CSCE 689: Computational Photography

Prof. Nima Kalantari

Assignment 1 - Report

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1. Task 1: Designing the Pinhole Camera

We built a pinhole camera following the steps as given in the assignment document. We cut a hole in the box for the pinhole, and covered this hole with an aluminum foil with the inner side painted with black color to avoid internal reflections as the aluminum foil's surface is glossy, so that we can easily increase the size of the pin hole. On the opposite side of the pinhole, we placed a plain white paper as the screen by sticking it to the box with adhesives. We cut a hole for the DSLR/phone to capture images. We sealed the corners of the box with duct tape to avoid any light entering the camera. Fig 1 is the image of our pinhole camera.

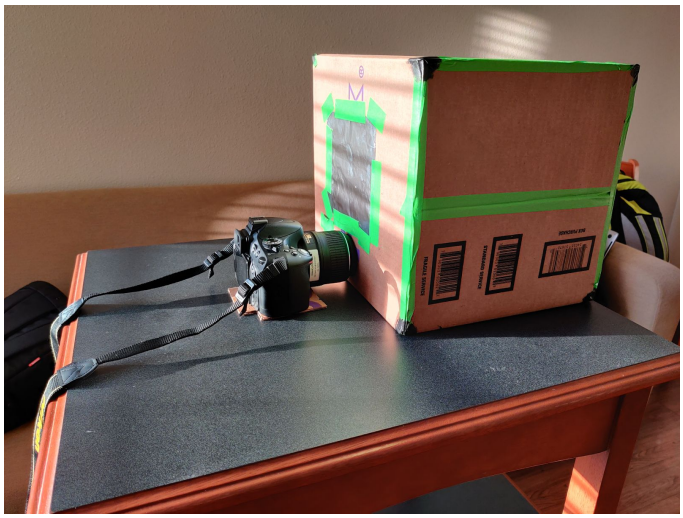


Fig 1. Picture of our Pinhole Camera

2. Task 2: Image Capturing

Tools and Setup:

- Camera: Nikon DS5100
- Scene 1: Window Frame in sunlight
- Scene 2: Candle in under-illuminated room
- Pinhole Sizes: 1 mm, 2 mm & 5 mm

All experiments were performed considering three pinhole sizes (diameters): 1mm, 2mm, and 5mm (approximately measured). For each of the three pinhole sizes, we used two objects: a window frame in bright sunlight (Fig 2) and a candle in the dark (Fig 4). We experimented with long exposure times from 15s to 30s and observed that 30s gave the best images as longer exposure times allow more light which enhances the overall quality of image. Thus, we used 30s as the exposure time for capturing all the images. In addition to this, we used a smartphone camera to capture the same images from the pinhole camera to contrast with the images captured by the digital camera.

Scene 1: Window Frame

Fig 2. The window frame and the setup

Diameter = 1 mm | Diameter = 2 mm | Diameter = 5 mm

Fig 3. Images from Pinhole Camera for Scene 1

Scene 2: Candle

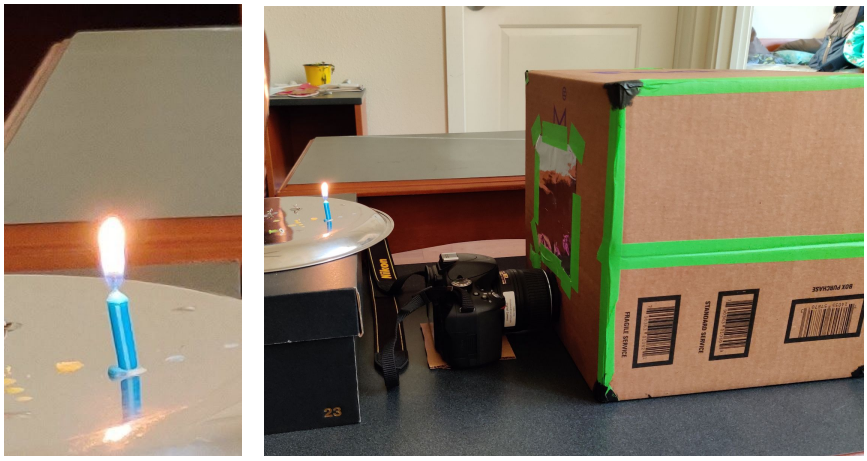
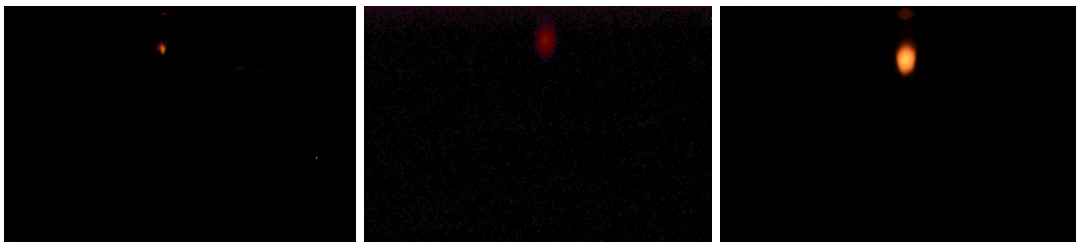


