Homework Assignment 4
Computational Photography

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1 Lightfield rendering, depth from focus, and confocal stereo

1.1 Initials

```
def create_lightfield(image: np.ndarray, lenslet_size: int):
    h, w, c, = image.shape

    light_field = np.zeros((h//lenslet_size, w//lenslet_size, lenslet_size, lenslet_size, 3))

    for j in range(0,h, lenslet_size):
        for i in range(0,w, lenslet_size):
            light_field[j//lenslet_size,i//lenslet_size,:,:,:] = image[j:j+lenslet_size,i:i+lenslet_s

    return light_field
```

1.2 Sub-aperture views

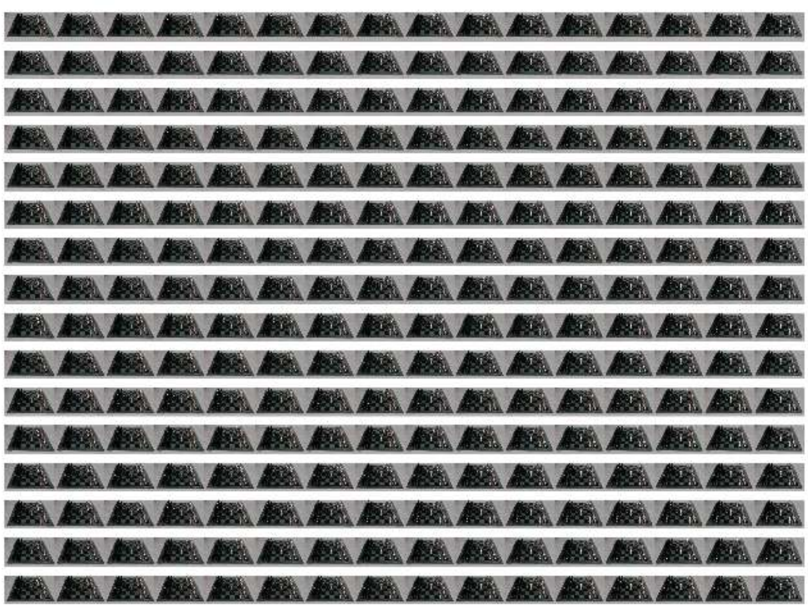


Figure 1: The figure is a mosaic of all the sub-apperture views formed using the lightfield.

1.3 Refocusing and focal-stack simulation

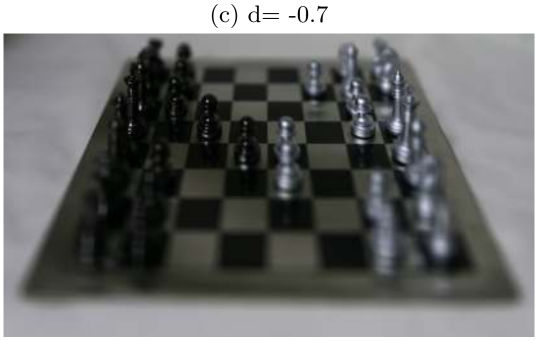
Figure 2 shows images refocused with different depths.

(a) d= -1.2

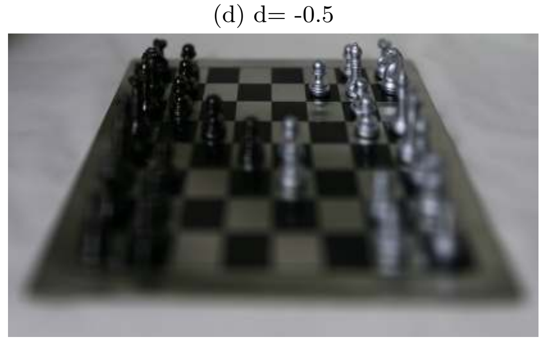
(b) d= -1

(c) d= -0.7

(d) d= -0.5



(e) d= -0.3



(f) d= 0

Figure 2: The figure shows refocus images at 6 different depths.

1.4 All-in-focus image and depth from focus

Figure 3 shows all infocus image formed using various σ_1 and $\sigma2$ values. The best result I got is with using $\sigma_1 = 0.7$ and $\sigma_2 = 5$. Figure 4 shows the depth estimate using different focus images. Parts of the images that are smooth i.e, that dont have a lot of textutre have wrongly estimated depths. The all-in-focus image similarly affected at those parts as we cant estimate the "sharpness" correctly.

