

# PAPER IMPLEMENTATION: ZERO-SHOT IMAGE RESTORATION USING DENOISING DIFFUSION NULL-SPACE MODEL

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Yinhuai Wang, Jiwen Yu, and Jian Zhang.  
Zero-Shot Image Restoration Using Denoising Diffusion Null-Space Model.  
2022. arXiv: 2212.00490.

# Background

- State-of-the-art diffusion model presented in Denoising Diffusion Probabilistic Model (DDPM)
- Range-Null Space Decomposition: any sample  $x$  can be decomposed into its range-space and null-space as follows:

$$x \equiv A^\dagger A x + (I - A^\dagger A) x$$

# Problem and Constraints

$$Ax = y$$

- $A$ : degradation operator
- $x$ : ground-truth image
- $y$  = degraded image

Produce  $\hat{X}$  that satisfies

- Consistency:  $A\hat{X} \equiv y$
- Realness:  $\hat{X} \sim q(x)$

# Proposed Solution

Algorithms:

1. DDNM
2. DDNM+ (noise and time-travel)

« the time-travel trick produces a better 'past', which in turn produces a better 'future' »

Zero Shot: no need for a model explicitly trained for the IR task

# Roadmap of our approach

1. DDPM sampling algorithm
2. DDNM
3. DDNM+ with no time travel
4. DDNM+ with time travel
5. Mask-Shift trick
6. Final evaluation

# Algorithm Iteration

1. Compute estimation using pre-trained model
2. Compute rectified estimation using range-space and null-space decomposition
3. Sample new value for the next iteration

At each iteration we reduce the disharmony between range-space and null-space resulting in a final output which yields better realness.

Now let's dive  
into the code!



Open in Colab