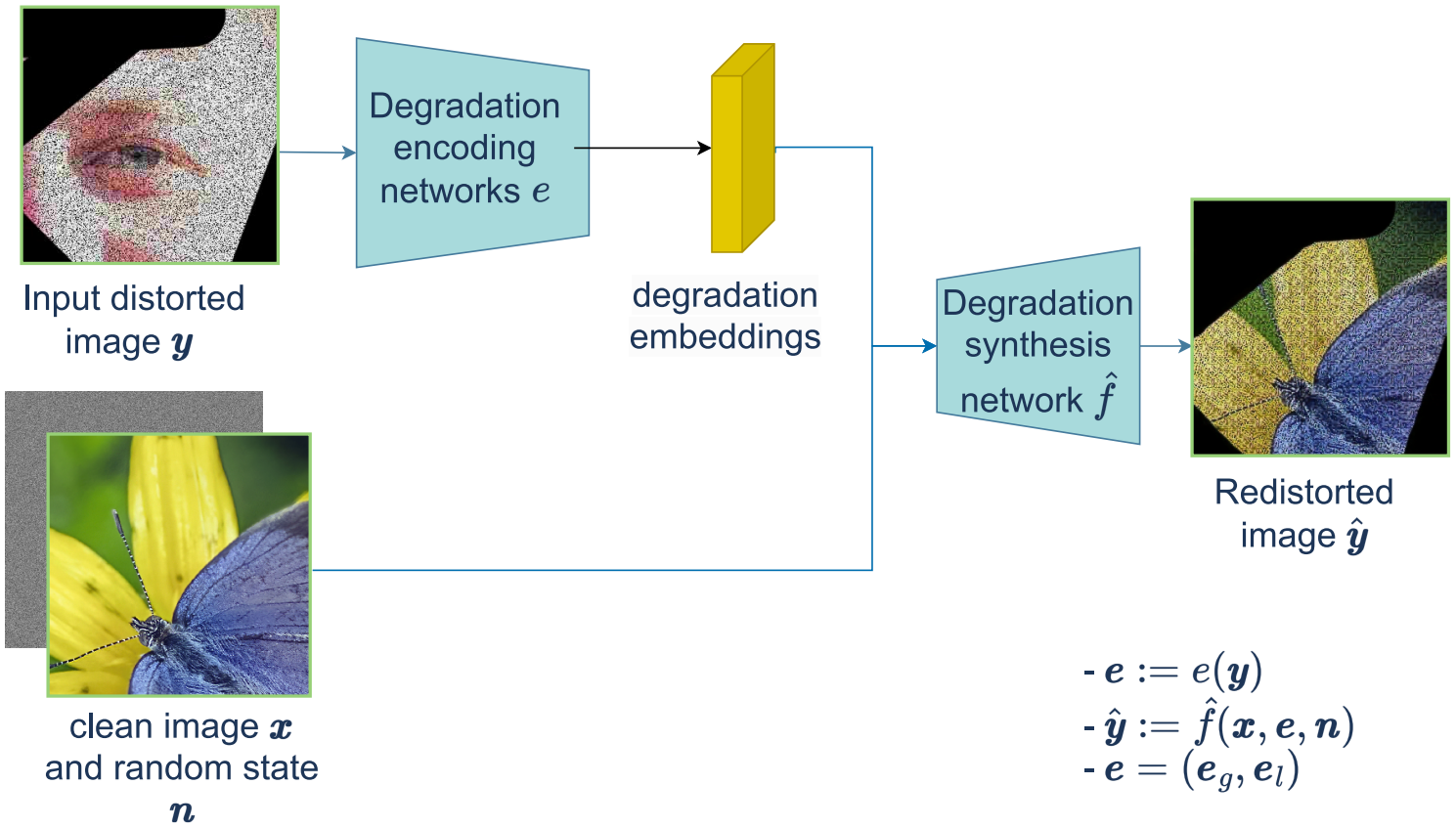
- First **universal degradation model**: **one architecture for all types** of **global and localized** degradations
- **Disentangle-by-compression** method: learning disentangled degradation representation **without explicit supervision**
- **Plug-and-play**: enabling **blind image restoration** for inversion-based methods for the first time

2. Overview of Architecture



Training and testing time

Degradation reproduction: extracting degradation information from one distorted image and reapplying it to the clean version of the image.

