Lucas Junginger
EECS 442 W16
Homework 2: Photometric stereo

1. To prepare the data I tried to avoid loops by using the bsxfun function to scale the values. I scaled them to the local max at a range of 0-1. Next to estimate the albedo and surface normals I did not escape the nested for loop iterating through each pixel. This likely makes my solution much slower compared to MATLAB's efficient solutions. I set up a linear system for each pixel which frankly took me very long to figure out and still seems a bit like magic. I used the backslash operator for this. Then I calculated the magnitude of g(x,y) with the function sqrt(x^2 + y^2 + z^2) which can be used to calculate the surface normals. I then used bsxfun to scale the z-plane to a max of 30, which was around what the example had. My integration procedure was done using the functions diff() and sum(). I looped through each pixel and using its coordinates I called diff() on each submatrix to produce the change along the submatrix from element to element, which was then summed up as the integral. Again, I looped through the whole image.
2. The differences in the output were very subtle because overall my 3D faces were pretty distorted as they approached the center of the image. I assume this is because of the shadows surrounding the nose area and the assumption that light is reflected equally, which in turn reads the shadows as a sharp indentation and places the nose deeper into the face than it should be. On the other hand, my best algorithm did a decent job reconstructing the extremities of the face, as can be seen in the chin, the eyebrows, the cheeks and the eyes. I'd say the best one was the random path, simply because it had the highest number of averages (4). I think this contributed to the evening out of sharp edges that can be seen in the row and column methods. Random still seemed better than average, particularly around the inner eye and lip area, which are fairly deep into the picture. However these were ultimately pretty similar. Their run times were very similar as well, meaning that they're probably very easy to make efficient and don't depend much on the optimization technique.

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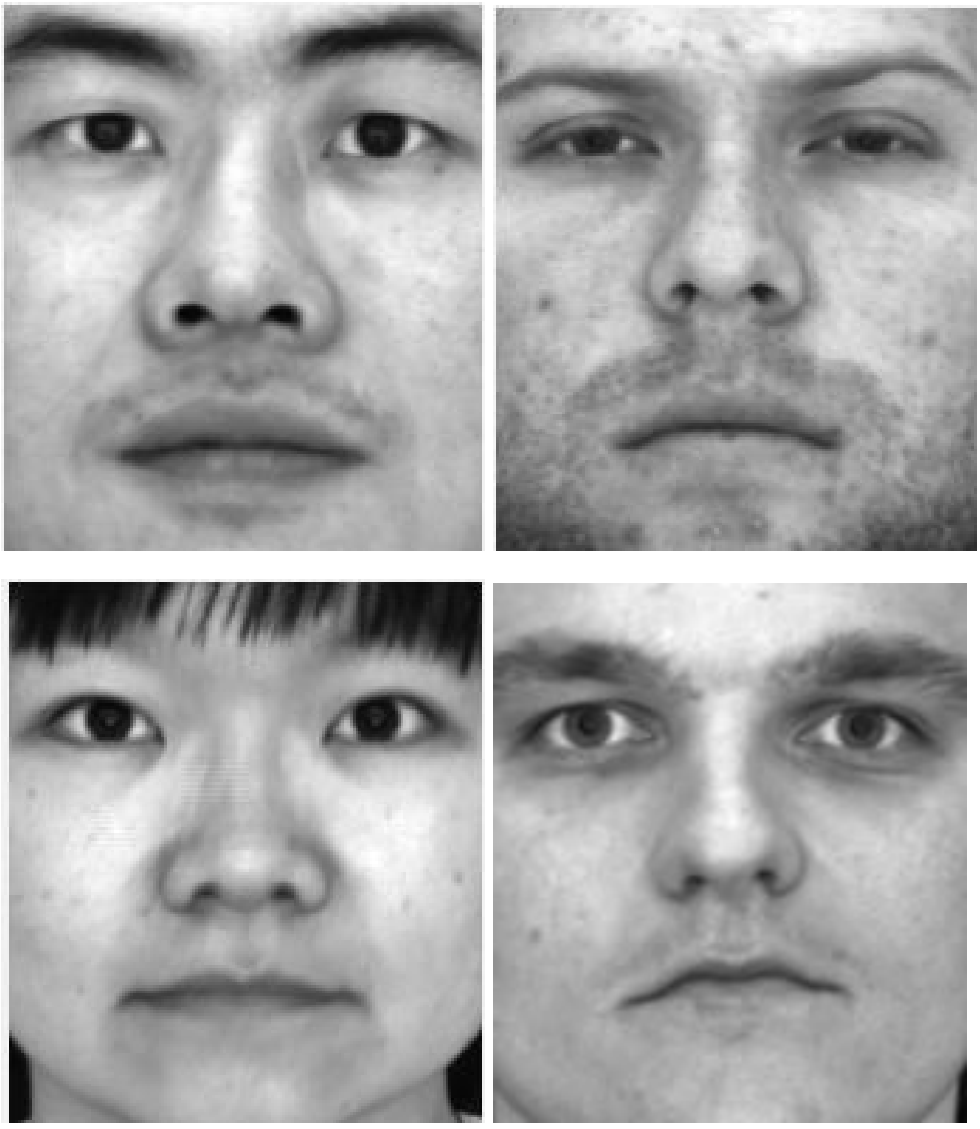
3.



