Computational Photography

Assignment #1: Camera Obscura

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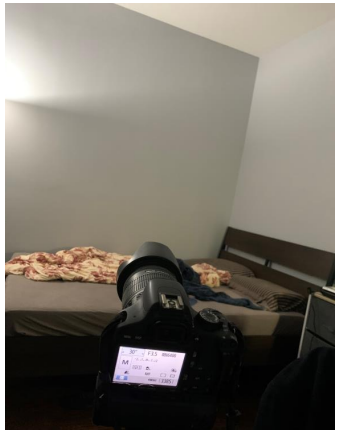
CS6475 - Spring 2020

Camera Obscura Project Overview

The Scene

The Final Image



The Set Up

Other Images

Project Summary and Image Descriptions:

I set up the Camera Obscura in my room. I used the foil to cover all the windows in my room, only leaving a coin-sized hole in the middle. Since my room has a good natural structure for a Camera Obscura, I simply used my white wall as the projected screen.
An SLR was placed near the light source of the room, to capture the reflective image in this work.
I did this experiment around 4PM, the scene is the building and dawn opposite to my apartment.

The Scene - Details

The Scene - Details

- What was the **scene** of your camera obscura experiment?

It is the building and the dawn outside my apartment.

- What was the **site** of your camera obscura experiment? In other words, where were you standing when you captured this scene? (e.g. living room)

It is the bedroom of my apartment.

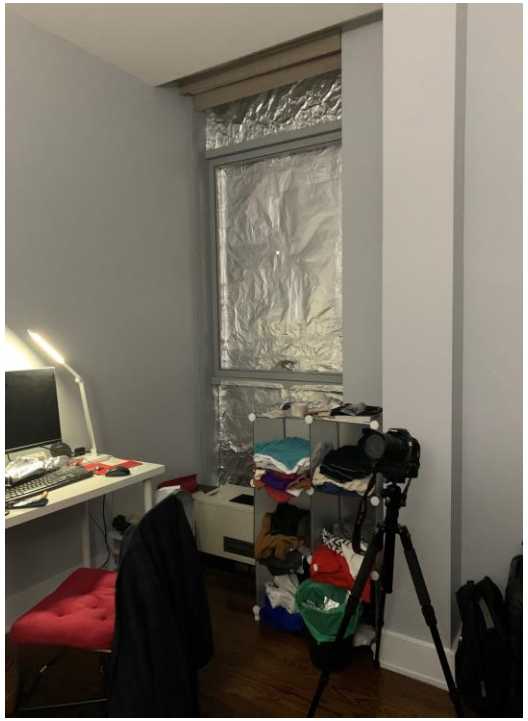
- Why was this **site** appropriate for your camera obscura experiment?

My bedroom has a good naturel structure for this experiment: a window and a white wall were face-to-face positioned and it is very small. It has only one window, reducing some bothersome work when one try to cover light sources from outside.

The Setup - Images

SLR camera setup: positioned to capture the reflective image on the wall

Light cover setup: Foil to cover all the window surface, leaving a nickel-sized small hole in the middle for outside light rays.



Positioning: SLR camera and covered window.

The Setup - Details

- If you constructed a box camera obscura, explain why you were not able to build a room camera obscura.
    - This question is **required** for those who built a box camera obscura for the base assignment. You may skip this question if you did a room camera obscura.
    - If you made a serious attempt to build a room camera obscura and failed, make sure to discuss your failed attempt(s) in “The Setup - Failures” section.
- Discuss what you used to capture your image on (i.e. screen material)

White wall. White wall is perfect because firstly its coarse and reflective. Secondly, it’s white paint is relatively light-emphasizing, reflecting discrete points of light.

The Setup - Details

- Describe & explain the construction of your camera in detail.

Firstly, I tried to cover my window in my room. I decided to use foil considering its soft texture, flexibility. Cardboards have been a choice in my mind, it was rejected because it will leave some space around window's frame, leading the light to leak in.

The foil was set up piece by piece, connected with plastic tapes. The frame was sealed by foil. After 98% of the window was covered, I opened a coin-sized small hole in the last piece foil and put it right in the middle of the window, completed the whole process.

Secondly, I set up the camera with a tripod near the window.

Last step, I turn off all the lights and start to capture.

The Setup - Failures

- Did you have any initial setups that failed?

No, my experiment succeeded in the first attempt.

The Image - (No post processing)

Camera Settings

- Aperture: F3.5
- Shutter Speed: 30 secs
- ISO: 6400

The Final Image(s) - Details

- Compare your final image with the projection inside the camera obscura viewed with a naked eye. How did your camera settings impact your results? Be sure to discuss what apps or methods you used to control your camera settings.

The final image is upside down compared to naked-eye view. This is understandable because when the light ray spreads in straight and the ray from the upper side in the real world will go bottom after traveling through the small hole and vice versa.

I viewed the reflective image with naked eye, some light spots were discovered. They have some opaque shape of the outside building, but without color and details.