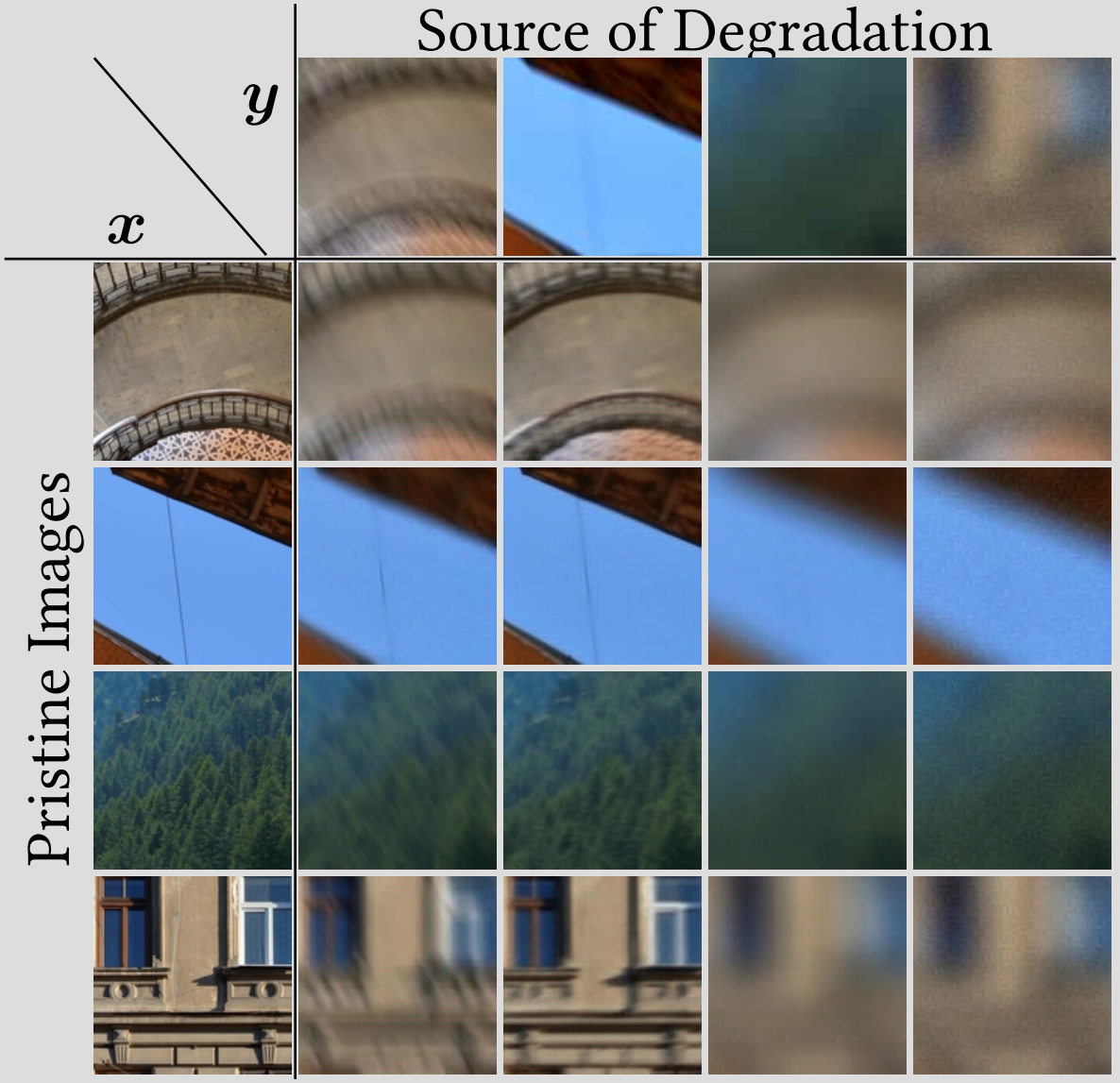


Testing time

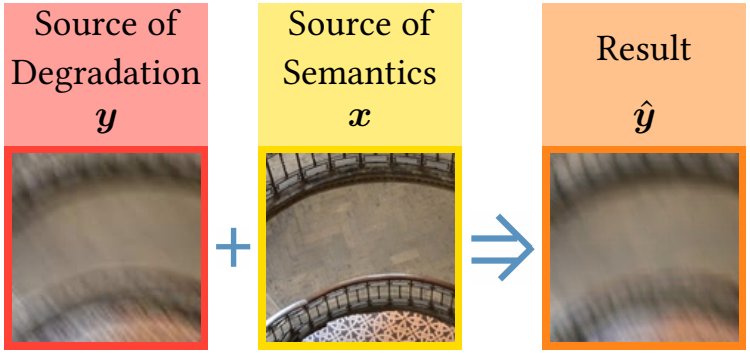
Degradation transfer: applying degradation information from one image to another unrelated image.

