15463 Assignment 4

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Notice : I requested an extension due to some unexpected personal matters. Basically Professor Yannis agreed to give two extra late days. Please take this into consideration.

1 Lightfield Rendering, depth from focus, confocal stereo

1.1 Sub-aperture views

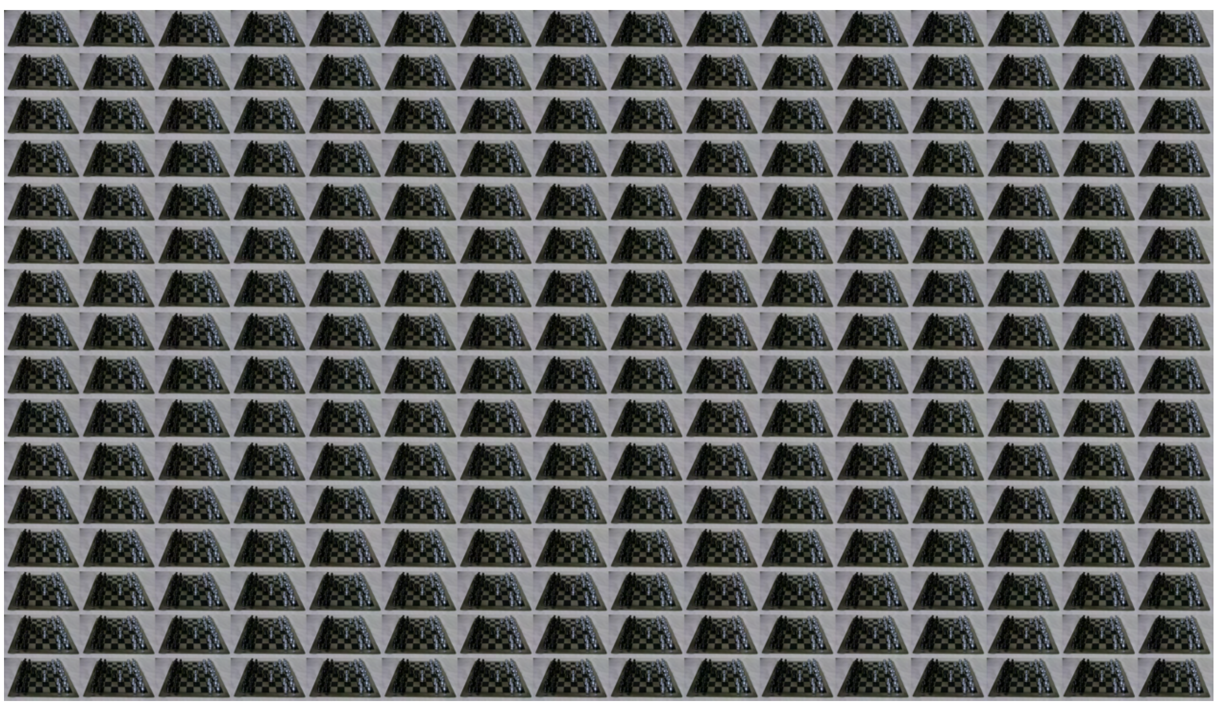

Figure 1: mosaic

1.2 Refocusing and focal-stack simulation

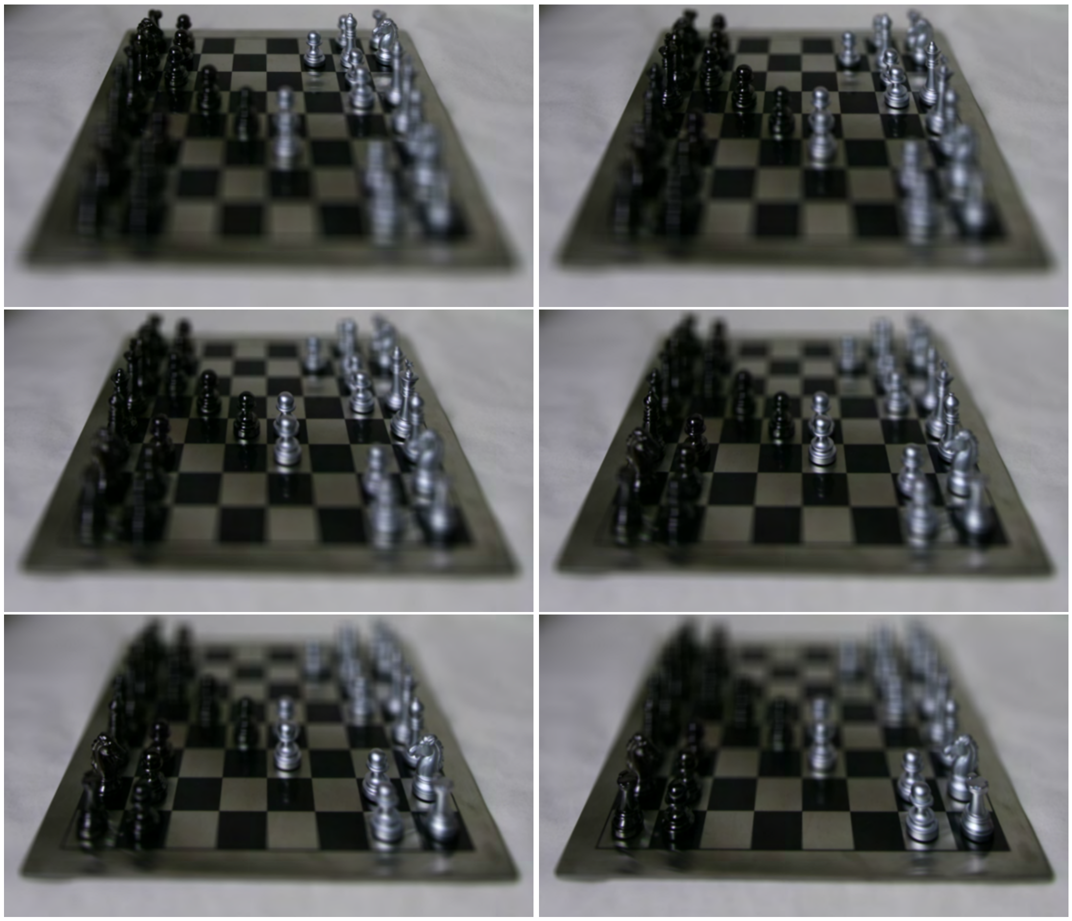

Figure 2: depth order from left to right, top to bottom: 0, 0.25, 0.5, 0.75, 1, 1.25

1.3 All-in-focus image and depth from focus

Best result: Gaussian radius $r = 9$, $\sigma_1 = 16$, $\sigma_2 = 64$

The parts incorrectly estimated are the grids where no pieces are on it, this is because inside the grids the colors and details are very uniform that there is little variation with the sharpness among different depth. The all-in-focus image is not similarly affected at those parts. For instance, in the far end (close to depth 0) the depth on those "empty grids" are overestimated and in the front end(higher depths) the depth on those "empty grids" are underestimated.