Fig 4. Candle and setup



Diameter = 1 mm Diameter = 2 mm Diameter = 5 mm

Fig 5. Images from Pinhole Camera for Scene 2

3. Observations and Analysis

We analyzed the images captured from the pinhole camera (shown in Fig 3 and Fig 5) and observed differences with respect to the sharpness and brightness for the different pinhole sizes.

- For the pinhole with diameter 1 mm, we noticed that the images were sharp (less blurry) but less bright.
- For the pinhole with diameter 2 mm, we observed that the images were brighter but less sharp when compared to the ones captured with 1mm diameter.
- For the pinhole with diameter 5 mm, we observed that the images were brightest and blurriest when compared to the images captured with 1 mm and 2 mm diameters.

Conclusions:

1. The smaller the size of the pinhole (or the aperture of the camera) lesser is the blurriness of the image. But the brightness of the image is also less. This is because, a small pinhole allows less light to pass through resulting in less bright images. Additionally, a small pinhole concentrates all the light in a single direction, which creates sharp or less blurry images.
2. When the size of the pinhole is large, more light passes through the hole, which creates brighter images. But a large pinhole spreads the light from the object in different directions (i.e. not properly focused) which makes the images blurry. Therefore, there is a tradeoff involved while deciding the size of the aperture of the pinhole camera.
3. If we keep decreasing the aperture size, another optical effect starts to dominate. As the size of the aperture becomes comparable to the wavelength of the light, the light rays experience diffraction, and hence the image becomes less sharp.

4. Light Painting

Light painting involves creating patterns on a dark screen using a light source with long exposure times to capture the paintings. To achieve this, we used a moving light source in an non-illuminated surrounding while taking a long-exposure photograph. The exposure time was set to 15s for best results. Some examples are shown in Fig 6.

Tools used:

- Camera: Nikon DS5100
- Tripod: To keep the camera stationary while taking the long-exposure (15 seconds) photo.
- Light Source: Various light sources of distinct chrominance were used to form patterns in the photo. We used flashlights, small portable lamp, and mobile applications to produce different colored light waves.

Caution had to be taken to prevent vibrations during the capture. Fig 6 shows our results for light painting.

Fig 6. Light Painting

5. Stereo Pinhole Camera and Anaglyph Image

The following steps were followed to build a stereo pinhole camera and construct anaglyph images.

- The pinhole camera designed earlier was altered where two pinholes, each of 2 mm diameter were created in collinearity with the digital camera. The reference image is shown in Fig 7.
- One of the pinholes consisted of a transparent blue filter while the other consisted of a transparent red filter.
- Two images were captured. One by covering the red filter and another by covering the blue filter completely.
- The two images were then used to construct an anaglyph image using the stereoAnaglyph(Image1, Image2) function available in Matlab (Fig 10 and Fig 13).

