

Weak Diffusion Priors Can Still Achieve Strong Inverse- Problem Performance

ICML 2026, spotlight

Jing Jia^{1*}, Wei Yuan^{1*}, Sifan Liu²,
Liyue Shen³, Guanyang Wang¹

1. Rutgers University

2. Duke University

3. University of Michigan

*Equal contribution



Paper



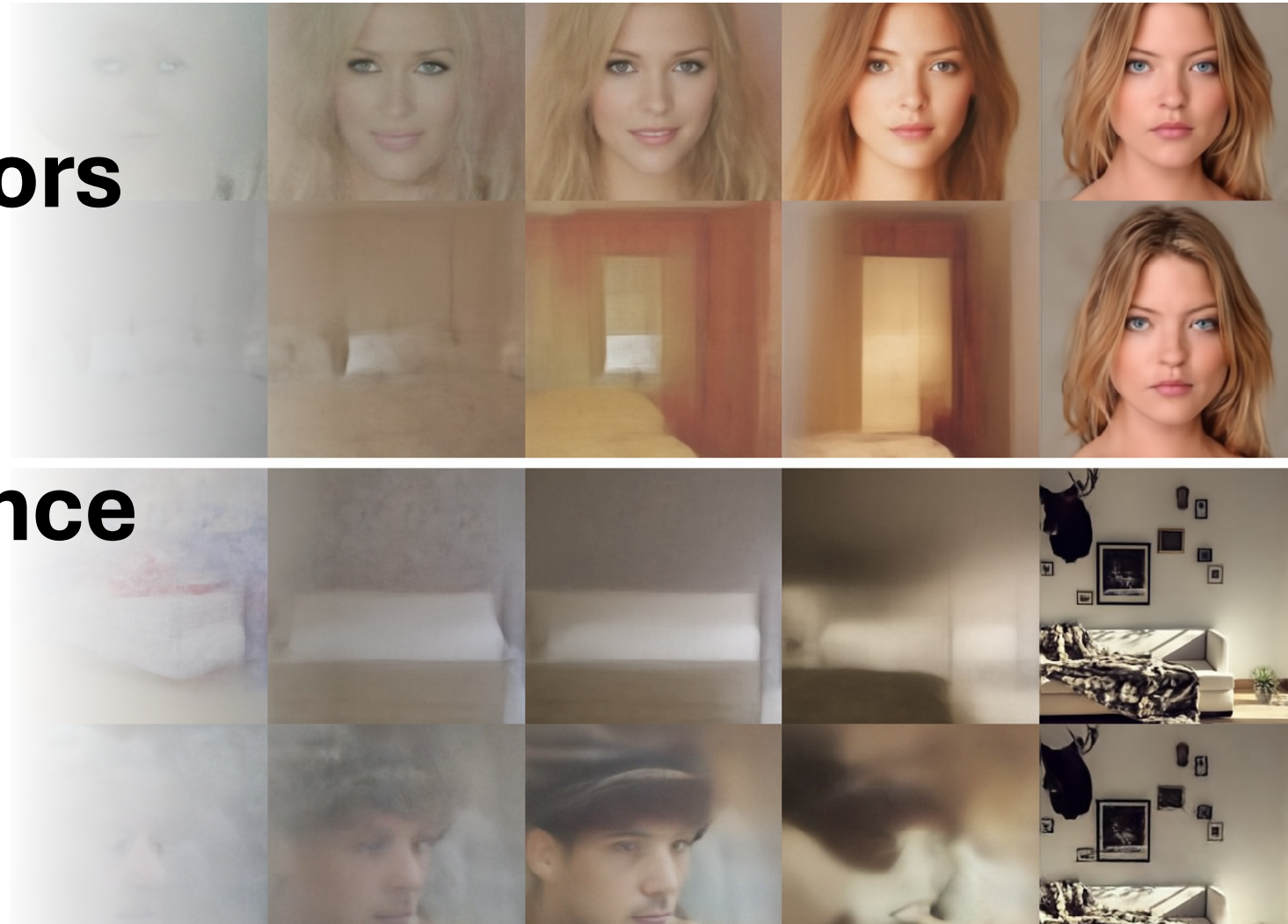