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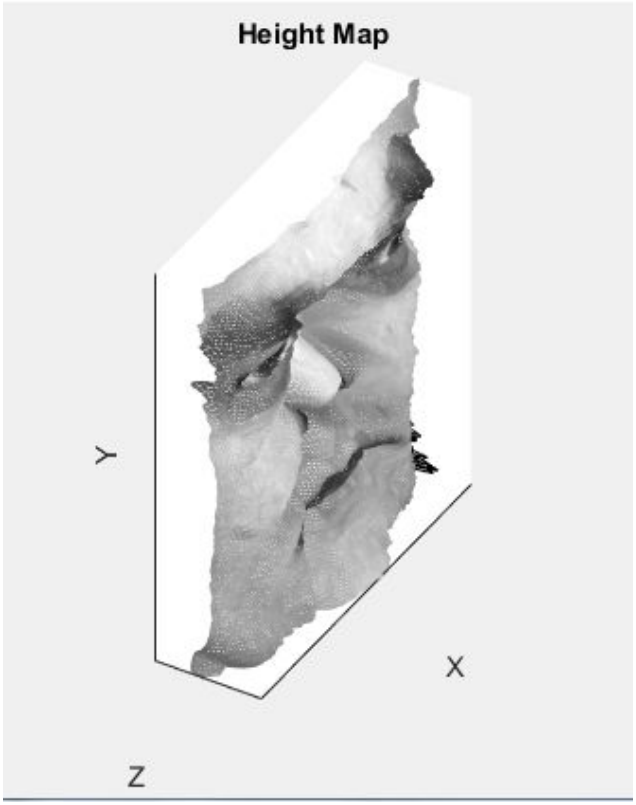
**Random: Elapsed time is 6.378097 seconds.**


