A1 - Camera Obscura

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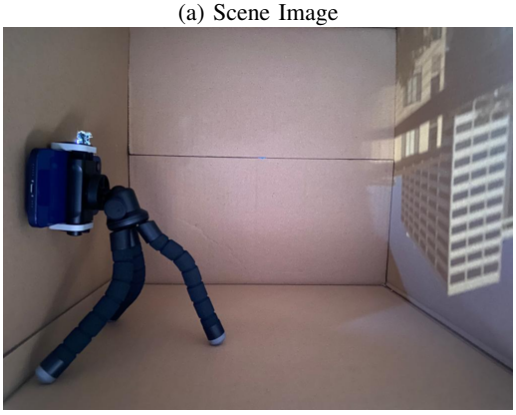
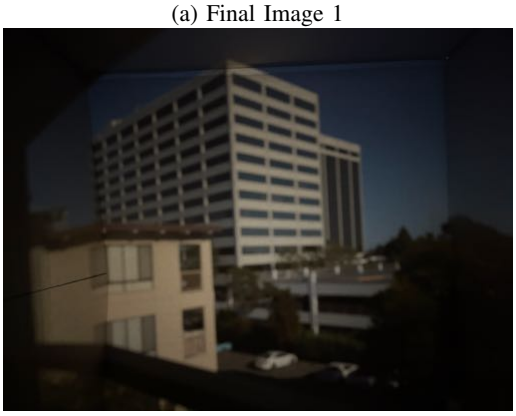
(a) Scene Image

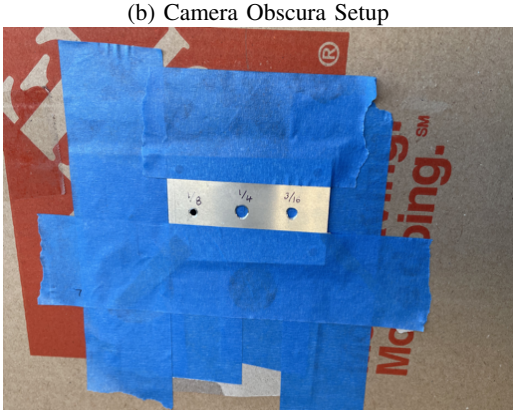
(a) Final Image 1



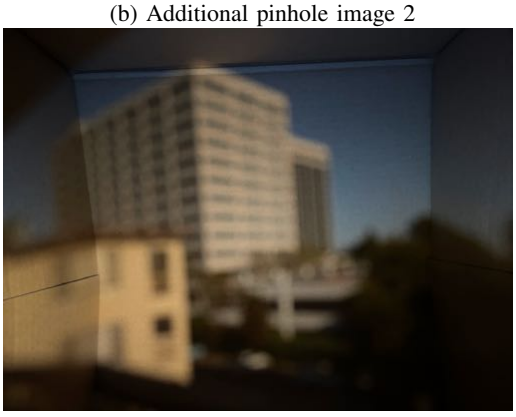
(b) Camera Obscura Setup



(b) Additional pinhole image 2



(c) Image of the pinholes



(c) Additional pinhole image 3

I. The Scene

Discuss the scene. Insert an image at Figure 1a you chose to capture for the camera obscura experiment. Where is this scene located? What subject(s) in the scene were you trying to capture?

The scene is located outside my balcony. There are two office buildings to the left of our residential building. The sun sets opposite the buildings so ample sunlight reflects off them from noon to sunset at 7 pm. This provided a good working window for me to experiment and develop my camera obscura setup.