1.5 Focal-aperture stack and confocal stereo

Figure 5 shows the mosaic of images with different focus and aperture settings. Figure 6 shows the image estimated using confocal sterio. This depth is different from the one got via depth-of-focus procedure as this has depth calculation per pixel it is not as smooth as the previous depth map in figure 4.

Figure 7 shows the AFI for 2 pixel locations.

2 Bonus: Better blending and depth map

3 Capture and refocus your own lightfield

3.1 Capturing an unstructured lightfield

Figure 8 shows the frame of video captured for and unstructured lightfield

3.2 Refocusing an unstructured lightfield

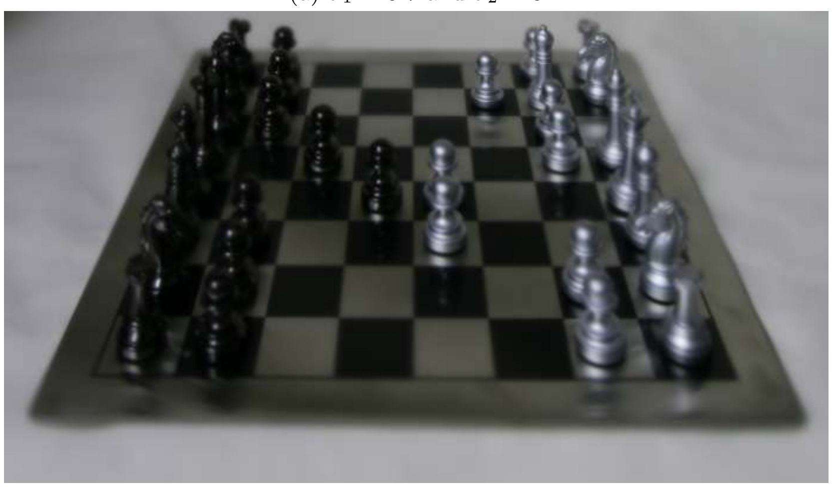
The following is the algorithm used to so the template matching

```
Select the object to be focused, this is the template
Select the search space for template matching

Create a box filter of the size of the template
Normalize the template with the mean value
Calculate the variance of the template

For each frame :
Crop the region in the search space
Correlate this region with the box filter
Create High Frequency image by substracting the image and the box correlated image
Calulate the variance of this High Frequency image
Create a correlation map correlating  High Frequency image  with template and normalize them by thei
Find the co-ordinate with the max value.
Calculate the sift using this co-ordinates
```

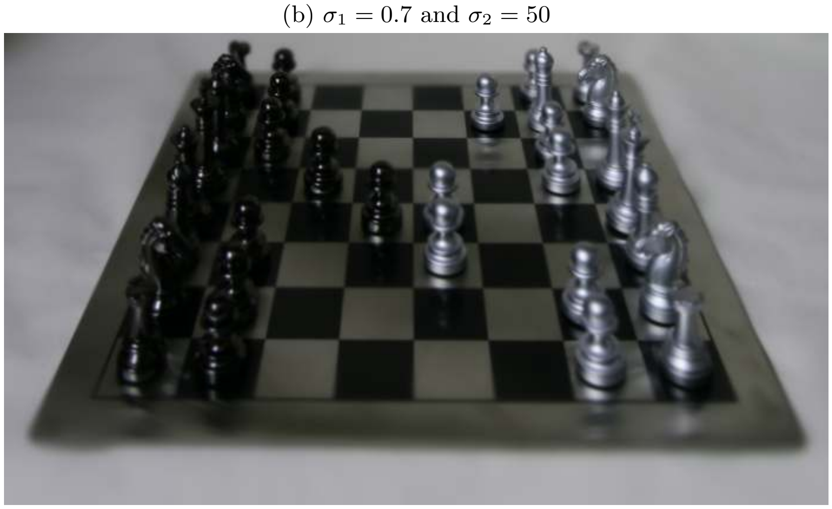
Figure 9 shows 2 results of focusing at different parts of your captured video.

4 Bonus: Capture and process your own focal-aperture stack

(a) $\sigma_1 = 0.7$ and $\sigma_2 = 5$



(b) $\sigma_1 = 0.7$ and $\sigma_2 = 50$



(c) $\sigma_1 = 1$ and $\sigma_2 = 10$

Figure 3: The figure shows all infocus images with different σ_1 and σ_2 values.