**Column: Elapsed time is 6.156322 seconds.**



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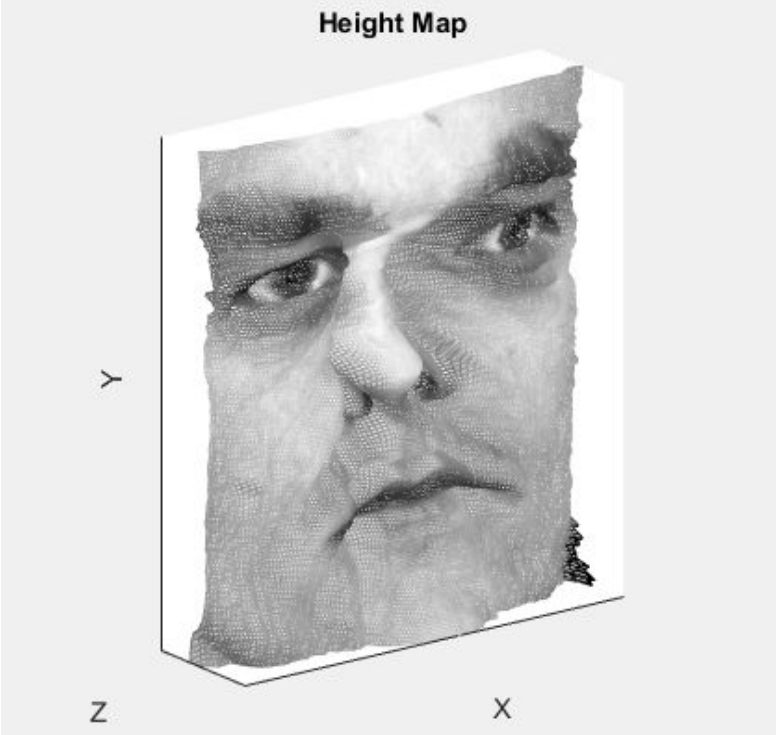
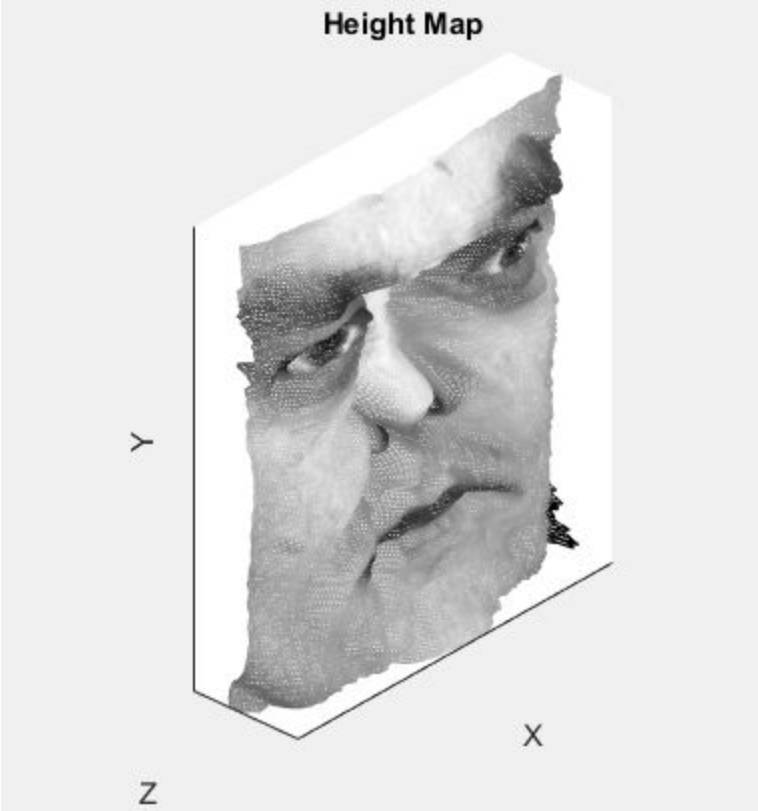
**Row: Elapsed time is 6.158181 seconds.**




**Average: Elapsed time is 6.637162 seconds.**



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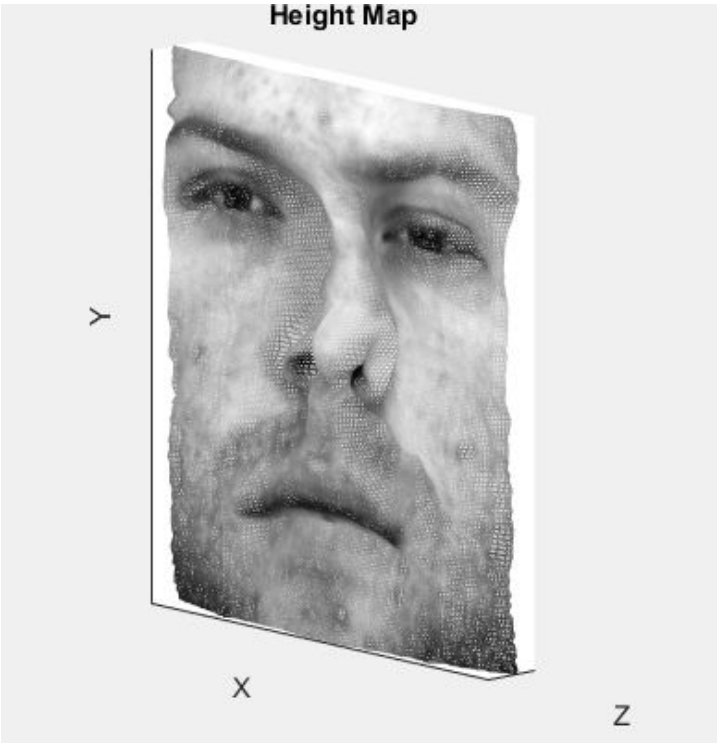
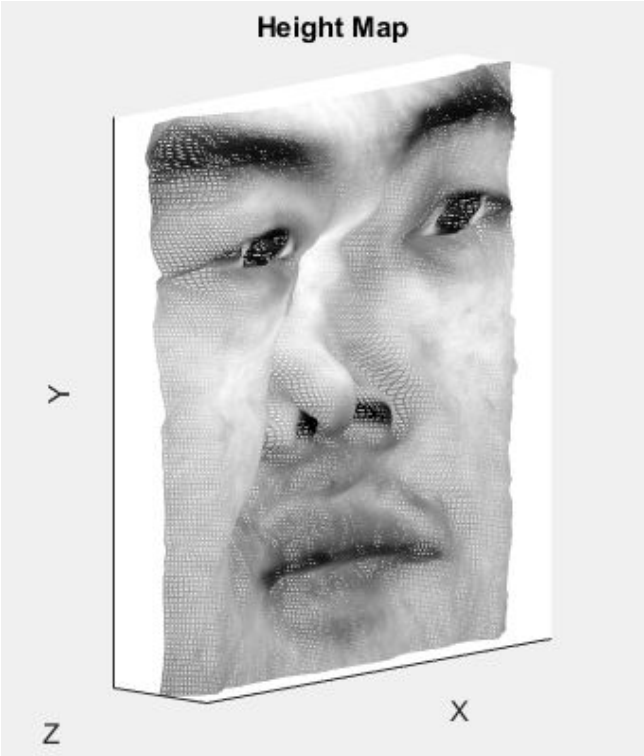
**Random:**