Code



Project

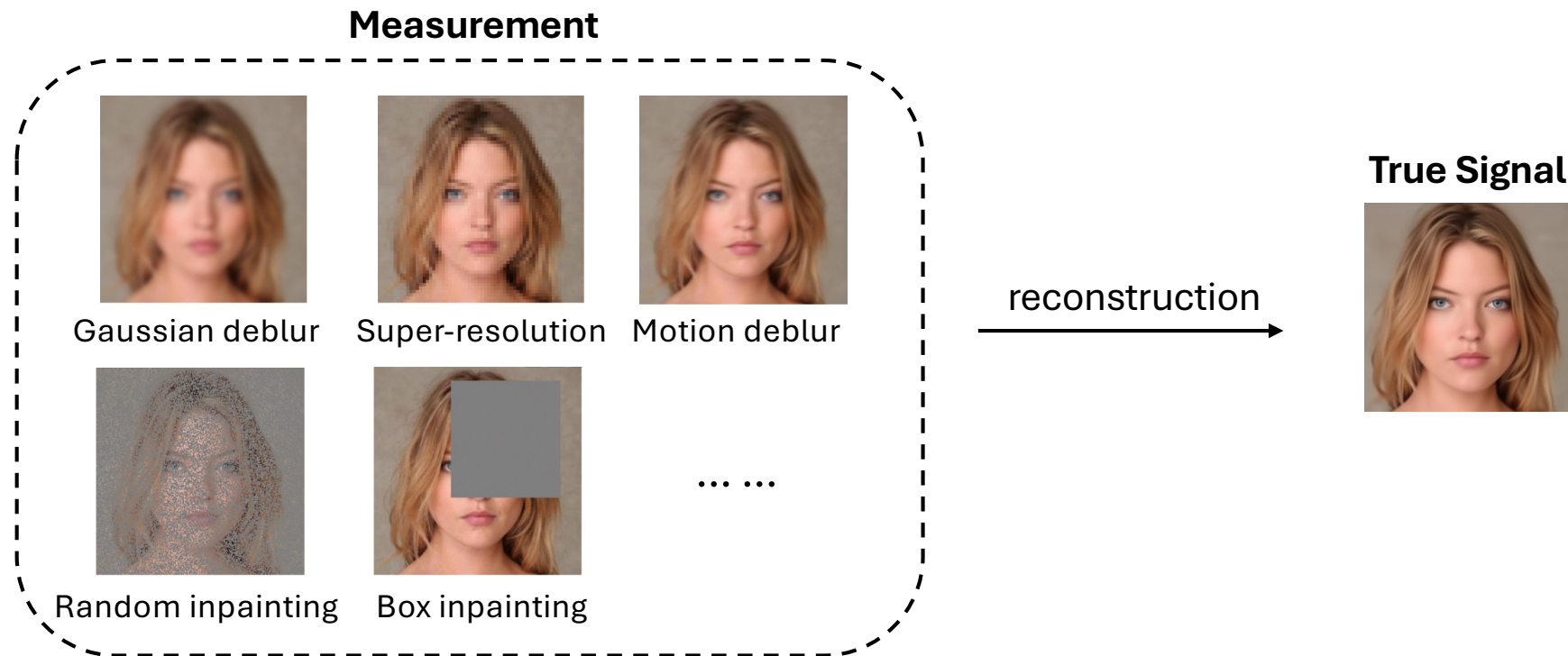


知乎

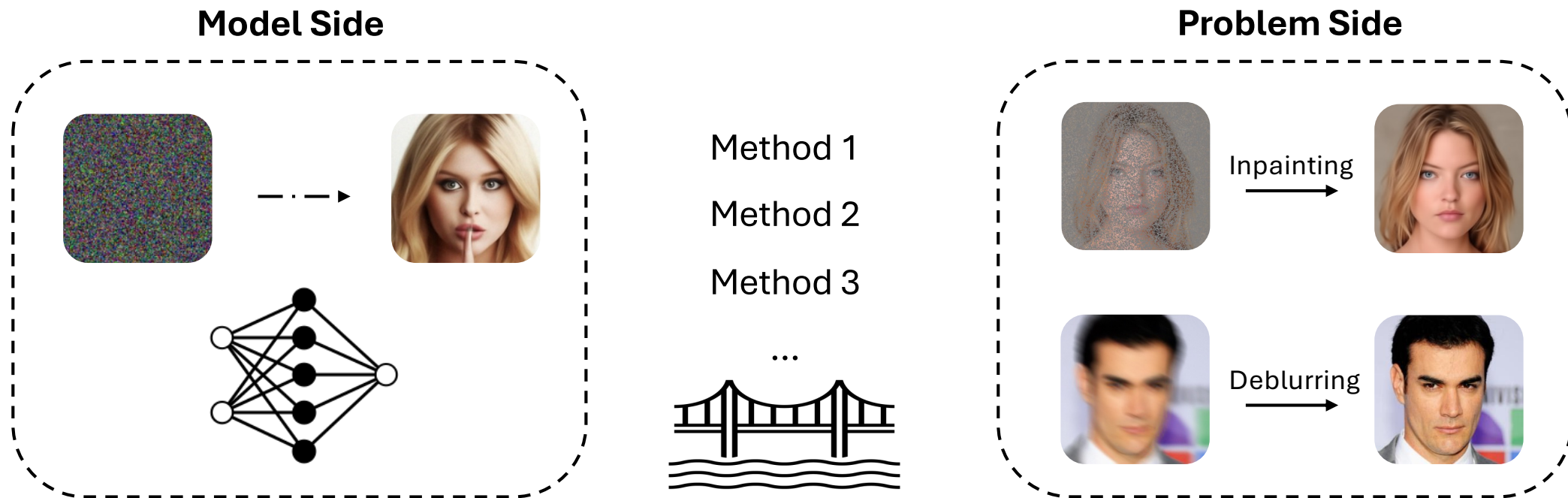


Inverse problem

Goal: Recover the unknown signal from observed measurement



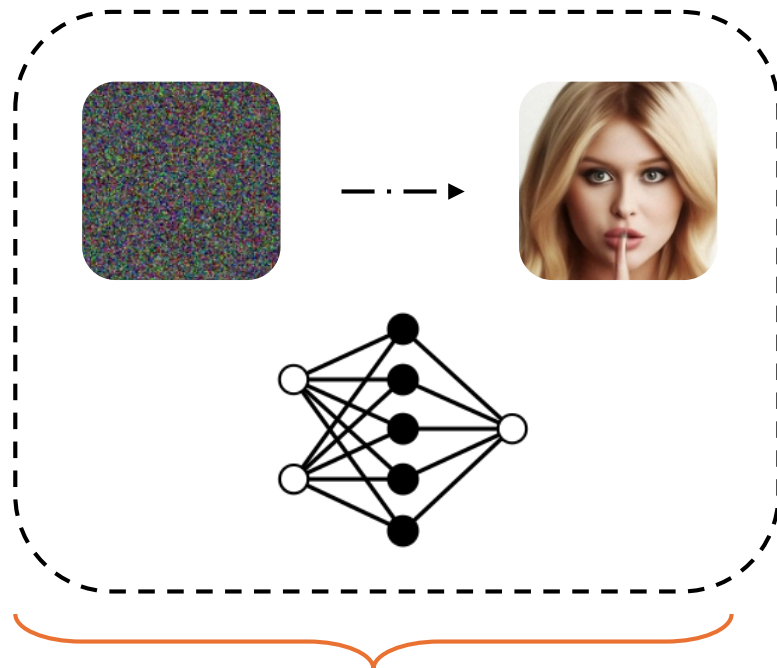
Diffusion Model for Inverse Problem