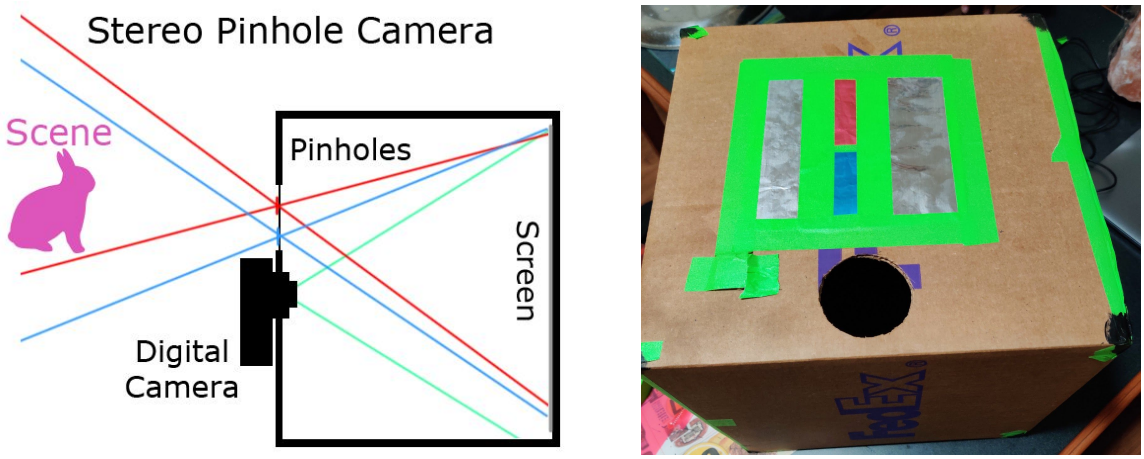


Fig 7. Stereo Pinhole Camera

Scene 1: Window Frame

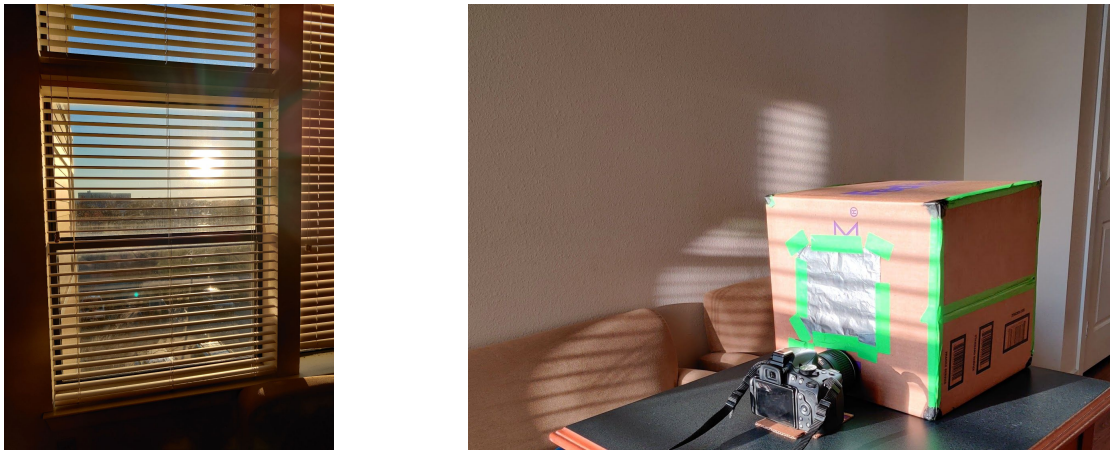


Fig 8. Window Frame and setup

Image captured with red filter Image captured with blue filter

Fig 9. Images from stereo pinhole camera for scene 1

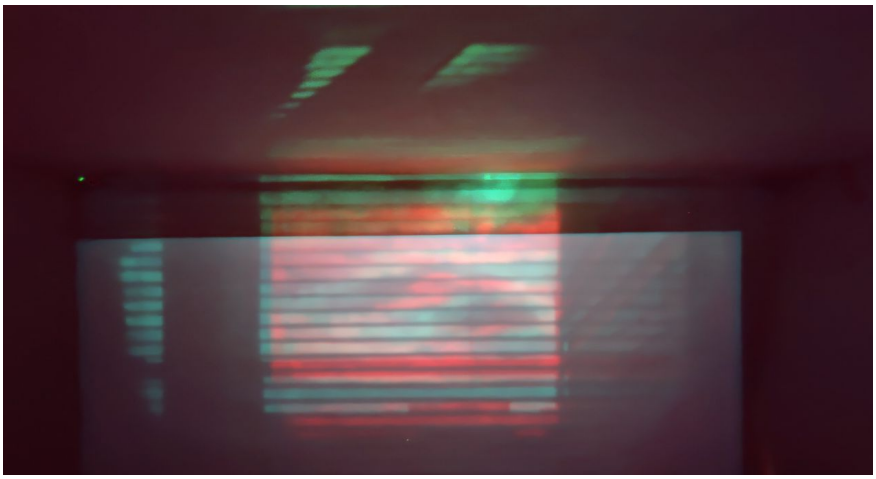


Fig 10. Anaglyph of images in Fig 9

Scene 2: Water Jug

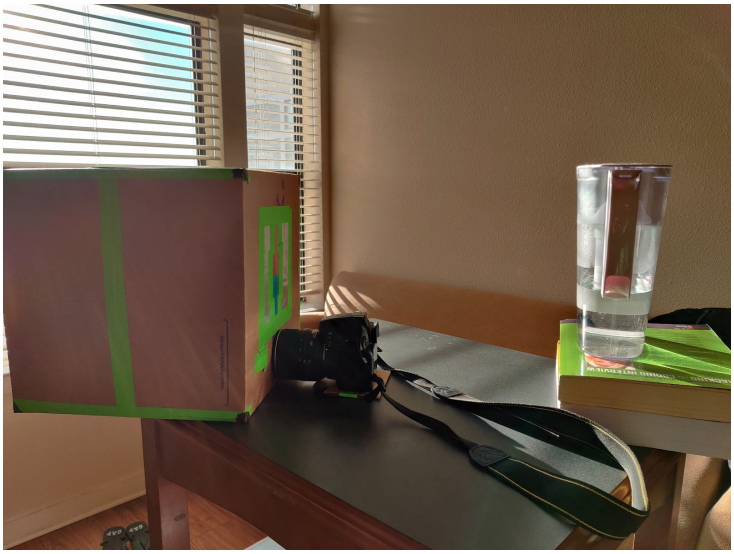


Fig 11. Water Jug Setup

Image captured with red filter Image captured with blue filter

Fig 12. Images from stereo pinhole camera for scene 2

Fig 13. Anaglyph of images in Fig 12

6. Digital Camera Vs. Smartphone Camera

Through this experiment, we observed that our smartphone camera captures images that are of much higher quality than the DSLR camera. This was contrary to our hypothesis, so we tried to learn more about how smartphone cameras capture images in “night mode”. The smartphone camera which we used was OnePlus7, and this is how the night scape feature works in OnePlus7.

