Assignment 4: Computational Photography

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1 Lightfield rendering, depth from focus, and confocal stereo

1.1 Initials

Following is the block of code I used to create the lightfields

```
def form_lightfield(image, size):

height, width, channels = image.shape

lf = np.zeros((size, size, height//size, width//size, 3))

lf = np.zeros((size, size, height//size, width//size, 3))

for j in range(0, height, size):
    for i in range(0,width, size):

        j_idx = j//size
        i_idx = i//size

        lf[:,:,j_idx,i_idx,:] = image[j:j+size,i:i+size,:]

return lf
```

1.2 Sub-aperture views

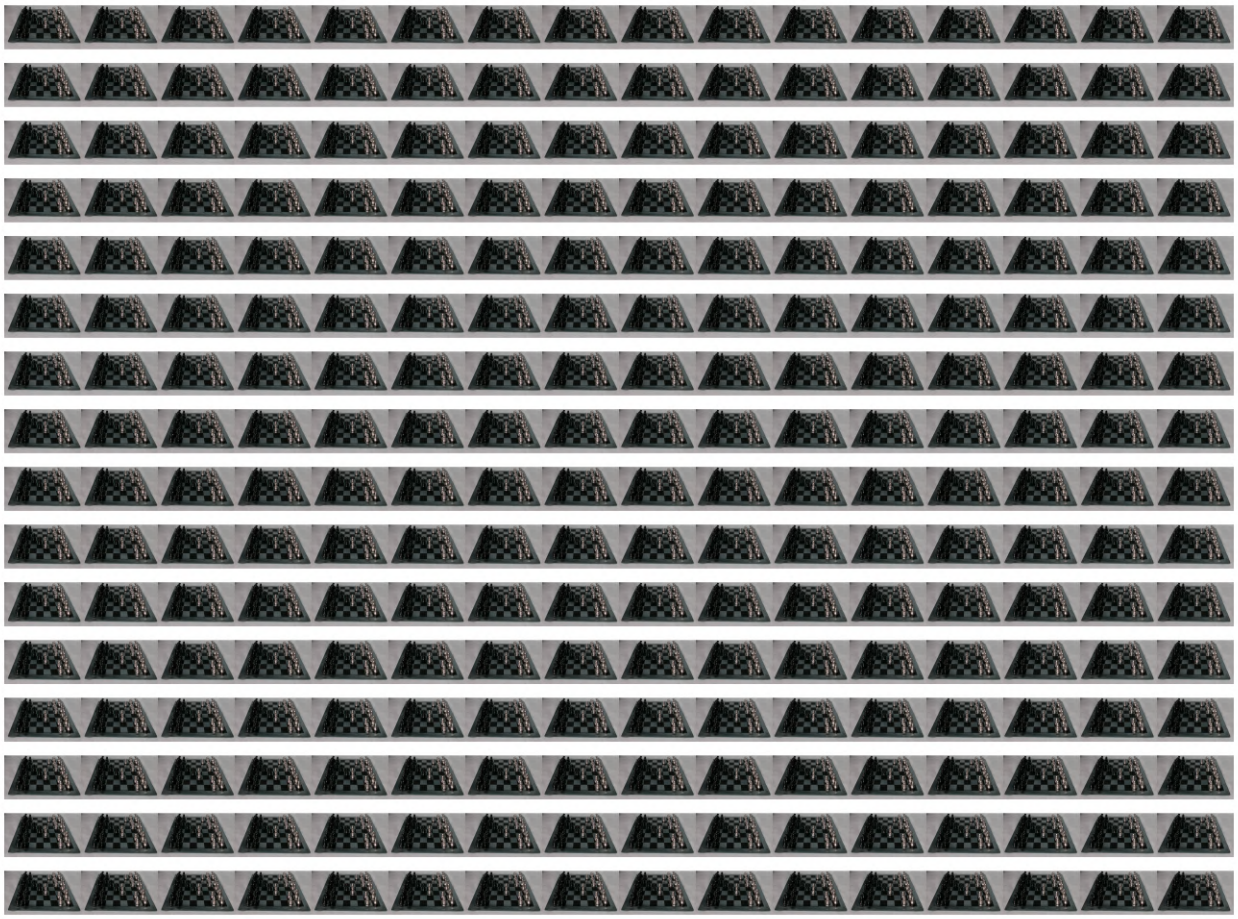


Figure 1: Mosaic of Sub aperture views. The vertical dimension correpsonds to the u values and the horizontal direction corresponds to the v values