I used an SLR camera to capture the image. It's clear that more aperture, ISO and shutter time, the capture will be more visible. Because larger aperture control more light to flow into camera, larger ISO will let the camera to be more sensitive to the light rays, thus creating brighter outcome in camera and obviously, longer shutter time will allow the SLR to get more information from the light rays.

So I used the 'Manual' model in my SLR, set ISO and Aperture to current maximum: 6400 and F3.5, and shutter time to 30 seconds, based on my research on other's similar experiment. I got a satisfactory image from the first shot.

The Final Image(s) - Details

- If your image is too dark and noisy you can use external software packages to process your result. Discuss image enhancement and/or cropping, if used here.

I didn’t use any external software to process my result.

The Final Image(s) – Field of View

- What is the camera obscura field of view (FOV) that you observed? Show your work/method.

Camera obsura's FOV is measured as 68 degrees. I measured camera obscura's FOV through: Observe and mark the edge points of the projected image's naked eye view on the wall, connect them with the pinhole in same vertical level using measure tape, record the tape's shadow projected on ground near pinhole's position, measure the degree between lines by a protractor.

- What is the FOV for your lens-based digital camera that you used? Show your work/method or say where you got the FOV from.

The SLR's FOV is approximately 77 degrees. I measured it by observing the edge points appear on my final image and marked them on the wall and the position where I set up my camera. I connected these points (left edge to camera and right edge to camera) in my room by using tape measure and record the tape's shadow projected on the ground by drawing lines of the shadow on paper, near the camera's position. Then, I used a protractor to measure the degree between lines.

*FOV is measured in **degrees** - See appendix in instructions for details*

The Final Image(s) – Field of View Continued

- How does your camera obscura's FOV compare to the FOV for your lens-based digital camera at the settings used to capture your final image(s)?

SLR's FOV is larger than camera obscura's FOV, based on my measurement in the previous slide.

Pinhole Dimensions

In addition to the pinhole dimension you used to capture your final image(s) (on template slide 8), experiment with at least 2 additional pinhole dimensions. Record the measurements and include the final image of your scene taken using each pinhole (replace the blank placeholders)

Make sure you specify which Final Image goes with which pinhole dimension.

Pinhole A dimension: one nickel-sized hole

Pinhole B dimension:

It's a pity that I forgot to do this repetitive experiment. After I realize this, I have removed my camera obsura and running out of time. If I have more time, I will definitely conduct it again.

Pinhole C dimension:

Pinhole Dimensions - Details

- Discuss the effect of pinhole dimension on each final image and compare

  Although I missed this part's experiment, as I thought, if the hole is too small the room will be too dark for me to see the image clear. If it is too large, the image will diffuse and will lose its sharpness and details. It's a tradeoff when selecting the size of the hole.

- What did you learn from this pinhole experiment?
- Human's naked eye capability is limited, but intelligence can help us see more.
- "Light rays go straight" get validated by myself for the first time.
- Teamwork is crucial when you trying to setup some manual work.
- Reading between lines carefully before start the project is extremely helpful.
- Light is every where. Wherever there is darkness, there exists light.

Post-processing - Noise reduction

- You are required to implement three filters to process your original(no-post processing) CO image. Show the Averaging filter and Gaussian Blur Filter kernel below. For median filter what was your window size(MxN)?

  (If you used a filter of a different size other than 3 x 3 replace the matrices with the ones you used)

$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

Averaging Filter

$$\begin{bmatrix} 0.059 & 0.097 & 0.059 \\ 0.097 & 0.159 & 0.097 \\ 0.059 & 0.097 & 0.059 \end{bmatrix}$$

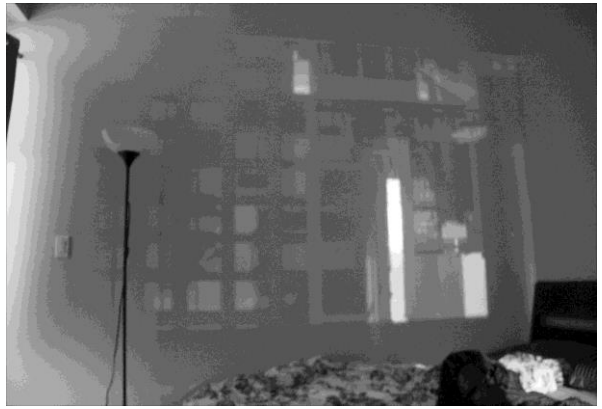
Gaussian Blur Filter

3 x 3

Median filter neighborhood size

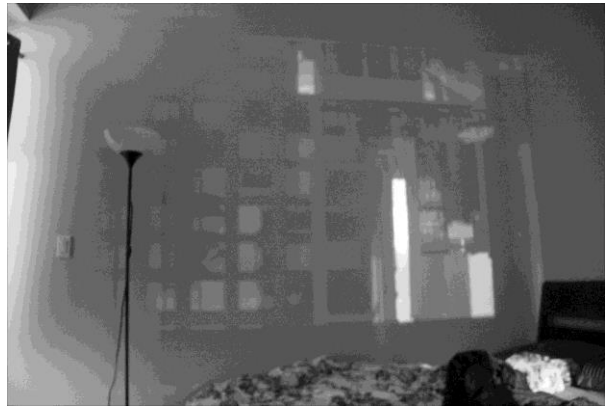
Post-processing - Noise reduction

- Show the output from the three filters



Averaging filter

Gaussian filter



Median filter

Post-processing - Noise reduction

- Compare the outputs of the three filters. Which one seems to work better? Why?