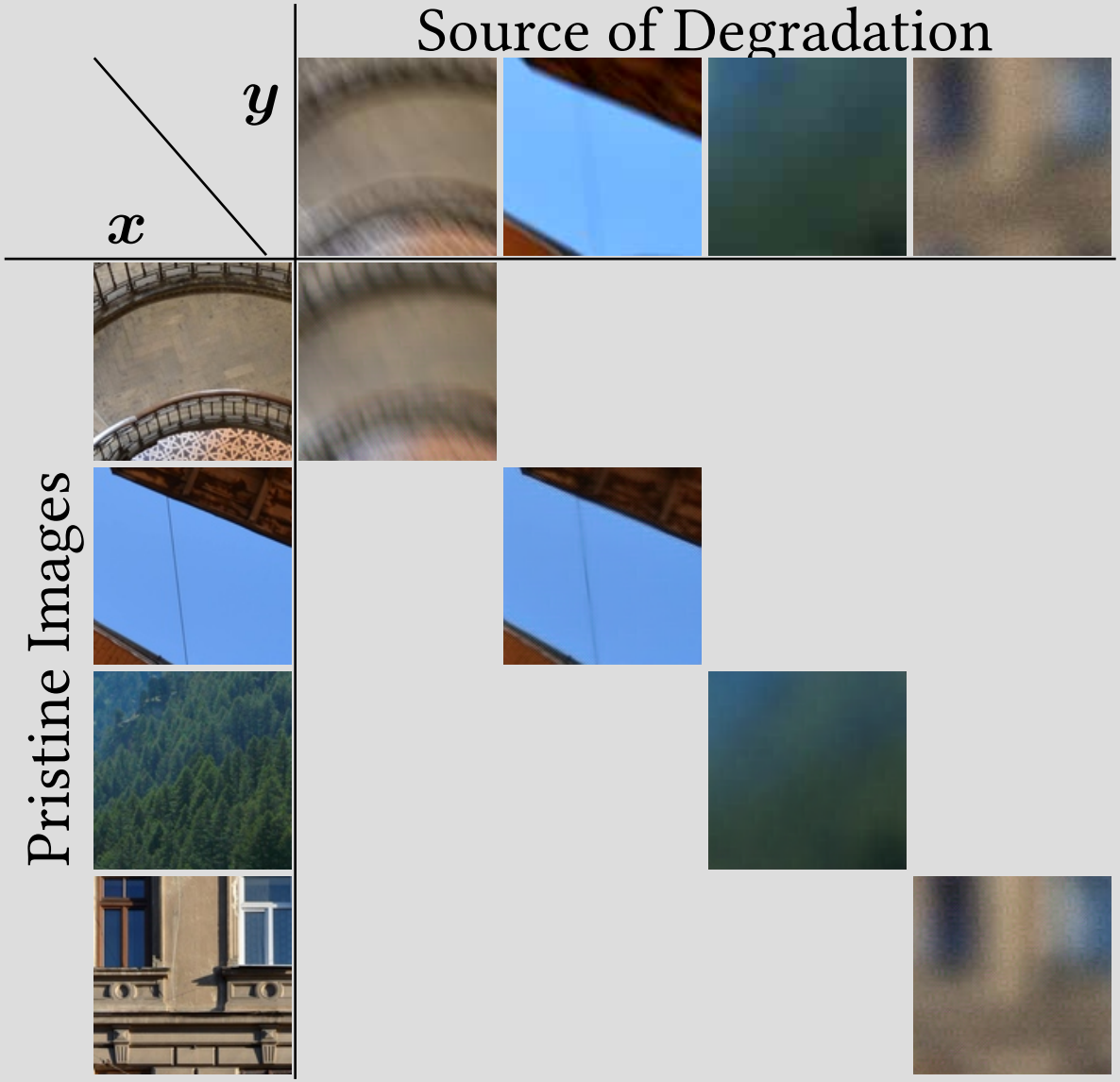
3. Visual results for degradation reproduction and transfer

