CSCI 5980 Assignment 1

1 Designing Camera Obscura

The dimension of the camera obscura is 12.7cm × 31cm × 38cm. In the Fig.1, we show the design of the camera obscura and some pictures.

(a) Camera obscura

(b) holes

(c) Bikes

(d) A building

Figure 1: Design of camera obscura and some pictures

2 Where am I?

The focal length of the camera is

$$\begin{aligned} f &= f_m * \frac{h_{img}}{h_{ccd}} \\ &= 2.01\ mm * \frac{4160\ pixel}{4.8\ mm} \\ &= 1742\ pixel \end{aligned} \tag{1}$$

where the focal length in meter is 2.01 mm.

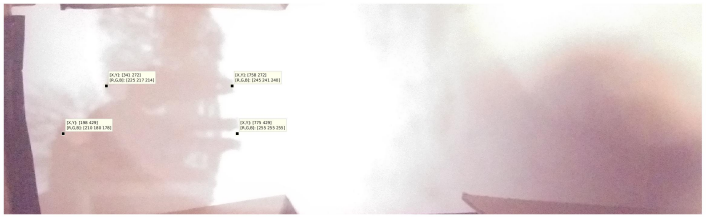

Figure 2: First picture

Given the first picture Fig. 2, we list the heights of person A(male, closer to the pinhole) and person B(female, further to the pinhole) in meter and pixel respectively as below

$$
\begin{aligned}
H_A &= 1.65\ m \\
h_A &= 775 - 198 = 577\ pixel \\
H_B &= 1.69\ m \\
h_B &= 758 - 341 = 417 pixel
\end{aligned}
$$

Then we can compute the distance of A and B from the pinhole respectively

$$
\begin{aligned}
d_A &= f * \frac{H_A}{h_A} \\
&= 1742 * \frac{1.65}{577} \\
&= 4.9815\ m \\
d_B &= f * \frac{H_B}{h_B} \\
&= 1742 * \frac{1.69}{417} \\
&= 7.0599\ m
\end{aligned} \tag{2}
$$

3 Dolly Zoom

We take another picture Fig. 3 of A and B after taking a few steps back, and we measure the pixel height of A $h_A^{'}$ and compute the distance of A from the pinhole $d_A^{'}$ again

Figure 3: Second picture taken after taking a few steps away

$$
\begin{aligned}
h_A^{'} &= 654 - 205 = 449\ pixel \\
d_A^{'} &= f * \frac{H_A}{h_A^{'}} \\
&= 1742 * \frac{1.69}{449} \\
&= 6.4016\ m
\end{aligned}
$$

Then we can get the distance of how far we step back and thus compute the current distance of B from the pinhole

$$\begin{aligned}\Delta d &= d_A^{'} - d_A \\ &= 6.4016 - 4.9815 \\ &= 1.4201\ m\end{aligned} \tag{3}$$

$$\begin{aligned}d_B^{'} &= d_B + \Delta d \\ &= 7.0599 + 1.4201 \\ &= 8.48\ m\end{aligned} \tag{4}$$

Figure 4: Resized image of the second picture to make dolly zoom effect for A

We can scale the second picture using MATLAB imresize function to make the dolly zoom effect such that A appears the same as shown in the first picture, and the scaled image is Fig. 4. Then we can predict the height of B in the resized image.

$$c = \frac{h_A}{h_A^{'}} \tag{5}$$

$$\begin{aligned}h_B^p &= c * f * \frac{H_B}{d_B^{'}} \\ &= 1.2851 * 1742 * 1.69/8.48 \\ &= 446.1449\ pixel\end{aligned} \tag{6}$$

To reason about the prediction, we propose a rough lower bound on h_B^p. Since we know $d_B > d_A$, i.e., B stands further from the pinhole. Then we know

$$\frac{d_A}{d_A + \Delta d} < \frac{d_B}{d_B + \Delta d} \tag{7}$$

and A and B has quite close height then we know Δd has less impact on the pixel height of B, then in the second picture, the pixel height of B is at least

$$h_B^{'} > h_B * \frac{h_A^{'}}{h_A} = 324.5 \tag{8}$$

And after resizing, the pixel height of B is at least $c * h_B * \frac{h_A^{'}}{h_A} = 417\ pixel$ which is the lower bound of the prediction (6).
Then we measure the pixel height of B in the scaled image and get $h_B^m = 448\ pixel$, and we can see that the prediction value is quite close to the measured value.