  The Gaussian filter seems to work better. Unlike simple average or median method, the Gaussian filter use a Gaussian function to make a mapping from the neighborhood pixel value to the post-processing value. So, it has a more smooth photo compositing approach.

  For my understanding, Gaussian filter give weights to its 3x3 neighborhood that follows a 2D Gaussian distribution, which is in cater of human eyes' perception mode.

  So, Gaussian filter will make people feel more smooth and comforting than average or median filter when observing the post-processing photos.

  Note: The images look different and little bit wired if this document converted to PDF. Please see the original ones in Resoures.zip

Post-processing - Noise reduction

- Explain your code that you used for the three filters here

Firstly, the “applyConvolution” function. Average and Gaussian filter did nothing but a convolution on the image. I followed the definition of convolution shown on slides, looped through the original image array except the border area, found the 3x3 neighborhood and conducted an element-wise multiply & summation with filter array, pumped out the summation number in output matrix at the same place.

Secondly, average and Gaussian were done by adjusting the filter.

Thirdly, there is no need to create filter for median method, since it use the median of 3x3 neighborhood as output for each pixel. “Numpy.median” function was exploited here.

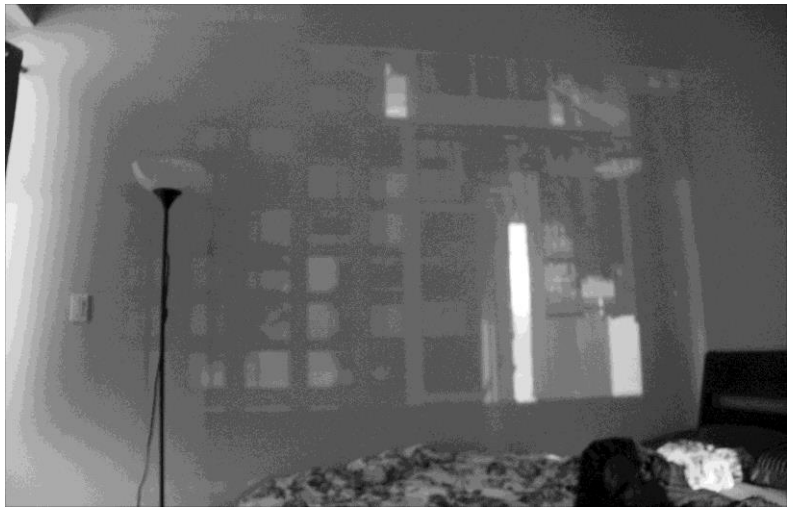
So, the core function is the “applyConvolution”, the outputs (except median) are based on this function by adjusting “filter” attribute in function input.

Post-processing - Image Sharpening

- Design a simple image sharpening pipeline with an image sharpening kernel. Show your output image and the Kernel here

-0.11	-0.11	-0.11
-0.11	1.89	-0.11
-0.11	-0.11	-0.11

Sharpening Kernel



Post-processing - Image Sharpening

- Does your image look sharper with the filter? Explain your code here

I used a liner combination on average filter and single filter (1 for center 0 otherwise) to sharpen the photo. The filter has all negative values except center.

Yes, it looks sharper. It can enhance its original color and reduce the effect of neighborhood in each pixel, for the negative values except center in the filter.

Project Retrospective

- If you were to repeat the project, is there anything you would do differently knowing what you know now? Discuss.

I would like to start the project earlier. The experiment difficulty is smaller than I expected but the coding part is beyond my expectation. I have to read the slides couple times to fully understand what's the mathematical presentation I have to finish by coding.

I would like to read through the report template again before start. I forgot to do the repetitive experiment by adjusting the pinhole's width. When I realize it, My foil and cover has been removed.

Resources

Record your sources here. We accept all reasonable formats that would allow us to verify your sources.

https://learn.zoner.com/experiment-making-a-room-sized-camera-obscura/

https://iva.velux.com/competitions/international-velux-award-2020/posts/light-and-materials

Remember: It is plagiarism if you don't reference your sources!

Help from Others

- You may have had help building the camera.
  - My friend helped me build the camera obscura by standing on a table and covering the window using foil.

Other Details

- Feel free to share other thoughts associated with this project. Add more slides if required after this slide