II. The Setup

1) **What was the site of your camera obscura experiment? In other words, where were you standing when you captured your chosen scene (e.g. Living room)? Why was this site appropriate?**
   The camera obscura (box setup) was placed on my balcony (fourth floor) pointing towards the left of our building. This site was appropriate because of the large buildings that are in view. Directly in front of my balcony, and windows are large trees that block sunlight and the view.
2) **If you constructed a box camera obscura, explain why you were not able to build a room obscura**
   I chose to build a box-camera because the view directly in front of my balcony/windows is of large trees that provide no discernible subjects. With the box camera, I was able to point my setup to a subject that was both large, far enough and directly in the angle of sunlight providing excellent lighting and views.
3) **Discuss what you used to project your image on (i.e. screen material.)**
   I didn't need to use any special screen material. The inside of the box did a surprisingly good job of capturing the bright white light reflecting off the white buildings. So the material was just the card box material (paper liner).
4) **Discuss the construction process of your camera obscura in good detail.**
   I chose a heavy-duty moving box for the stiffness and durability. The box dimensions were 22x22x20.
   I closed the bottom flaps and sealed it off using tape. I left the top open, and turned the box over to the side so that the box would lay sideways. I would use this side entry point to move my camera+tripod assembly in and out of the box.
   Picking the left adjacent side as my pinhole side, I marked off the center of the side using a ruler. With regards to the pinhole, as I wanted to test out various pinhole sizes, I didn't want to rely on a pinhole directly in the box, as that would just be one size, but more importantly, the box wall was quite thick. I needed the pinhole to be both interchangeable, and made of thin material. As I had access to a drill, I used a scrap piece of aluminum plate (0.03 inch thickness), I drilled three holes of sizes: 1/8, 3/16 and 1/4 inch. For a much larger hole size, I didn't have a drill size as large, so I used card stock and a pencil compass to draw out and cut a 0.75 inch hole using a blade. On the box itself, I cut out a 1 inch square hole. I could now cover the hole with either the aluminum plate or the card stock aligning the desired pinhole size on top of the cutout in the box. Using tape, I secured the pinhole in place, making sure that the plate was covering the box cutout completely. I had to raise the box on top of a small stand to raise the box above my balcony railing height.
   To help with positioning the box correctly, I used a thick black table cloth to cover the box. I was then able to look inside the box by ducking my head under the cloth and peeping into the open end of the box. The black cloth blocked off enough light for me to start seeing a dim outline of the target subject inverted on the back of the box. I moved the box until the target's reflection was lined up as desired.
   I used a small flexible leg tripod to position my cell-phone camera in landscape mode. I tried to line up the camera lens below and in line with the cutout in the box. The idea was to capture an image from the view-point of the cutout.
   To capture the image, I used a bluetooth remote. This allowed me to seal off the box to block out all other sources of light. Using the clicker I was then able to capture the projection images. Turning up the volume on the phone and using a shutter sound effect also helped with knowing if the image was done being captured, especially for the longer exposure shots.
5) **Did you have any initial setups that failed? If yes, discuss what you did and provide images of these failed setups. If no, say so.**
   No, I didn't have any setups that failed. I made small adjustments along the way so the overall setup and capture process was developed incrementally.

III. Final Image

Fig. 3: Original Image 1

1) **Enter EXIF camera settings below:**

Exposure	Aperture	ISO
4secs	f/1.6	iso 3200

2) **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 projection inside the camera obscura was extremely dim. The only way to view it was to use a large black tablecloth to cover the camera opening and to go under it. This is what prompted me to use the Slow Shutter iPhone app. The app allowed me to take a long exposure shot while also setting the mode to "low light". As I couldn't see the final projection once the box was sealed up, it was more effective to allow the app to auto-set the ISO for low lighting conditions.
3) **What post-processing did you use. Discuss the steps and software you used. If you did not do any post-processing, say so.**
   I didn't need any post-processing except for a rotation by 90 degrees clockwise and then flipping horizontally.
4) **What is the camera obscura field of view (FOV) that you observed? Do not just guess an approximate FOV. You have to show how you arrived at the FOV reported.**
   Using a protractor on top of my box camera, I lined up the protractor's vertical line with the pinhole location. Estimating from my captured images, I looked for the furthest object to the left and the right that I could identify in the images. I used a pencil to mark off the approximate left and right degrees where these object line up. My left was at 50 degrees and right at 130 degrees. This gives an approximate FOV of 80 degrees. Because of a wall on one side, and a large tree on the other the actual edges of the image are hard to identify.
5) **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.**
   I used an iPhone-12 with the default rear camera. To calculate the field of view, I referenced the *FocalLengthIn35mmFilm* value from my final image's EXIF data which was 26mm. Using this value and the formula: $FOV = 2 * arctan(35/(2 * 26))$, I calculated a FOV of 67.88 degrees.
6) **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)?**
   The camera obscura's FOV is greater than the default phone camera angle. This is supported by the fact that the images captured by the phone camera are cut off on each side, while the projection continues outside the frame of the captured image.