1.3 Refocusing and focal-stack simulation

Given below is the refocused images for various depth values.

depth = -1.2

depth = -1

depth = -0.7

depth = =0.4

depth = 0

1.4 All-in-focus image and depth from focus

Results with different σ_1 and σ_2 values have been highlighted below. The best results according to me are for $\sigma_1 = 0.2$ and $\sigma_2 = 5$. For the depth image at these sigma values, the overall depth results look good. Failure cases can be seen at places where there is a smooth patch in the image such as patches that do not have textures/edges/corners. Similar corresponding areas are also affected in the all-in-focus image as it is hard to measure sharpness in such smooth areas.

$\sigma_1 = 0.2$ and $\sigma_2 = 5$

$\sigma_1 = 0.5$ and $\sigma_2 = 5$

$\sigma_1 = 0.7$ and $\sigma_2 = 5$

Figure 2: Depth image at $\sigma_1 = 0.2$ and $\sigma_2 = 5$

1.5 Focal-aperture stack and confocal stereo

The below figures show the focal aperture stack with varying focus and aperture size.

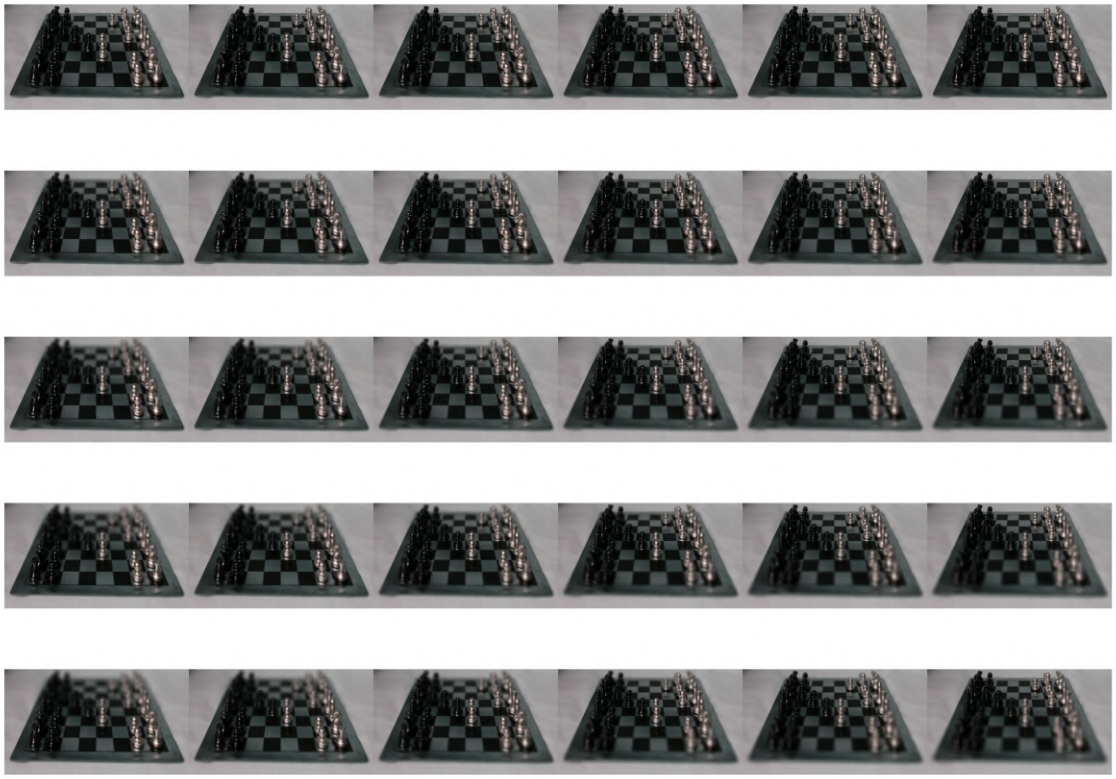


Figure 3: Focal aperture stack with varying aperture size and focus. The aperture size changes in the horizontal direction and focus changes in the vertical direction.