**Column:**



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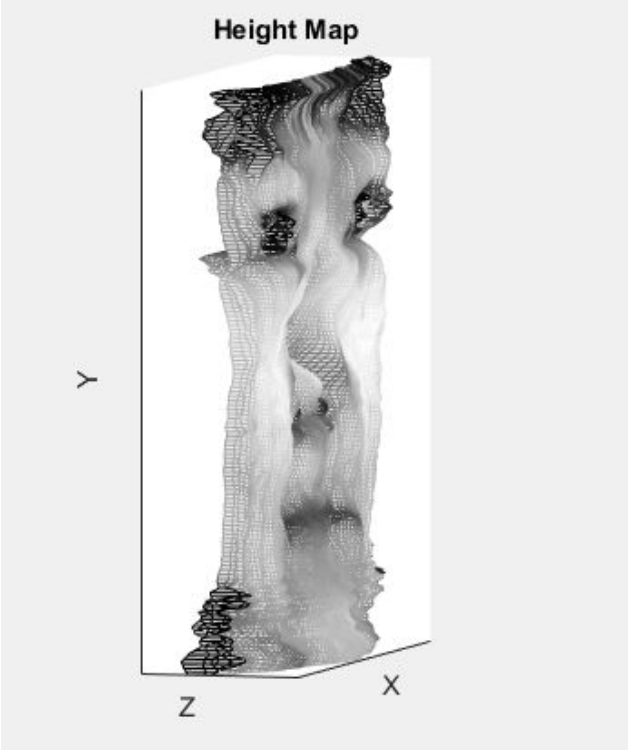
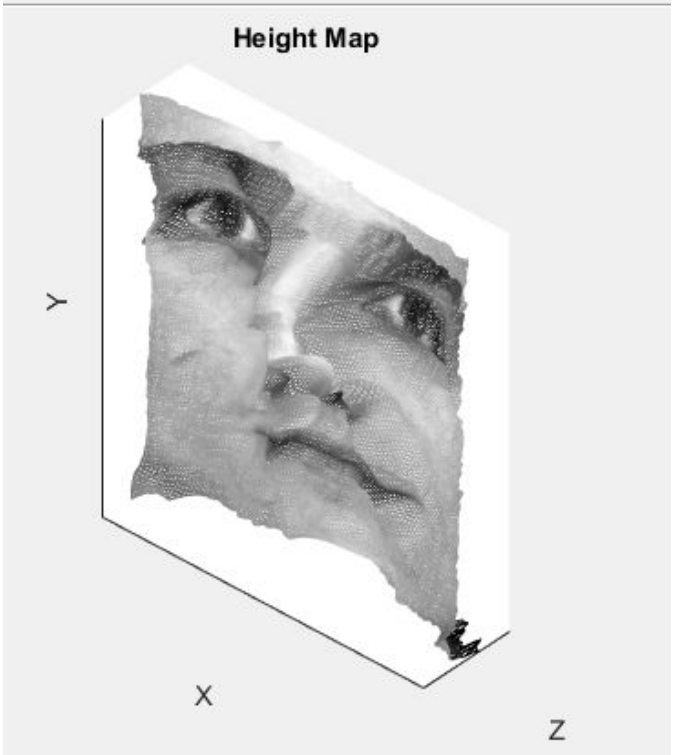
**Row:**




