ME491(B)
Homework 1 - Camera Obscura

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Contents

1 Introduction

Today, the digital camera is widely used. Due to new technology and mobile phones, the digital camera is easily accessible and can almost be regarded as a part of the daily life. This is especially true for the younger generation and their use of social media like Instagram and Snapchat. In 2015, it was estimated that well over 1.8 billion photos were taken and uploaded daily [3]. Further, combining ever-improving deep learning techniques and AI with the digital camera, the field of computer vision has seen an impressive progress over the last years [2].

The forerunner to the photographic camera is the camera obscura. In this homework, a primitive camera obscura will be developed and the projections made by the device captured. First, the camera obscura will be presented and the development process described. The projections made by the camera obscura will then be presented.

2 Camera obscura

As mentioned, the camera obscura is the forerunner to the photographic camera. Another name for the camera obscura is the "pinhole camera", and how the camera obscura works is described by the pinhole camera model. The model describes the mathematical relationship between the coordinates of a point in three-dimensional space and how the point is projected onto an image plane. In short, the camera obscura only allows light rays from one point in the scene to strike each point on the image plane. An illustration of the camera obscura principle is shown in fig. 1.

The performance of the camera obscura is heavily dependent on the size of the opening, which is generally referred to as the center of projection or focal point. If the opening is too big, light rays from different points in the scene will be projected onto the same point on the image plane, resulting in an averaging of the light rays. If the opening is too small, the projection will suffer from diffraction effects. The consequence of either a too big or too small opening is a blurred image.

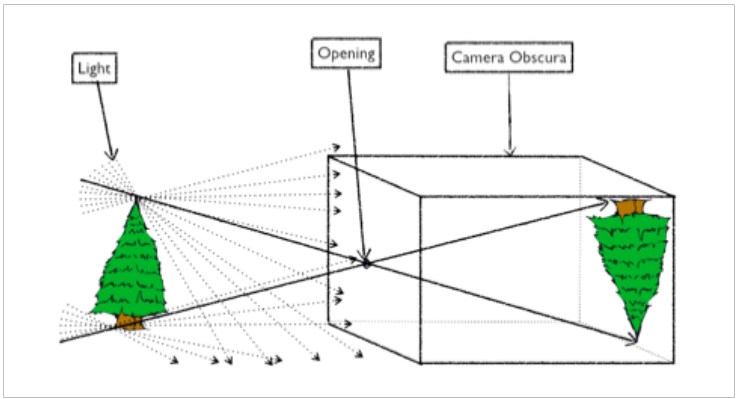

Figure 1: Camera obscura principle. Taken from [1].

2.1 Making a camera obscura

Inspiration and instructions on how to make a primitive camera obscura was found on YouTube [4]. The materials used to create the device included a shoe box, tin foil, tape, scissor, knife, paper and a pen. The materials are shown in fig. 2.

Figure 2: Materials used to make a camera obscura (pen is missing).

First, two rectangles were cut out of one of the sides of the shoe box. On the opposite side of the two rectangles, the inside of the shoe box was coated with paper. The result is shown in fig. 3. Then, one of the rectangles was covered with tin foil. Finally, a hole was made in the tin foil using a pen.

Figure 3: Inside of the homemade camera obscura.

The finished camera obscura can be seen in fig. 4. The left rectangle with the penetrated tin foil will work as the focal point. Here, light rays will pass through the opening and create a projection on the paper background inside the shoe box. The right rectangle works as a peephole. In order to see the projection, it is possible to look inside the right rectangle. When the projections were captured as photos, a mobile phone with camera was placed onto the right rectangle.

Figure 4: Outside of the homemade camera obscura.

2.2 Results

Due to being quarantined, it was not possible to go outside and capture exciting projections. In other words, all the projections had to be captured from indoors. Generally, a camera obscura requires a substantial amount of light to make display a projection. In order to get enough light for the projections, the camera obscura was aimed out of two different windows.

The first projection is of a garage and is shown in fig. 5. The same projection was captured with two different camera settings. It was generally difficult to capture the projection due to several factors. One of them was keeping the camera steady while taking the photos, and the effect of a shaky camera can be seen in fig. 5b. Having an unsteady camera combined with long shutter speed distorted the left side of the photo. Further, the projection in both fig. 5a and fig. 5b is somewhat blurred. This is due to a combination of the pinhole size, camera settings and the how the photography was executed.

(a) Lower sensitivity (ISO=1600) and shorter shutter speed (SS=0.5s).

(b) Higher sensitivity (ISO=3200) and longer shutter speed (SS=1s).

Figure 5: Projection of garage taken through window.

The second projection is of a neighbour house and can be seen in fig. 6. It should be noted that the scenery is not completely identical in the two photos. Similar to the previous photos, these photos are also somewhat blurry. The photos are also quite dark, as a result of insufficient lighting.

(a) Lower sensitivity (ISO=1600) and shorter shutter speed (SS=0.5s).

(b) Higher sensitivity (ISO=3200) and longer shutter speed (SS=1s).

Figure 6: Projection of neighbour house taken through window.

Lastly, it was tested out to capture projections using a smaller pinhole size. Instead of using the tip of a pen to make the hole, a 0.5 mm carbon rod was used to make a hole in the tin foil. The result is shown in fig. 7. Due to the smaller pinhole size, fewer light rays enter the camera obscura. As a result, the projection is much darker. Because of the lack of light, it is impossible to determine if the smaller pinhole made the projection clearer or not.

Figure 7: Projection of neighbour house with smaller pinhole size (ISO=3200, SS=1s).

References

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[2] Rostyslav Demush, ed. *A Brief History of Computer Vision (and Convolutional Neural Networks)*. URL: https://hackernoon.com/a-brief-history-of-computer-vision-and-convolutional-neural-networks-8fe8aacc79f3 (visited on 03/24/2020).

[3] Rose Eveleth, ed. *How Many Photographs of You Are Out There In the World?* URL: https://www.theatlantic.com/technology/archive/2015/11/how-many-photographs-of-you-are-out-there-in-the-world/413389/ (visited on 03/24/2020).

[4] Angela Wiser, ed. *Camera Obscura aka Pin Hole Camera for Solar Eclipse*. URL: https://www.youtube.com/watch?v=pTjzSsk4Lw8&list=WL&index=3&t=0s (visited on 03/23/2020).