Inverse problem solvers serve as bridges between diffusion models and downstream tasks.

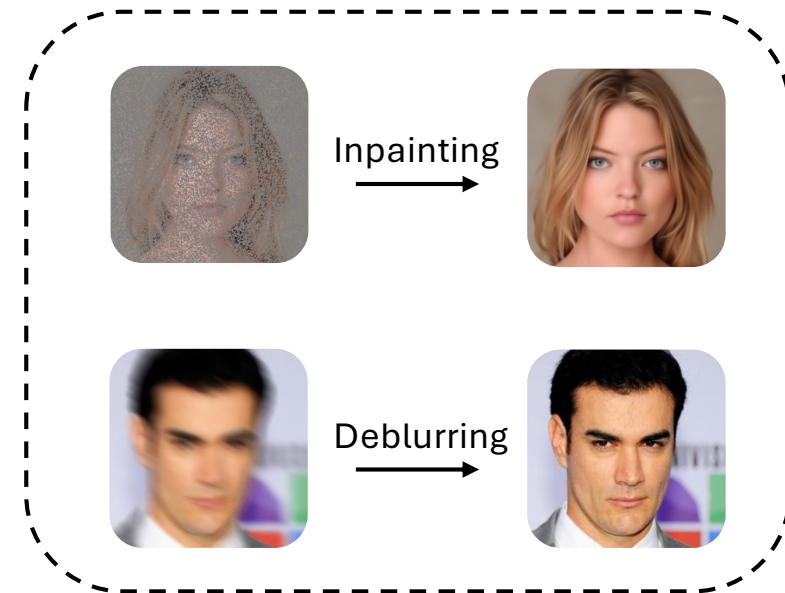
Diffusion Model for Inverse Problem


Model Side



Implicit requirement:
In-domain pretrained model
+ 1000 steps sampling

Problem Side



Method 1
Method 2
Method 3
...