Results on Wikimedia Quality Images

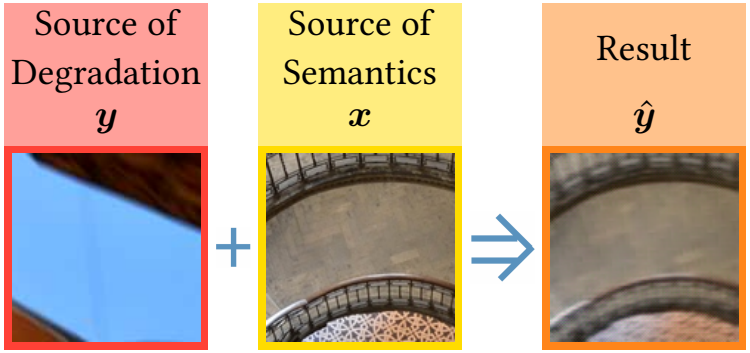


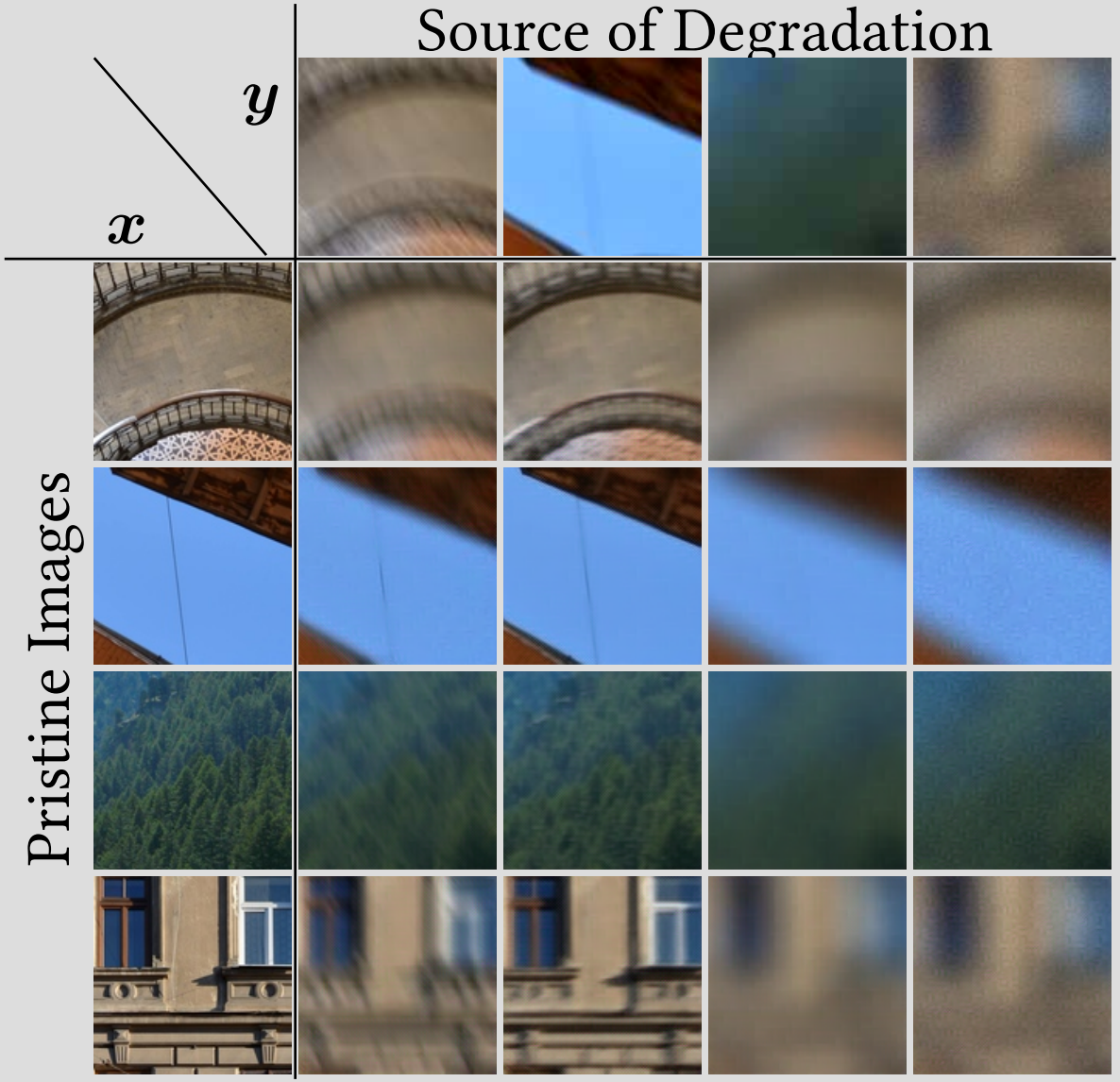
Degradation Reproduction





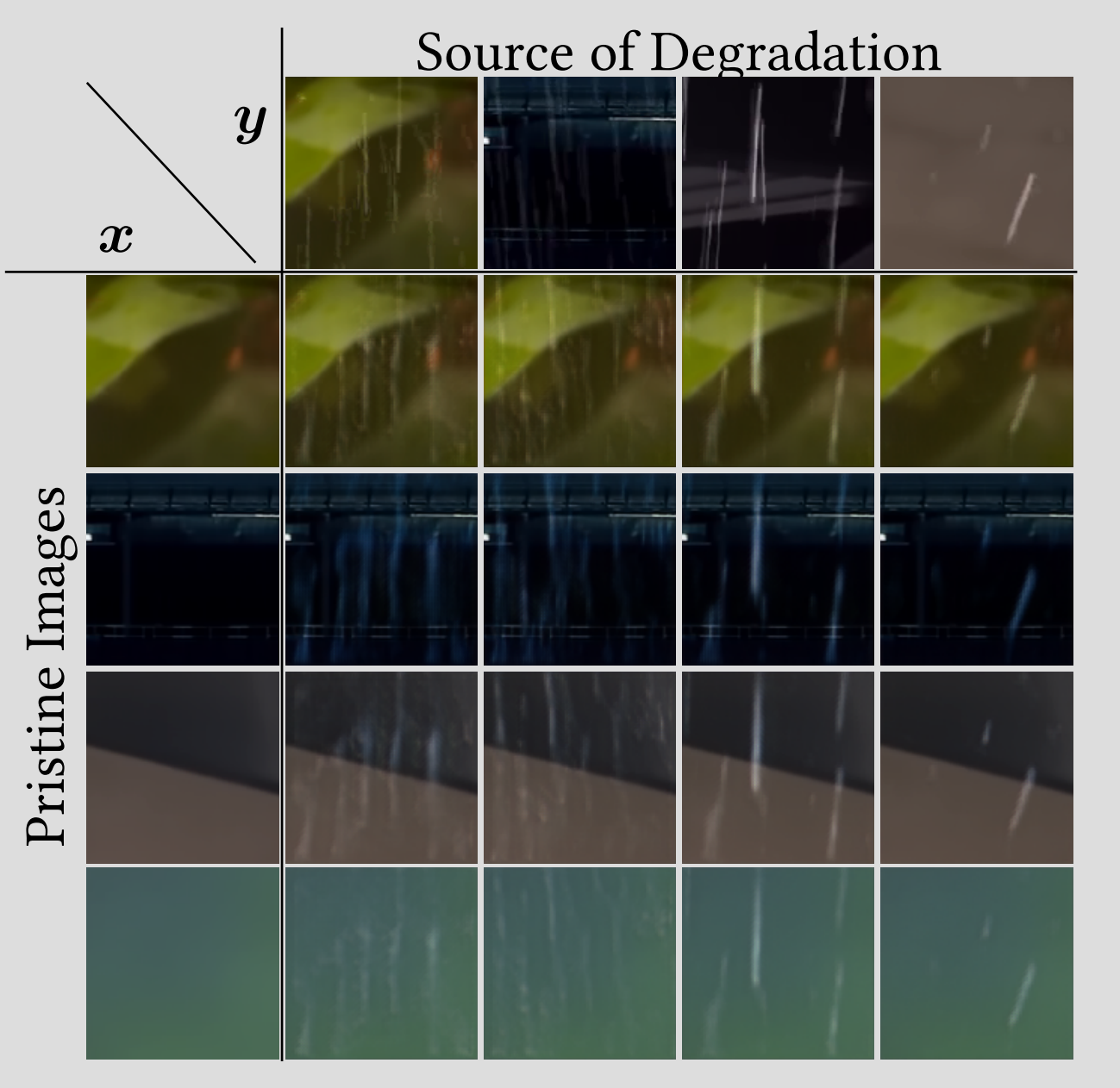