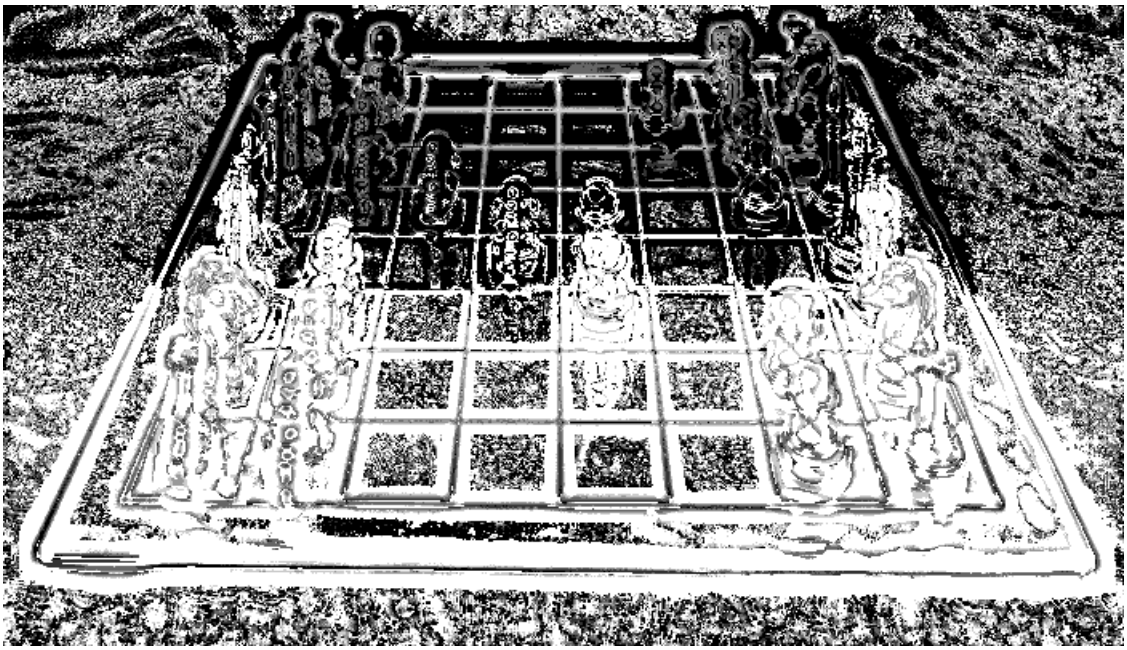


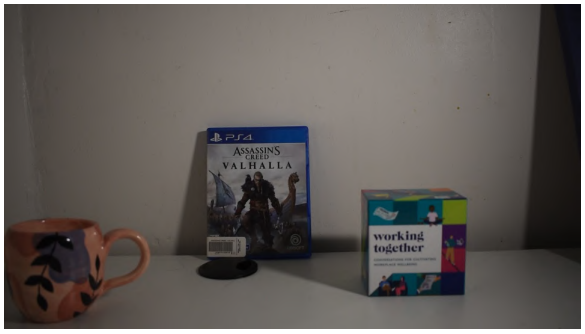
Figure 4: Depth image formed by confocal stereo

The above figure shows the depth estimation using confocal stereo. The depth calculated here is significantly different than the one used in the previous experiments. This could mainly be because depth here is calculated per pixel. This may lead to poorer depth estimation than the previous method as the smoothness of the depth is not preserved.

