EE367 Project Proposal

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1 Introduction

Low-light conditions pose a considerable challenge for downstream perception tasks. This is due to the high amount of photon noise introduced when capturing scenes with low photon count at low exposure times. With the rising popularity of diffusion models for image generation and image recovery, these models have also been applied in the context of image denoising for low-light settings [4]. Diffusion models are inherently trained on recovery images from Gaussian noise, however, it is well-known that photon noise follows a distribution that is closer to a Poisson distribution. This sparks the question, can we learn a diffusion model trained on Poisson distributed noise, and recover images corrupted by photon noise by following the native diffusion trajectory of the denoising model?

2 Related Work

Diffusion models for low-light image denoising. As mentioned above, existing work such as Nguyen et al. [4] has explored the potential of using diffusion models for low-light image denoising. However, such images are applied to the diffusion model as an external conditioning signal, rather that treating the input image as a point on the diffusion trajectory.

Non Gaussian Diffusion Denoising Models. Traditionally, diffusion denoising models are trained with the assumption that the forward process involves the injection of Gaussian noise into the image. While Gaussian noise exhibit a variety of convenient properties (signal independence, closed under addition), in theory, other noise distributions can also be used to model the forward process. Existing works such as [1, 2, 3, 5] have explored using non-Gaussian distributions such as Gamma and Poisson distributed noise for training diffusion models, with performance closely matching that of Gaussian diffusion models.

3 Goals

- Create a low-light image denoising pipeline using Poission denoising model.

- **Stretch Goal:** develop a denoising model that can handle the injection of two separate noises, i.e. Gaussian and Poisson. This may be useful for modeling cases in low-light imaging where shot and photon noise are both relevant.

4 Timeline

- Week 1: Develop Poisson denoising model training regime. Gather low-light imaging dataset.
- Week 2: Train final model using Poisson distributed diffusion process.
- Week 3: Explore potential for diffusion models with Gaussian + Poisson noise.

References

[1] Wensen Feng and Yunjin Chen. Fast and accurate poisson denoising with optimized nonlinear diffusion, 2015.

[2] Eliya Nachmani, Robin San Roman, and Lior Wolf. Denoising diffusion gamma models, 2021.

[3] Eliya Nachmani, Robin San Roman, and Lior Wolf. Non gaussian denoising diffusion models, 2021.

[4] Cindy M. Nguyen, Eric R. Chan, Alexander W. Bergman, and Gordon Wetzstein. Diffusion in the dark: A diffusion model for low-light text recognition, 2023.

[5] Yutong Xie, Minne Yuan, Bin Dong, and Quanzheng Li. Diffusion model for generative image denoising, 2023.