Degradation Transfer





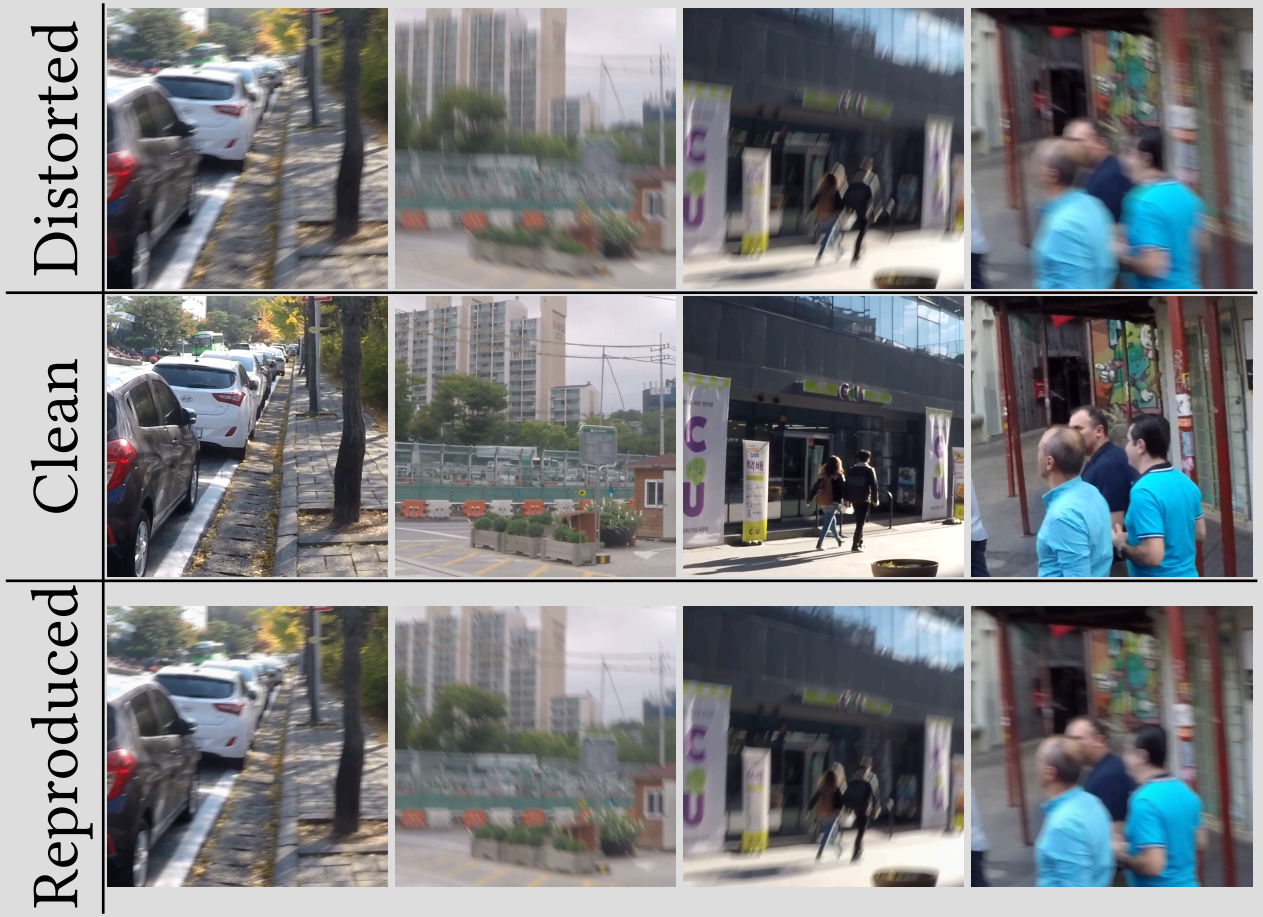
Application: Simulating Weather Effects

Raindrop dataset (Wang et al., 2019, CVPR)



Application: Simulating Artistic Effects

GoPro dataset (Nah et al., 2017, CVPR)



(Zoomed in)

Results for Film Grain Synthesis [on FilmGrainStyle (Ameur et al., 2023 ACM MSC)]

(Zoomed in)