**Average:**



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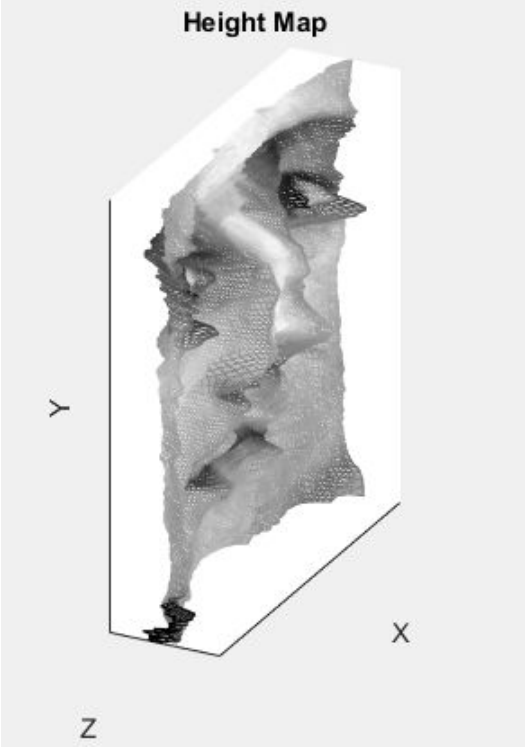
4. Importantly, the surface we are reconstructing here does not reflect light evenly in all directions like a matte surface would. This is a fundamental assumption which allows us to essentially ignore the material of the surface. This would be very effective in reconstructing smooth, uniform shapes. Faces naturally have an immense amount of variation in topography which show up as shadows in the albedo image. This problem can be seen consistently in certain regions of the face such as the corner of the eyes and corners of the nose, which retreat deep into the images (can be seen below). If this were a true lambertian surface



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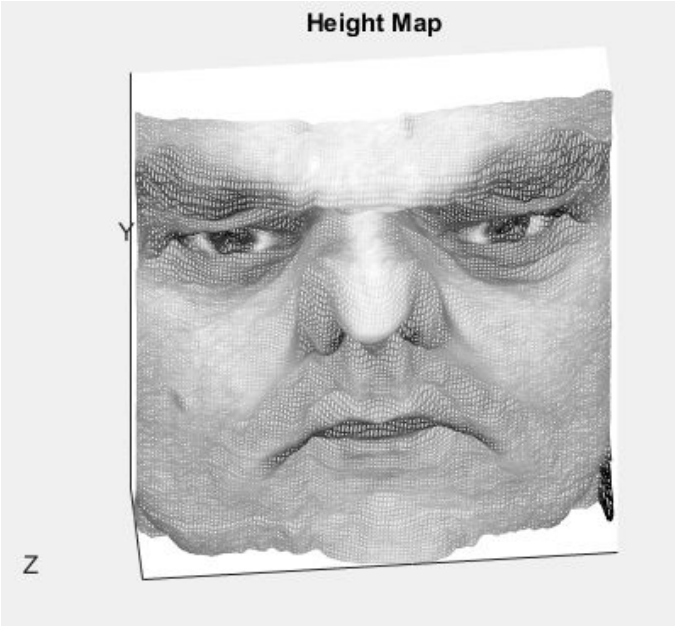
I can think of two good examples of how the image could look better depending on the viewpoint. If one picks a viewpoint with light shading to begin with (such as angled from above in the first picture below), the construction should be better.




Similarly, if a viewpoint is picked where the amount of light reflected would not be so different, the image will look better. For example, you would expect a dark lining around the nostrils when viewed from below, which is what the albedo shows. This looks somewhat normal.