Figure 4: Figure shows the depth esitmated using the different focus images.

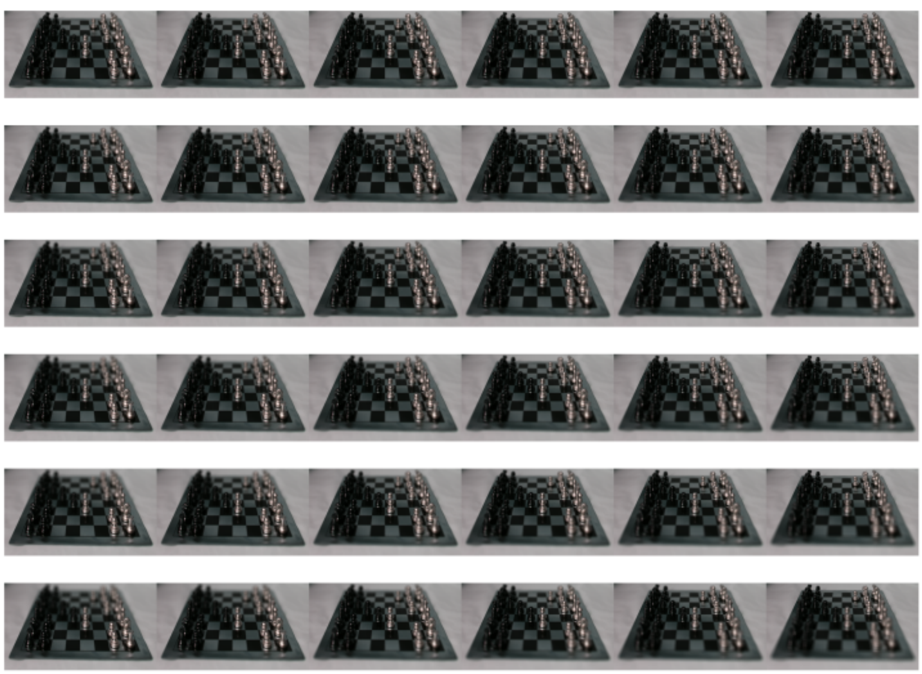


Figure 5: The figure shows the mosaic of images formed with using different focus and aperture settings. The x axis has focus changing, the Y axis has aperture size changing (from high to low)

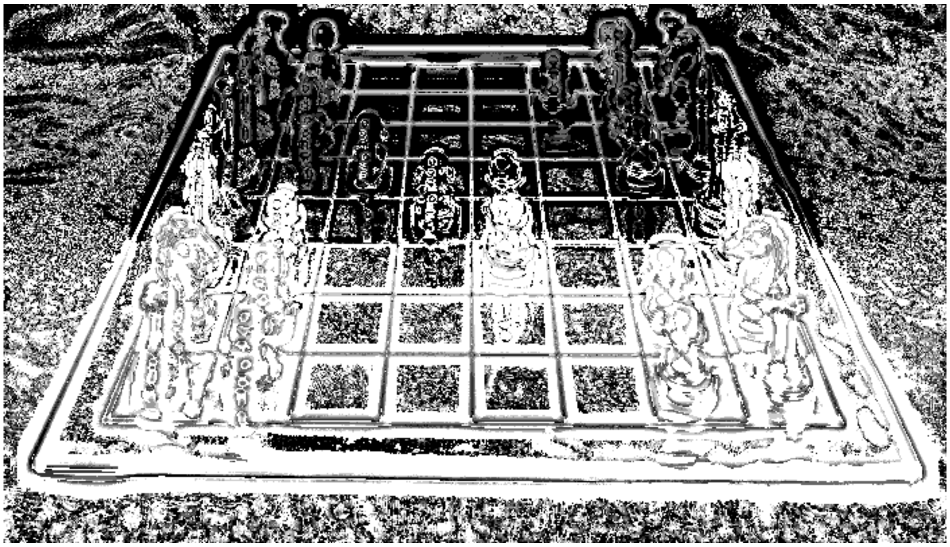
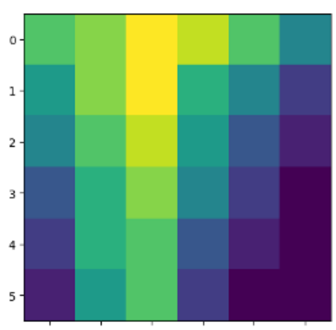
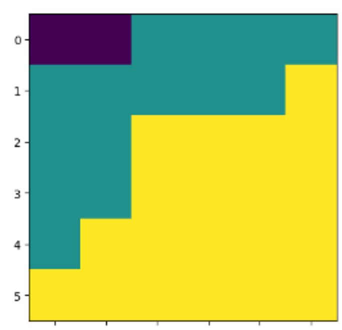


Figure 6: The figure shows the depth using confocal sterio.