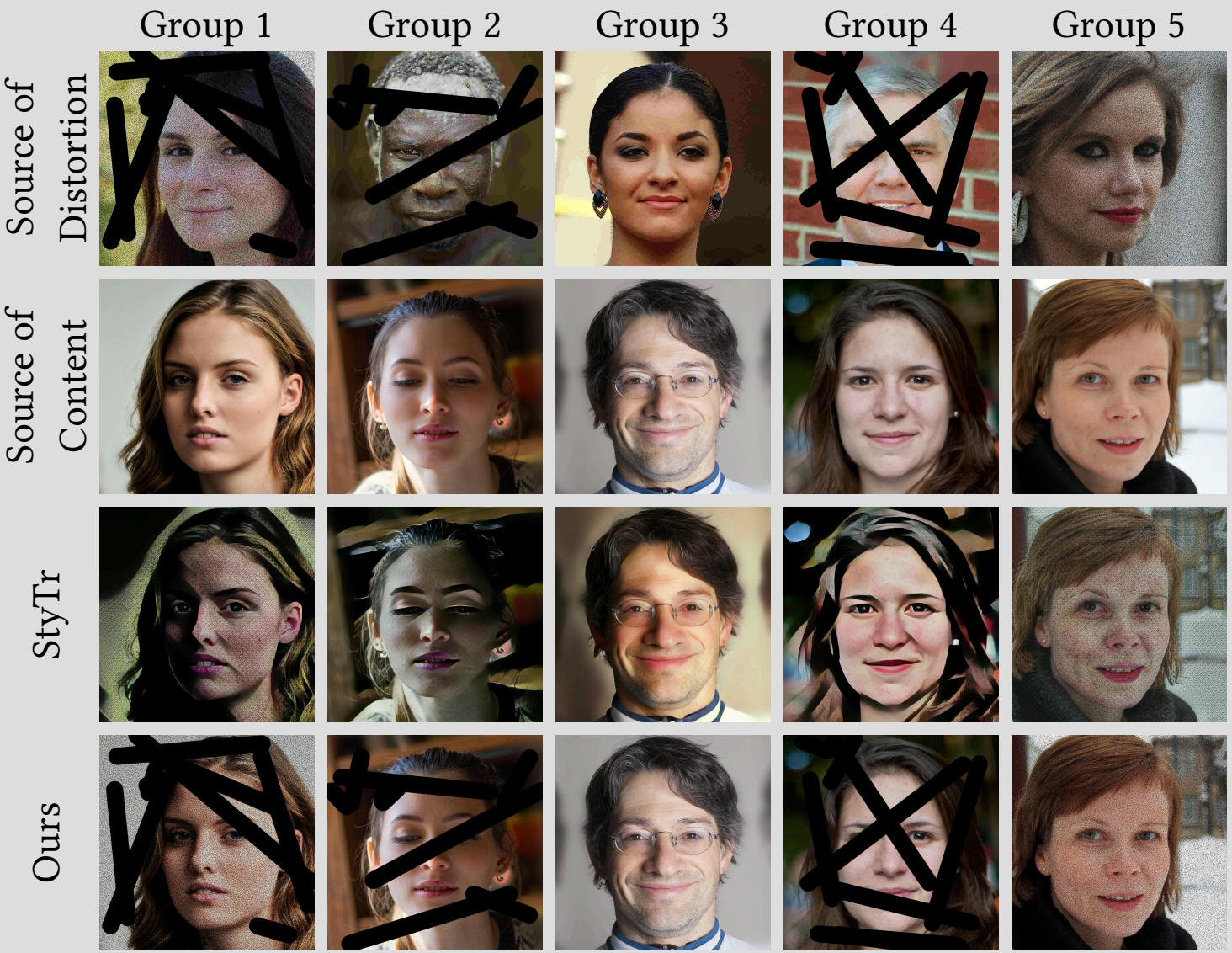
Clean	Ground Truth	Reproduce	Transfer
			

Results for Film Grain Synthesis [on FilmGrainStyle (Ameur et al., 2023 ACM MSC)]

Comparison with **existing degradation models**:

	Most existing models:	Chen et al (2020, SPL)	Our model
Architecture	Degradation-specific	Degradation-agnostic	Degradation-agnostic
Multi-degradation handling	Impossible	One group of weights for each degradation	Single model handles all

Comparison with SOTA Style Transfer StyTr2 (Deng et al., 2022, CVPR)



Our model can identify **independent degradation components**

1 Noise after JPEG

2 Blur-Sharpness

3 Blur after JPEG

4 Motion blur

5 Motion blur

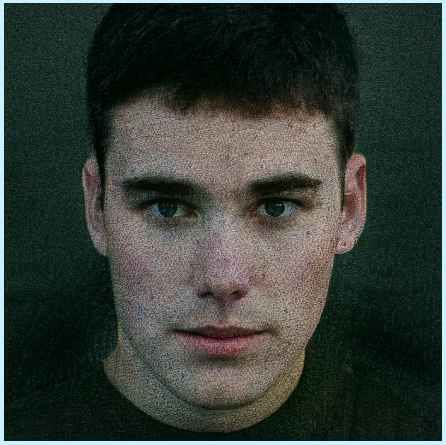
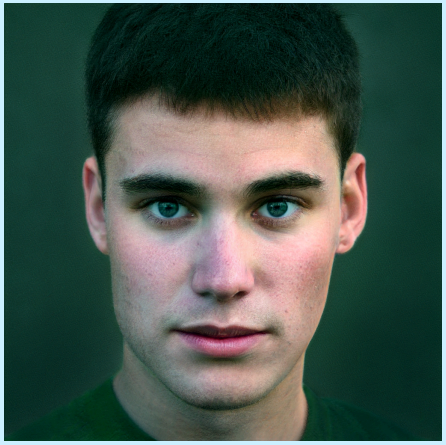
4. Indirect Application: Inversion-based Image Restoration

Distorted	Restored by RSG		
	Non-blind	Blind	Blind
	w/ GT deg	w/o deg info	w/ our model
			

Plugging in our model allows RSG to restore images without requiring degradation information, significantly improving its practicality.