Why “Weaker Prior”

Memory Constraints

- Diffusion processes must be truncated to just a few steps, yielding low-fidelity, blurry images

Data Scarcity

- Medical imaging and other domains lack training data for domain-specific models

Distribution Mismatch

- Must rely on pre-trained models from completely different distributions

Prior Works

Weak priors yield highly competitive reconstructions

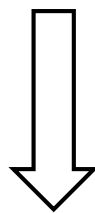
- DMPlug, BIRD: 2-6 dB PSNR improvement over baselines despite weak priors
- Medical imaging: performance using out-domain nearly matches in-domain models

Bedroom to reconstruct face?

Measurement



Bedroom diffusion model:
3-Step DDIM sampler



Reconstruction



Bedroom to reconstruct face?



Bedroom to reconstruct face?



← Post ...

 だけん
@kenji5012 X.com

Translated from Japanese by Grok

A diffusion model that was trained **only** on bedroom images actually turned out to be capable of generating human faces... an insanely errifying result.

ate this translation:  

 **Guanyang Wang** @GuanyangW · 1d

Can a diffusion model trained on bedrooms recover a human face? Surprisingly, yes!

In the new paper led by Jing Jia @MoMoJing131 and Wei Yuan, we show that a very weak diffusion prior still yield strong inverse problem performance.

[#GenerativeAI](#) [#diffusionmodel](#)

Visualization

4x Super-resolution + Gaussian noise $\sigma = 0.01$



Cross Domain Result

- Compare with DPS: 1000–step DDIM with in-distribution
- 3 pretrained model: Bedroom, CelebA, Church

		CelebA			Bedroom			Church			
	Method	Model	PSNR \uparrow	LPIPS \downarrow	SSIM \uparrow	PSNR \uparrow	LPIPS \downarrow	SSIM \uparrow	PSNR \uparrow	LPIPS \downarrow	SSIM \uparrow
Inpainting	DPS	In-Domain	31.98	0.14	0.88	27.97	0.23	0.82	24.15	0.25	0.73
	Ours	CelebA	33.78	0.15	0.91	27.78	0.27	0.83	23.56	0.36	0.72
	Ours	Bedroom	32.76	0.17	0.90	28.88	0.20	0.87	24.22	0.28	0.75
	Ours	Church	32.62	0.16	0.90	28.66	0.21	0.86	24.93	0.23	0.77
Super-res	DPS	CelebA	26.82	0.22	0.74	22.95	0.39	0.64	20.28	0.36	0.52
	Ours	CelebA	31.27	0.18	0.86	25.88	0.35	0.74	22.68	0.41	0.63
	Ours	Bedroom	30.34	0.22	0.84	26.59	0.25	0.78	22.86	0.33	0.65
	Ours	Church	30.10	0.22	0.84	26.30	0.27	0.77	23.09	0.27	0.67

Bayesian Consistency Theory

Background

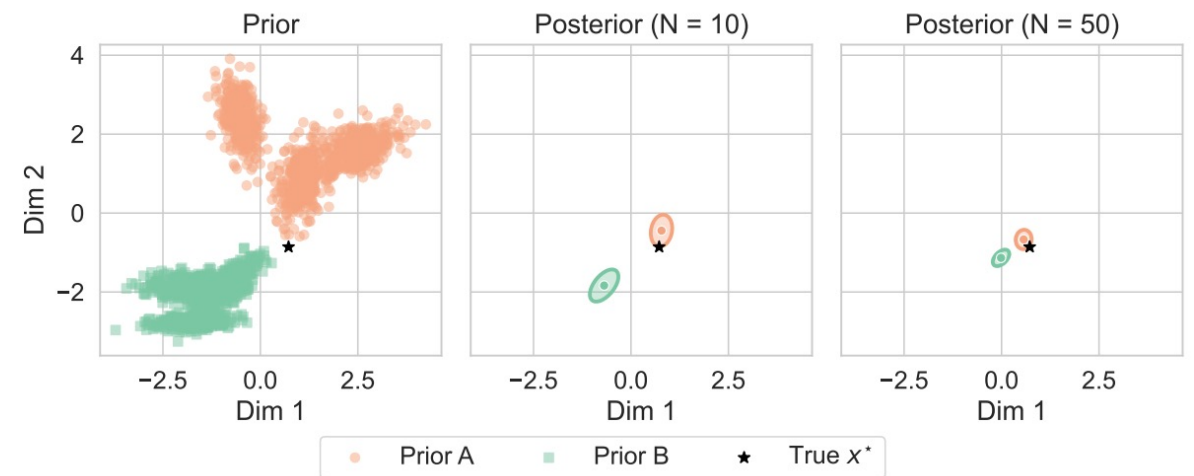
- Posterior $\pi(x | y) \propto$ Prior $\pi(x) \times$ Likelihood $p(y | x)$