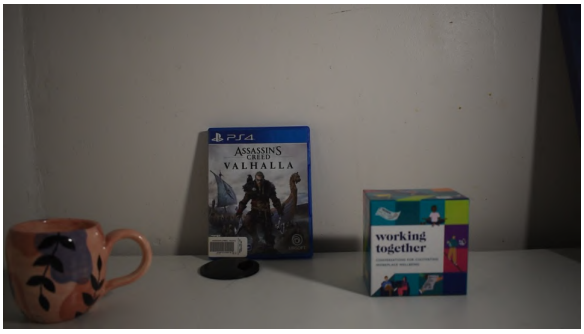
2 Bonus

3 Capture and refocus your own lightfield

Images from the Captured Video

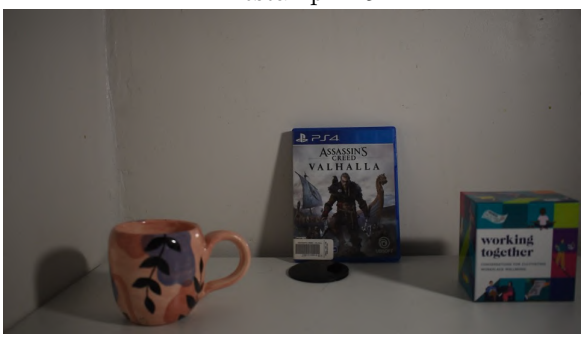


Timestamp = 44



Timestamp = 52

Timestamp = 136

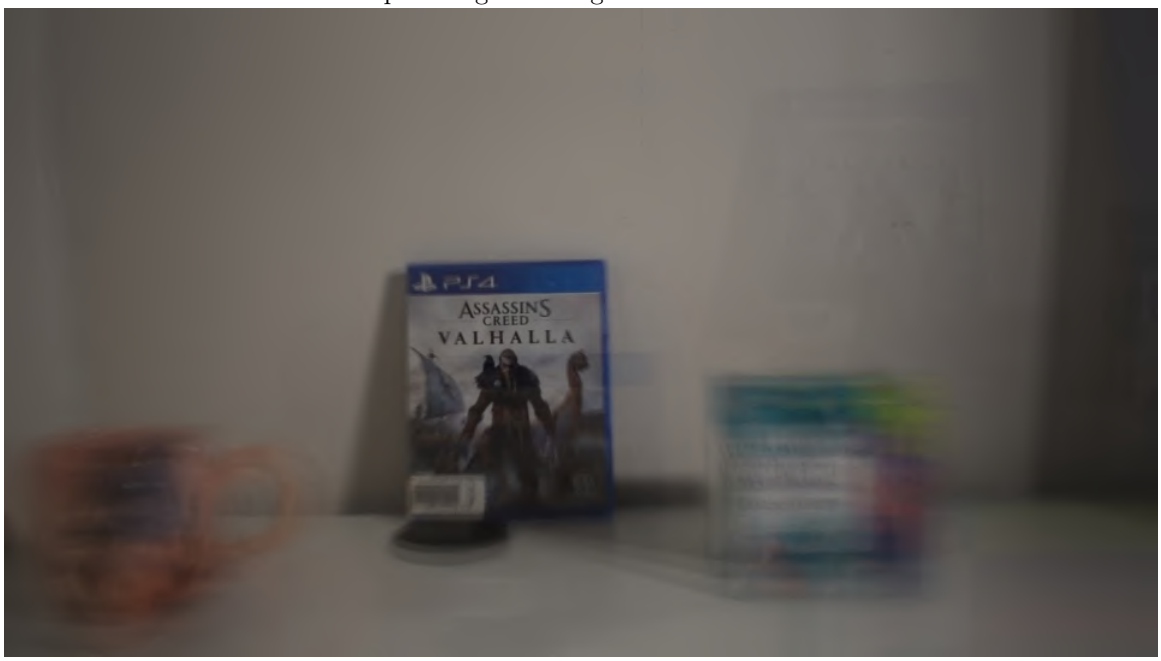


Timestamp = 170

Algorithm description for template matching and shift in images

- Select a search space window and a template (part of the object to be focused on)
- For each frame of the video:
  - Crop the region inside the search space coordinates
  - Carry out cross correlation with a box filter for this cropped region
  - Subtract image and the box correlated image
  - Perform cross correlation between this high frequency image and the normalized template image
  - Find the coordinate of the maximum value and calculate the shift with the first frame

Output image focusing on the cuboid box



Output image focusing on the video game