A pinhole camera is all you need?
(maybe? TBD…)

Niharika Gunturu

Motivation:

In this project, I want to consider the limiting case of having the most rudimentary camera hardware paired with an as-intelligent-as-possible image processing pipeline. In the first part of this project, I would like to investigate and implement an image restoration pipeline for pinhole photography: through a combination of standard image signal processing techniques as well as deep-learning based methods, and a combination of both.

If the image quality can be restored to a high degree with just deconvolution and de-noising - with no additional information added, and this leads me to the second motivation: would it be possible to perform perception tasks like image classification on the original pinhole camera with high success?

For both these tasks, I would like to investigate how poorly optimized the parameters of the pinhole photograph can be before:
a) the image restoration pipeline breaks down?
b) we can no longer satisfactorily perform image classification tasks?

Tasks:

I would like to perform the following tasks on a range of pinhole camera settings: including exposure times, and pinhole sizes while keeping the camera dimensions constant.

1) Calculate the PSF for a pinhole camera, for a given circular aperture with radius r.
2) Implement the entire Image Signal Processing pipeline: including deconvolution and denoising with the computed PSF to generate a final image with "classic" image processing techniques.
3) Perform image superresolution with this processed image and compare with results from image superresolution performed on the pre-processed image.
4) Perform image classification on pinhole photographs, document success as compared to classification on high resolution photos of the same scene.

Scientific Articles

Deep Camera Obscura: An Image Restoration Pipeline for Pinhole Photography:
https://opg.optica.org/oe/fulltext.cfm?uri=oe-30-15-27214&id=478821

Super-resolution:
Image super-resolution: The techniques, applications, and future

[Deep Learning for Single Image Super-Resolution: A Brief Review](#)

Many Perception Tasks are Highly Redundant Functions of their Input Data:
https://arxiv.org/abs/2407.13841

Tutorials/Blogs

Pinhole PSF:
https://tomroelandts.com/articles/the-psf-of-a-pinhole-camera
https://www.kth.se/social/files/5c7fae6756be5bc7488edcb5/Pinhole%20camera.pdf

Super-resolution:
https://www.digitalocean.com/community/tutorials/image-super-resolution