Bayesian Consistency

- The more informative the data, the less sensitive the result is to the prior.

Distribution Mismatch

- An 256×256 images has $\sim 200,000$ pixels
- Much more informative than we thought!



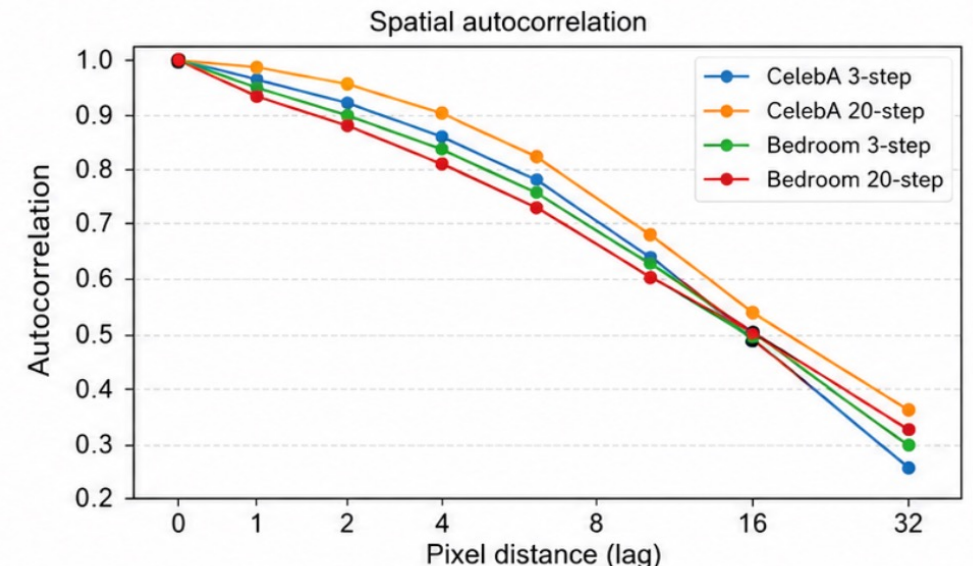
Weak priors preserve local structure

Question

- Is weak prior truly weak?

Key idea

- Measure short-range spatial correlation of samples from different models.
- This profile captures local structural information
- Weak and strong priors show very similar decay rate