Distorted	Restored by RSG		
	Non-blind	Blind	Blind
	w/ GT deg	w/o deg info	w/ our model
			

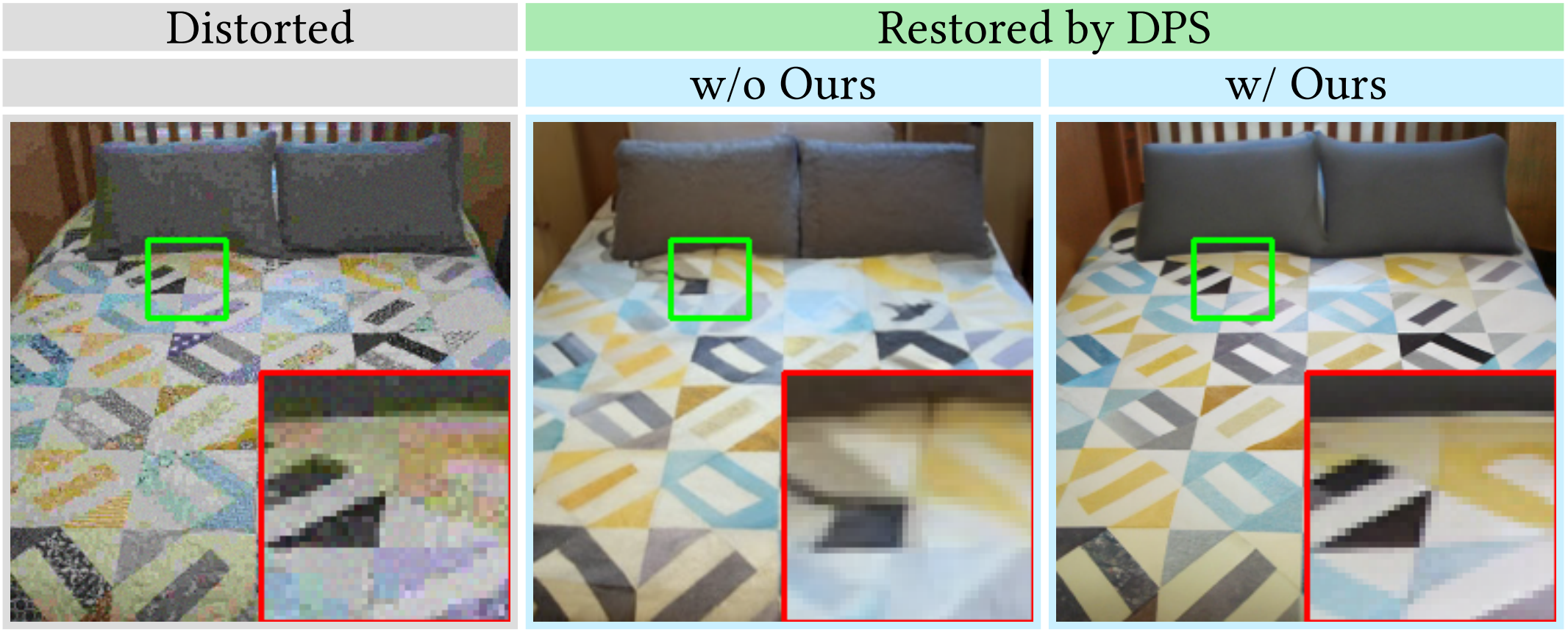
More visual examples are available in the technical supplement.

Distorted	Restored by RSG		
	Non-blind	Blind	Blind
	w/ GT deg	w/o deg info	w/ our model
			

More visual examples are available in the technical supplement.

Distorted	Restored by DPS	
	w/o Ours	w/ Ours

Our model can also be plugged into Diffusion Posterior Sampling (Chung, 2023, ICLR) for diffusion-model inversion-based image restoration.



Our model can also be plugged into Diffusion Posterior Sampling (Chung, 2023, ICLR) for diffusion-model inversion-based image restoration.

Preprint, code, dataset, pretrained model and supplementary material are available on **our project page**: https://ivc.uwaterloo.ca/projects/content-degradation-disentanglement/

Other projects from our lab: https://ivc.uwaterloo.ca/projects/