EE 367
Myles Ragins
2/21/24

Project Proposal: RGB Image Restoration for Sensor Noise Reduction in CMOS Sensors Using Diffusion Models

Motivations

Sensor noise in CMOS sensors is a common problem that degrades image quality. CMOS sensors are widely used in consumer electronics due to their low power consumption and quick processing speeds. However, they are vulnerable to various types of noise, including Gaussian noise, color noise, and temporal noise, particularly in low-light conditions or high ISO settings. This noise can adversely affect various imaging applications, from photography to autonomous systems.

Effective noise reduction methods can significantly enhance the quality of RGB images, which is crucial for improving visual clarity and enabling better performance in tasks like object detection and analysis. The goal of this project is to explore a practical approach to sensor noise reduction using diffusion models, offering a promising technique for cleaning noisy RGB images.

Related Work

CMOS sensors are widely used for their efficiency and low cost but are prone to several types of noise. Past research has focused on hardware-based solutions to address these challenges. Early works like those of Hui Tian (2000) discussed intrinsic noise sources, while later works like Li Hai-feng's (2009) explored nonuniformity correction techniques. Recent advancements, such as El Gamal et al. 's (2022) work on RTS noise reduction, have developed algorithms that aim to address specific types of sensor noise more effectively.

Incorporating machine learning, recent studies have leveraged deep learning models for noise reduction. For example, Zhang et al. (2023) proposed a convolutional neural network (CNN)-based denoising model tailored to complex, non-Gaussian noise patterns. These machine learning approaches, while effective, tend to be computationally intensive and may require large datasets to perform optimally.

A novel approach to noise reduction that has shown promise in recent studies is the use of diffusion models, which have been successful in generating high-quality images from noisy inputs. These models work by progressively refining noisy images in a controlled manner, making them an attractive candidate for addressing sensor noise in CMOS images.

Project Overview

This project will explore the use of diffusion models for noise reduction in RGB images captured by CMOS sensors. The focus will be on Gaussian noise reduction, as it is one of the most common types of noise found in CMOS images. The approach will involve training a diffusion model to iteratively denoise RGB images while maintaining the structural integrity of the image, including preserving details in both high-contrast and low-light areas.

Timeline

Week 1 (2/24 - 3/2):

- Select dataset and preprocess images (apply Gaussian noise to clean images)
- Implement diffusion model framework and train on a subset of images
- Perform initial tests with the model on noisy images

Week 2 (3/3 - 3/9):

- Fine-tune the model based on results and improve denoising performance
- Implement traditional noise reduction techniques for comparison
- Evaluate and compare results using PSNR and SSIM

Week 3 (3/10 - 3/14):

- Final Refinement of results
- Prepare report and presentation summarizing findings and comparisons

References

[1] H. Tian, "Noise Analysis in CMOS Image Sensors," Ph.D. dissertation, Stanford University, 2000.

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