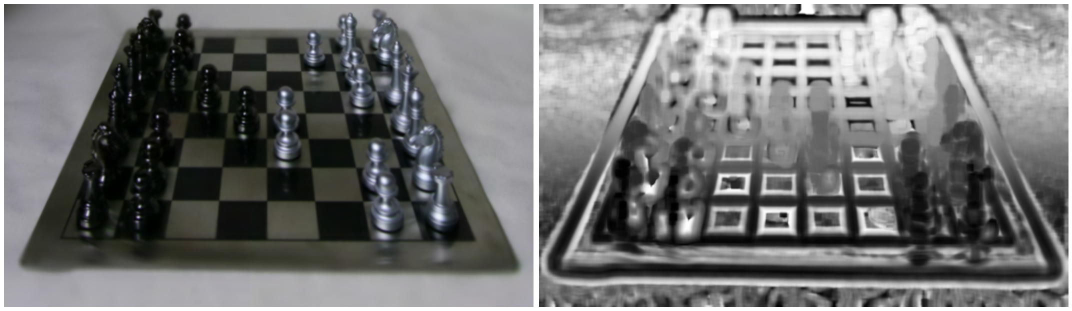

Figure 3: best image and its map

1.4 Focal-aperture stack and confocal stereo

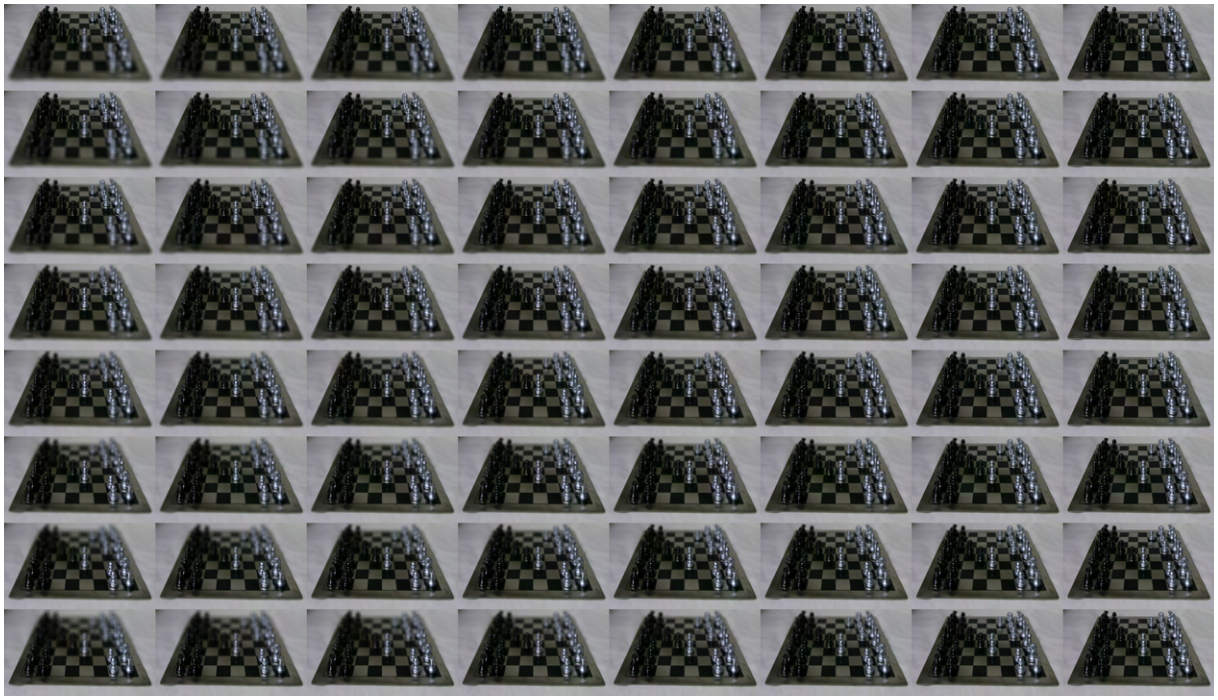

Figure 4: 2D collage, top to bottom: depth in $[0, 1.6]$, left to right: aperture size(square radius) from [16,14...4,2]

Comparison : reconstructed depth map has high resolution around the boundary and more accurate depth where the all-in-focus approach fails(place where no pieces on the board). However, it also has much more noise, especially outside of the board.

