Cornell Bowers C·IS
College of Computing and Information Science

Cold Diffusion: Inverting Arbitrary Image Transforms Without Noise

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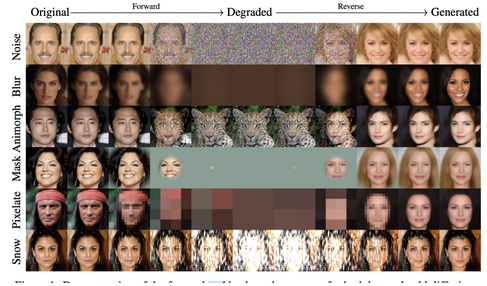


Introduction

Problem: **injecting noise** in diffusion is suboptimal for certain deterministic tasks such as unblurring

Investigate if **noise** for diffusion restoration is unnecessary → can we use deterministic degradation

Example task: recovering a given image

Cold Diffusion (Bansal, A. et al., 2022) shows that diffusion models can operate purely by undoing degradations without stochastic noise

Methodology

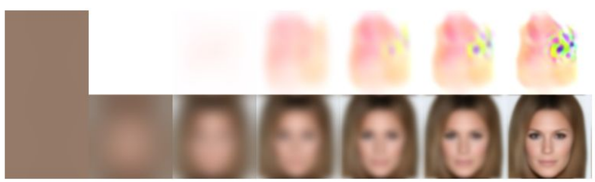
Algorithm 1 Naive Sampling

Input: A degraded sample x_t
for $s = t, t-1, \ldots, 1$ **do**
  $\hat{x}_0 \leftarrow R(x_s, s)$
  $x_{s-1} = D(\hat{x}_0, s-1)$
end for
Return: x_0

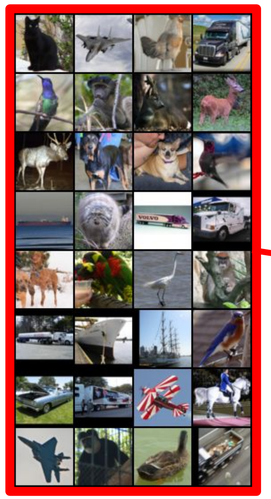
Algorithm 2 Improved Sampling for Cold Diffusion

Input: A degraded sample x_t
for $s = t, t-1, \ldots, 1$ **do**
  $\hat{x}_0 \leftarrow R(x_s, s)$
  $x_{s-1} = x_s - D(\hat{x}_0, s) + D(\hat{x}_0, s-1)$
end for

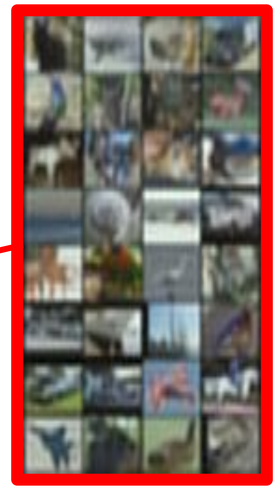
Implemented different sampling algorithm
Used a GMM to model the distribution of severely blurred images, ensuring they remain within the natural image manifold



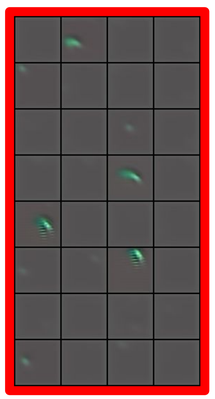
Results



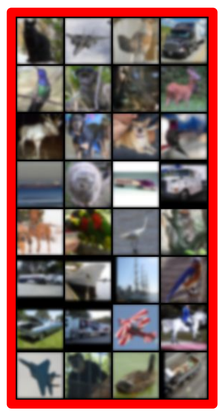
Original



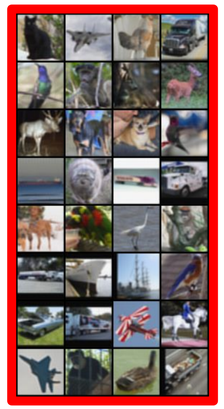
Degraded (Blurring)



Algorithm 1



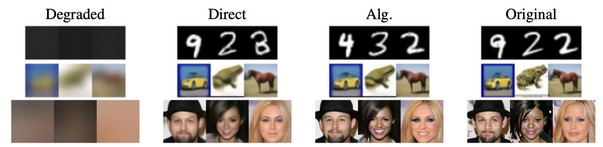
Direct Reconstruction



Algorithm 2

Conclusion

- Cold generation with fixed kernels shows significant ability to generate hyper-realistic images.
- Algorithm 2 makes a notable impact in this processes as converging to the exact “noised” version at a specific time step prevents prediction drift over time
- Our model generated realistic images using only ⅓ of the sampling steps in the original paper. This shows potential faster convergence when noise is not used.



Paper results correspond with our results

Future Work

Generalize to **more degradation transformations** (e.g. pixelation, swirling)
Apply to **new domains e.g.** audio and video
Study potential **mode collapse** compared to traditional noising

References

[1] Bansal, A., Borgnia, E., Chu, H.-M., Li, J. S., Kazemi, H., Huang, F., Goldblum, M., Geiping, J., & Goldstein, T. (2023). *Cold Diffusion: Inverting Arbitrary Image Transforms Without Noise*.