- The night scape feature increases the camera ISO before capturing the image
- Multiple images are captured with varying shutter speeds. The number of photos to be captured and length of the shutter exposure time is decided based on the brightness of the subject, the steadiness of the camera, etc.
- Then the phone employs AI and image processing techniques to “stitch” the images together. While combining the images, it decides the most accurate colors for the image, and the most natural light-to-dark tone mapping.

(Source:https://www.businesstoday.in/technology/news/nightscape-is-oneplus-implementation-of-night-mode-features-for-the-phones-camera/story/290825.html)

For comparison Fig 14 shows a few images taken from OnePlus7’s nightscape mode against DSLR, capturing the image formed inside the pinhole camera.

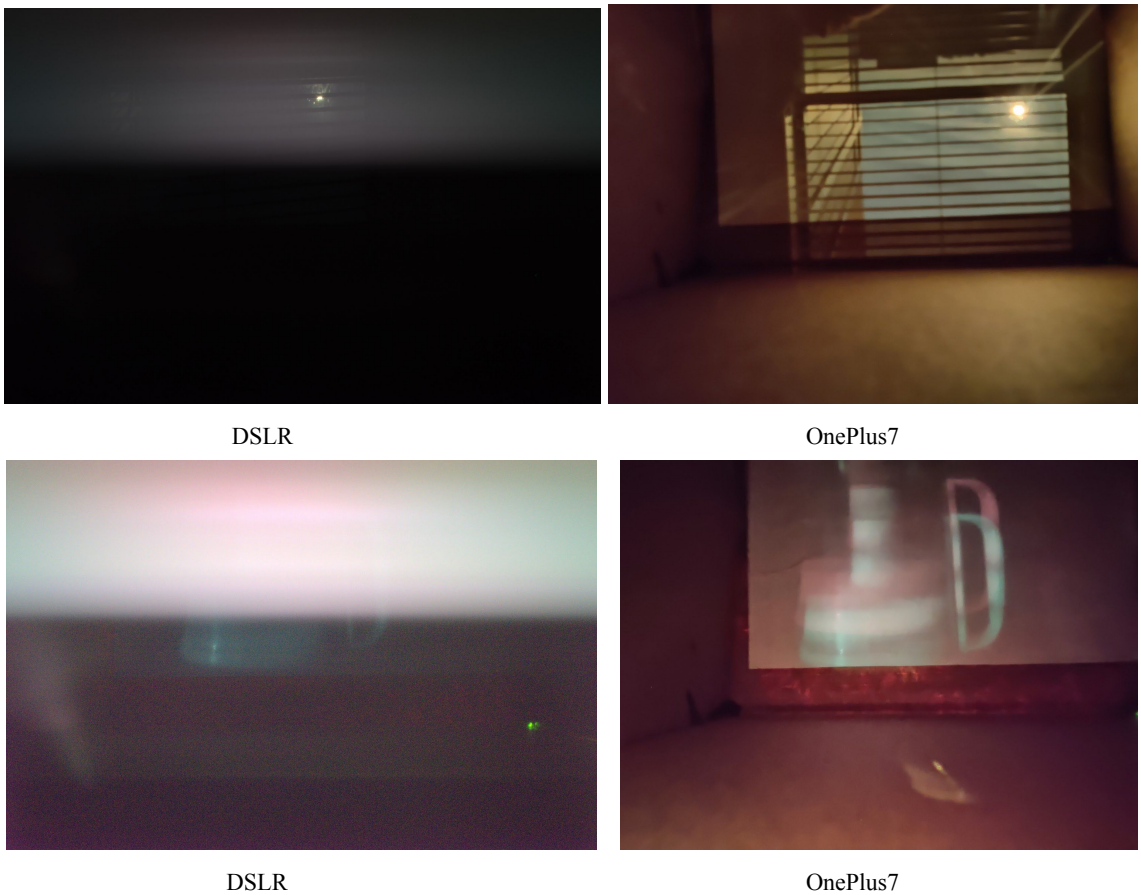


Fig 14. Image quality comparison between DSLR and OnePlus7