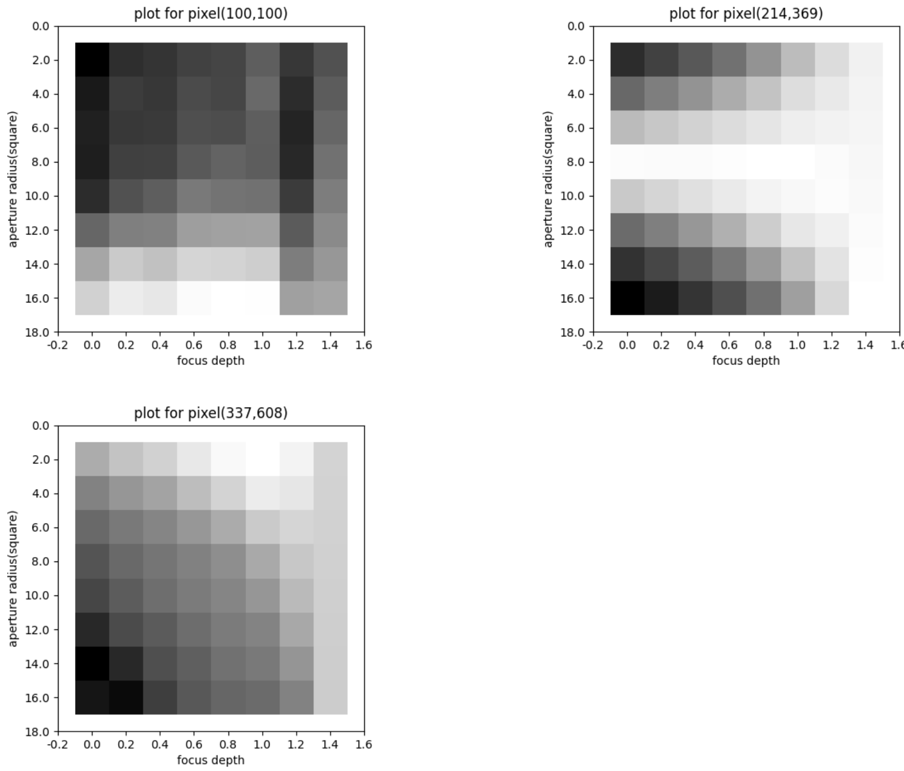

Figure 5: 3 AFIs

2 Capture and refocus your own lightfield

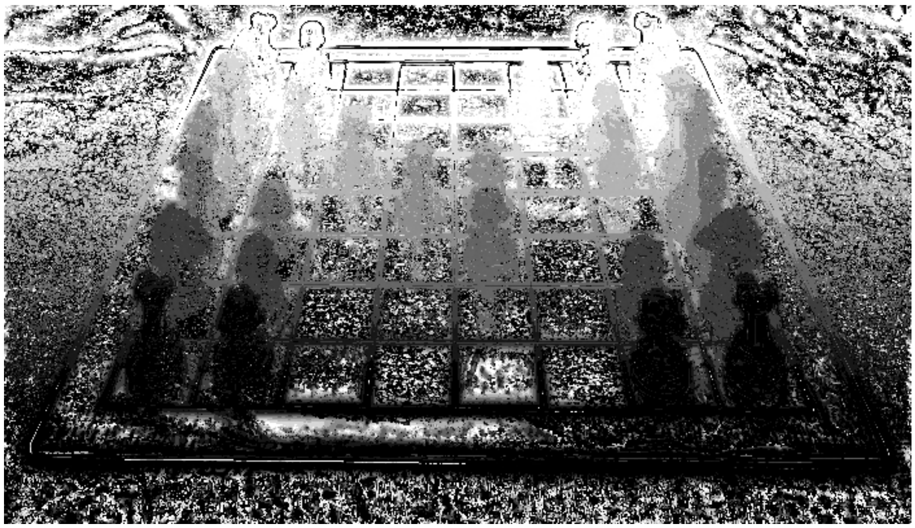

Figure 6: reconstructed depth map

2.1 Capturing an unstructured lightfield

Please see bear.MOV under data/

2.2 Refocusing an unstructured lightfield

Method: I did not use scipy's correlated 2d function. Here are the following steps:
(1)$\bar{g} = np.mean(g)$
(2)box = $np.ones((r, r))/(r^2)$ (box filter)
(3)$\bar{I}_t = np.convolve2d(I_t, box)$
(4)$nominator = \sum(g - \bar{g})(I_t - \bar{I}_t)$ (piecewise multiplication)
(5)$denominator_{left} = \sum(g - \bar{g})^2$
(6)$denominator_{right} = \sum I_t^2 + r^2 \bar{I}_t^2 - 2\bar{I}_t \sum I_t^2$
I just expand the square term into a quadratic formula, and $\bar{I}_t$ is a constant at (i, j), the other parts can be solved with piece-wise multiplication.

2.3 Some implementation details

the template size $r = 50$, the window size is about 400×400

Figure 7: 3 refocus images based on different templates