IV. Pinhole Experiment

Fig. 4: Original Image 1

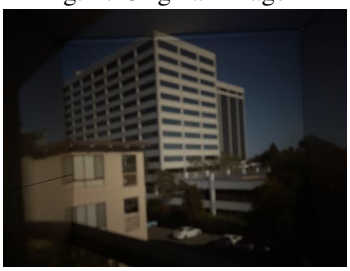


Fig. 5: Original Image 2

Fig. 6: Original Image 3

In addition to the pinhole dimension you used to capture your final images, experiment with at least 2 additional pinhole dimensions.

1) **Discuss the effect of the chosen pinhole dimension on each of the final images and compare your results**
   The best image I captured was using a 1/8 inch hole. However, I first started off with a much larger hole of 3/4 in diameter. Noticing that the image was quite blurry, I tried smaller hole sizes of 1/8, 3/16, and 1/4 inch. The 1/8 inch showed the sharpest image. The 3/16 inch hole showed slight blurring, but it was difficult to differentiate from the 1/8 capture. The 1/4 inc showed slightly more blurring but less than the 3/4 inch diameter. While the lower diameter images were sharper, they were also dimmer - which required a long exposure to get a usable image.
2) **What did you learn from this pinhole experiment?**
   This experiment showed that the image pinhole size greatly influences the projection's sharpness and brightness. Larger holes allow more light in but diffuse the scene. Smaller holes have less diffusion but require a longer exposure time to be able to capture an adequate image. The thickness of the material used for the pinhole also plays a part. Using a cutout in the cardboard box was not effective because of the thick wall of the heavy-duty box I chose. Enlarging the cutout and using a thin metal cover plate with pinholes proved much more effective.

V. Project Retrospective

Even though I got a pretty good view of the subject from my balcony, my field of view was restricted due to my balcony placement. If I were to repeat this project, I would take the camera box to an open area for unrestricted view.

My box size was also a bit limiting. The projection surpassed the back wall of the box and distorted the image as it was projected on the sides. Using a box with the same focal point, but a larger projection area would help with this. Also having the back painted white would have improved the projection brightness for the smaller diameter pin holes, specially for the darker images in the scene like the trees direclty outside my balcony.

I captured all my images using the default f/1.6 camera on my phone. However, a second ultra-wide camera is also available with an aperture of f/2.4 which would have given me a larger capture angle.

VI. Acknowledgements

My wife loaned me her phone to take images of my setup while my phone was placed inside the camera box.

References

[1] Ed Lessons, Field of View, FOV Lesson, Accessed: Sept 5, 2022
[2] The Photo Forum, Field of View Calculations, , Accessed: Sept 5, 2022

APPENDIX

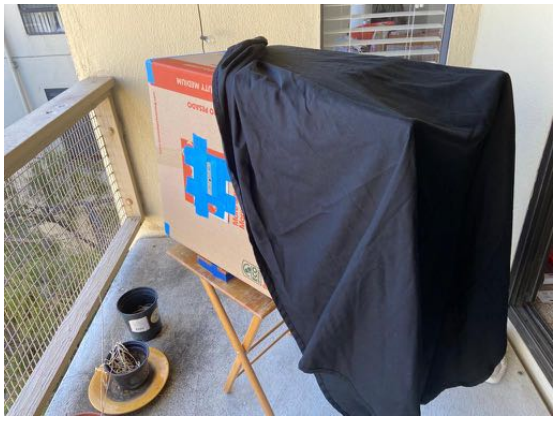


Fig. 7: Box-camera on stand

Fig. 8: Example projection

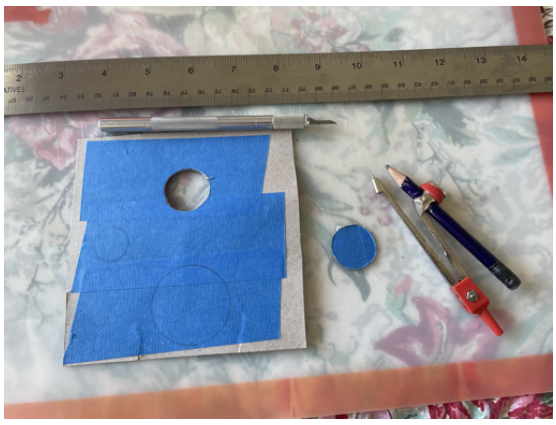


Fig. 9: Large pinhole construction