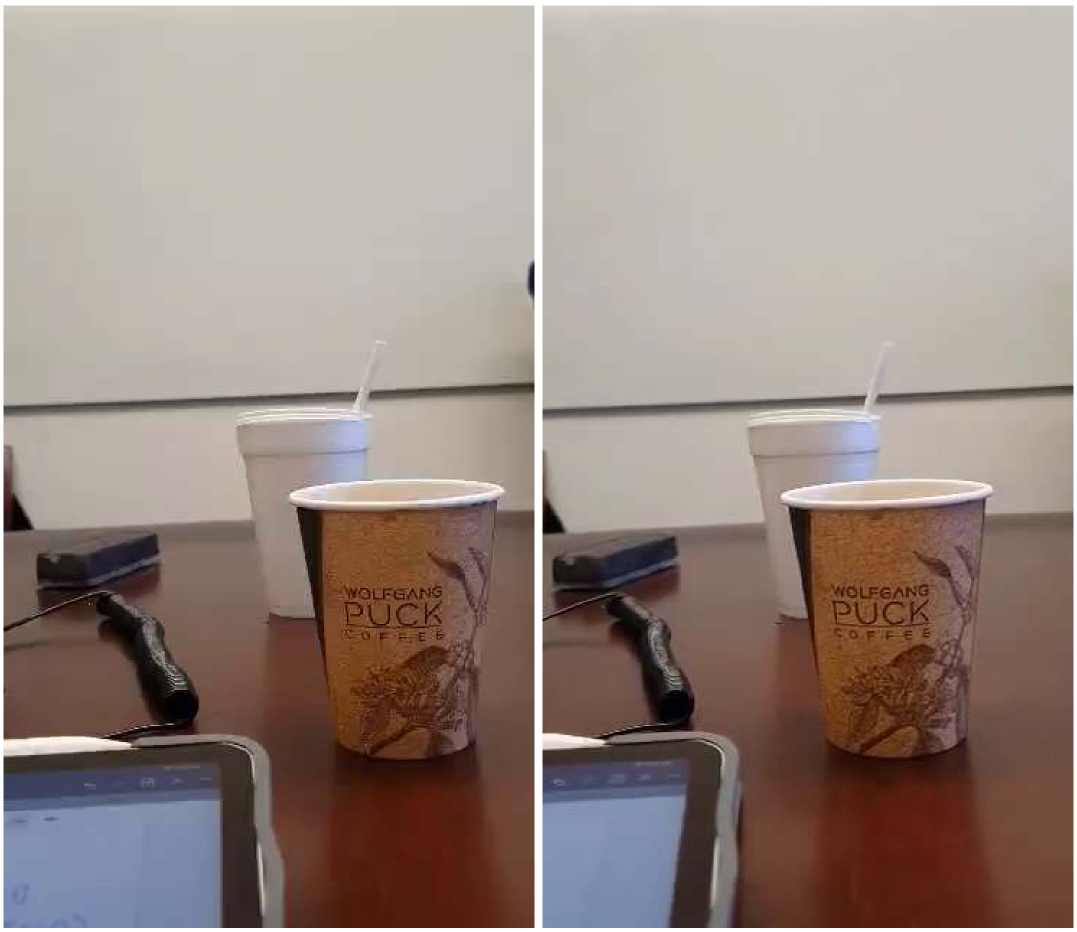


(a) AFI for pixel at 255, 310



(b) AFI for pixel at 380, 455

Figure 7: The figure shows the AFI for pixels at 2 locations.



(a) Frame 1 (b) Frame 28

Figure 8: Frames from the video

(a) Focus image on the cup

(b) Focus image on the duster

Figure 9: Figure with 2 images with different objects focused.