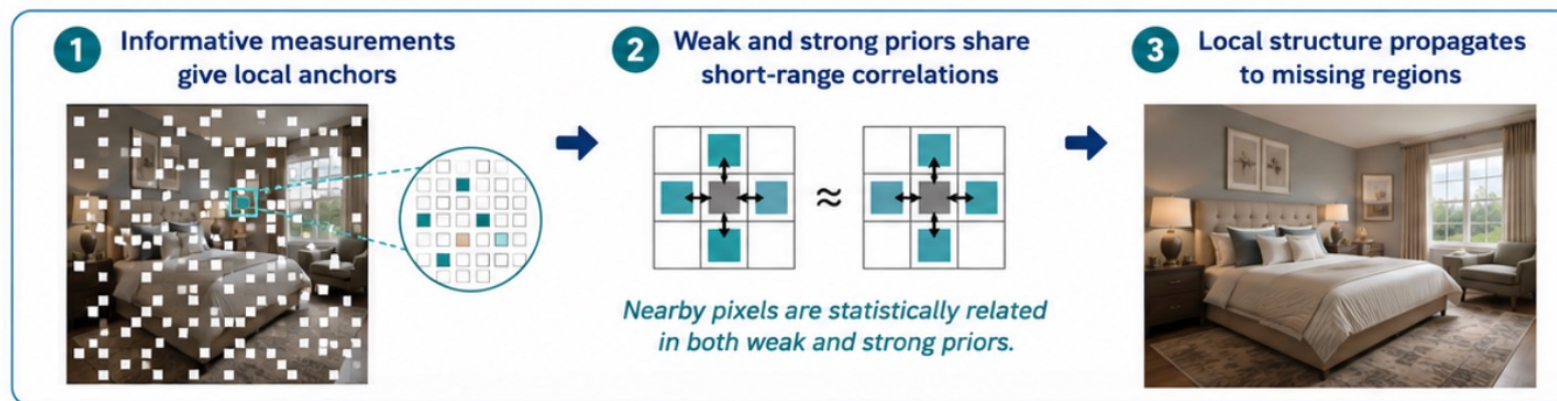


Example: $\text{corr}(\text{profile Bedroom 3-step, CelebA 20-step})$
over lags 1–32 = 0.9987.

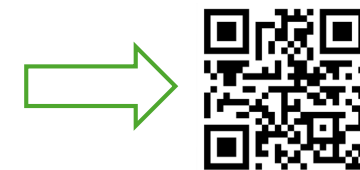
Key Message

Weak **priors** can yield strong results in **data-informative** regimes

- Data: Informative measurements provide anchors
- Prior: Local structural information to propagate these local anchors



[Weak Diffusion Priors can still achieve Strong Inverse Problem Performance]

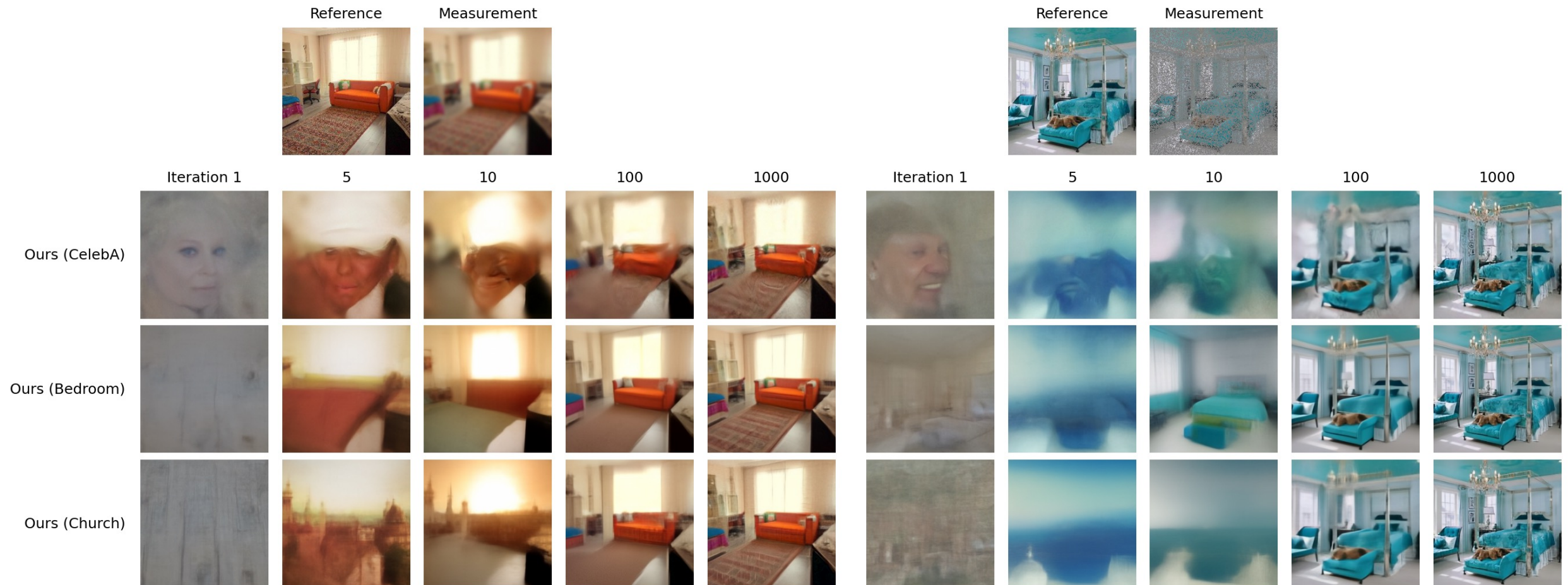


Takeaway

Informative **data** provide anchors, and even weak **priors** propagate useful local structure.

Thank you!

Visualization



Visualization

