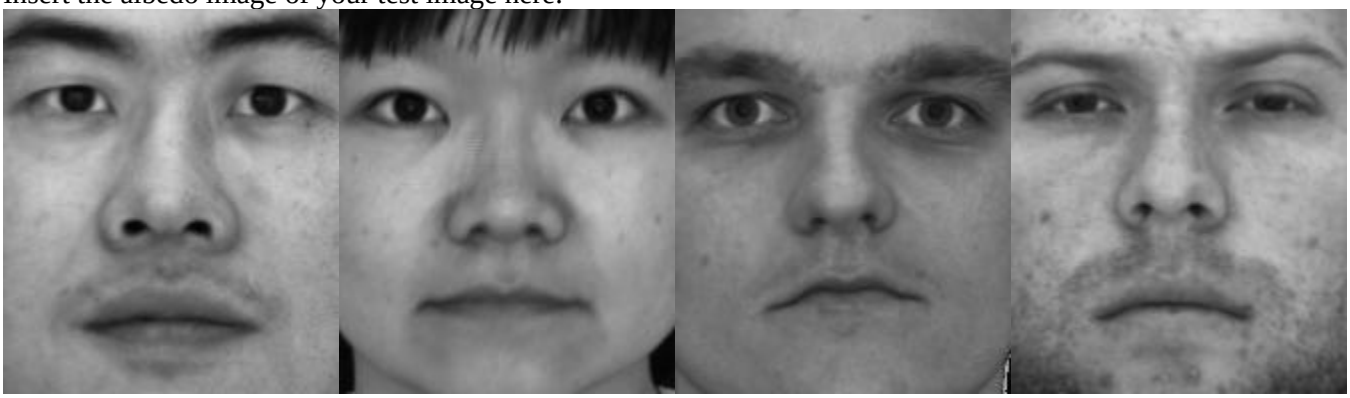
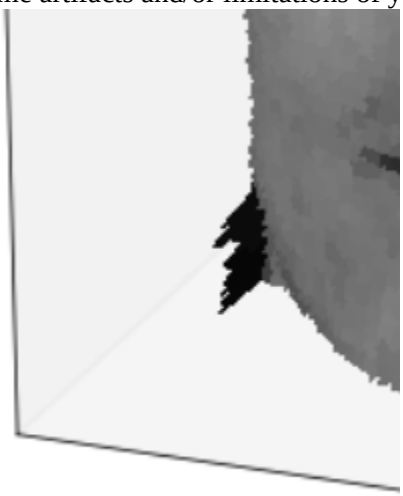
Name : Siddharth Garg

Part-1 : Estimate the albedo and surface normals

1. Insert the albedo image of your test image here:



2. What implementation choices did you make? How did it affect the quality and speed of your solution?
    A. I stacked the vectors for each matrix into a 3 x npix matrix to calculate the least squares solution of g. This prevented the need for looping over individual pixels and solved g for the entire image at once.
    B. To find the height map for each test image, I used the np.cumsum function that again prevents iterative looping over every pixel in the image and calculates the integrals in a more efficient way
3. What are some artifacts and/or limitations of your implementation, and what are possible reasons for them?



    A.
    B. In the random integration method for the B07 test image, there is a stretched area near the neck that is erroneous. This could be due to the sudden depth boundary between the face and the neck which my implementation may not be able to handle correctly.
4. Display the surface normal estimation images below:

    A. B01:

B. B02:

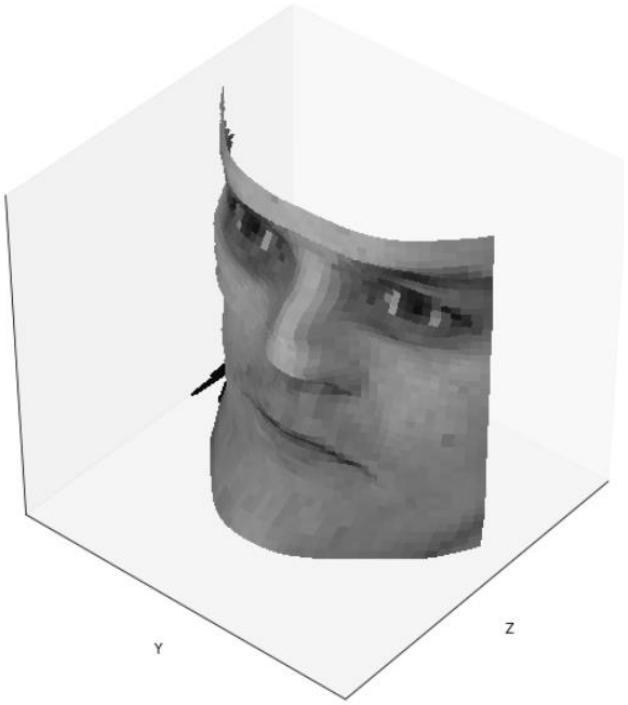
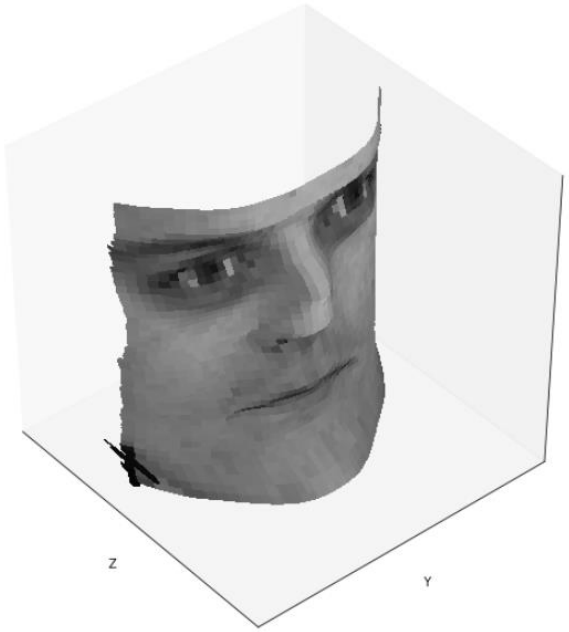
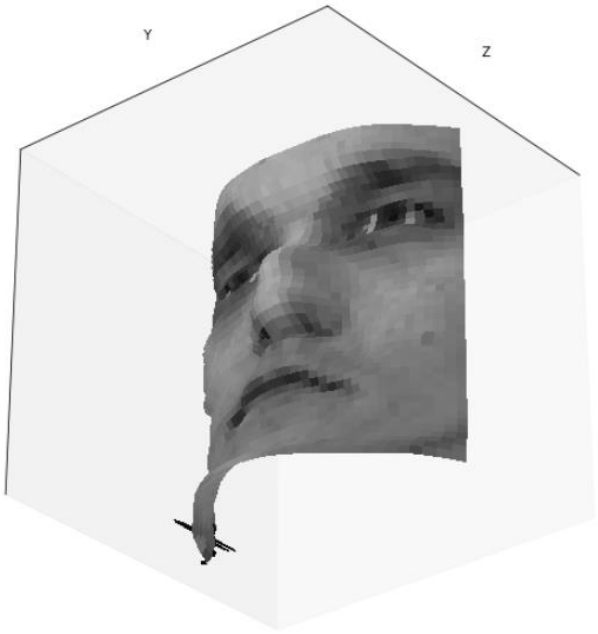
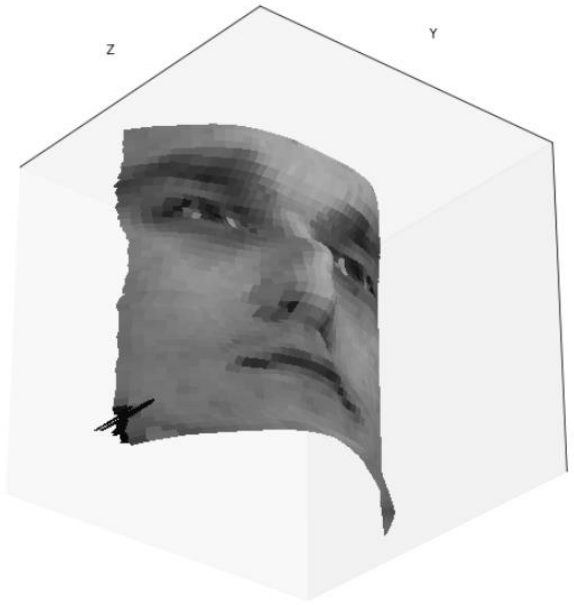
C. B05:

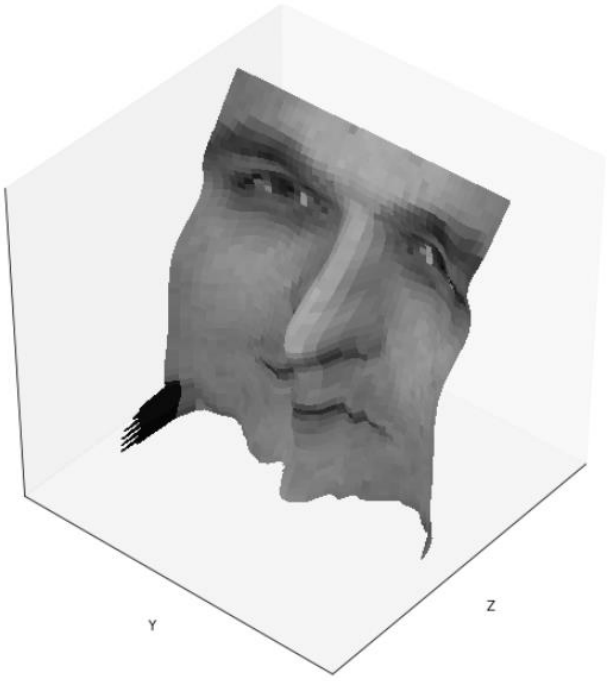
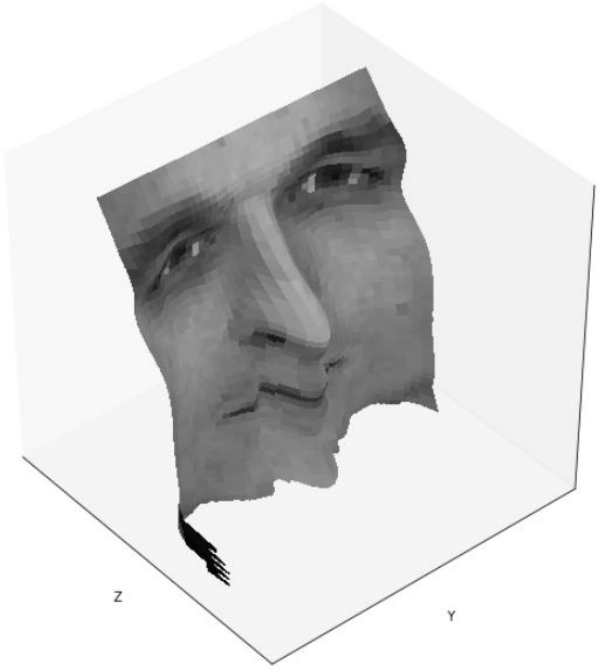
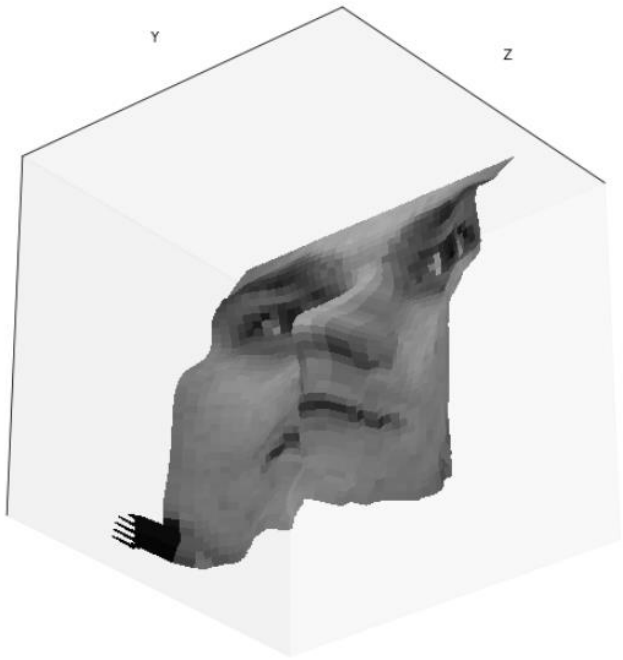
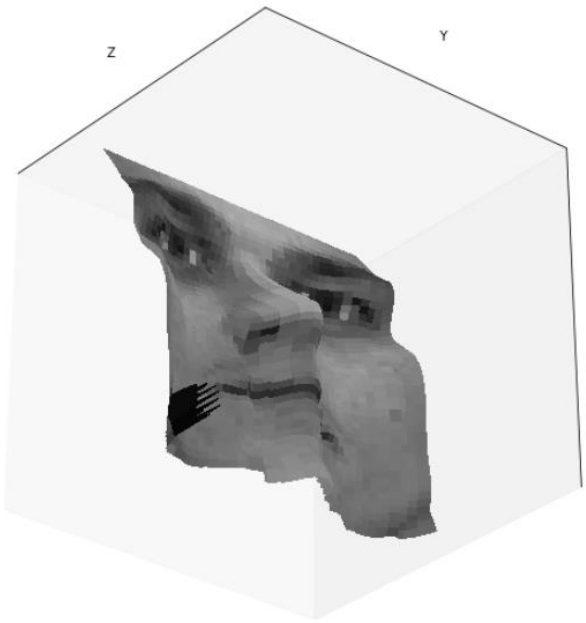
D. B07:

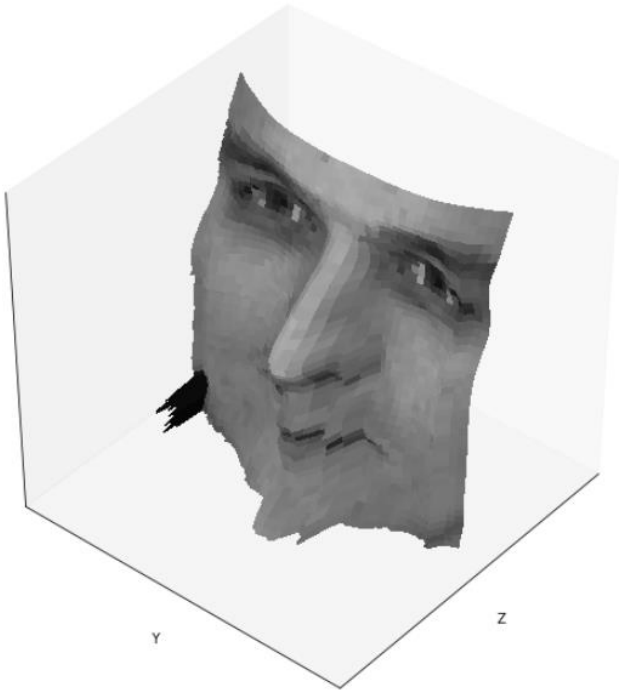
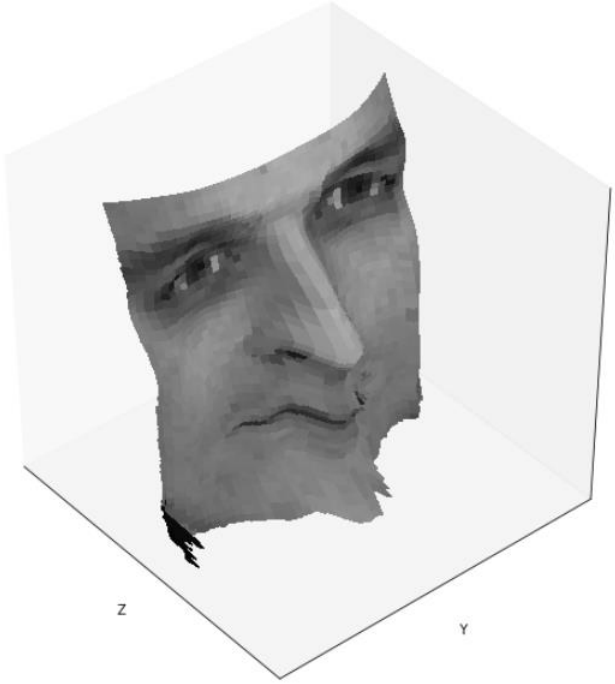
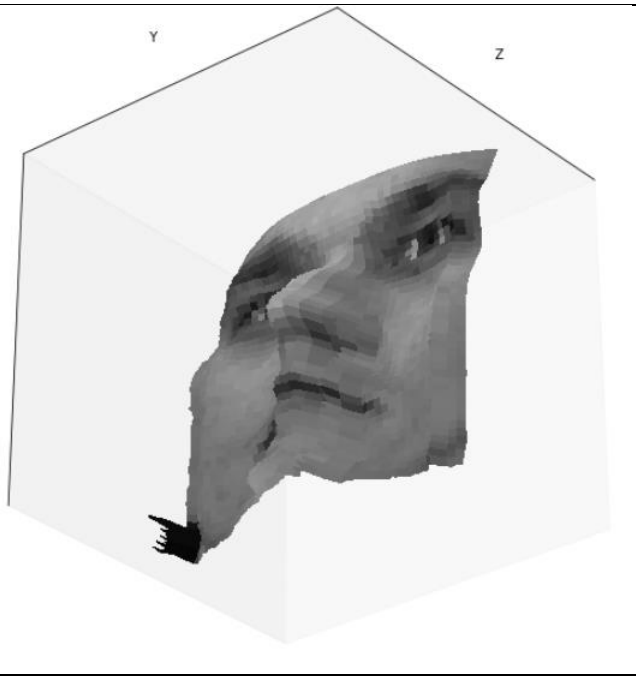
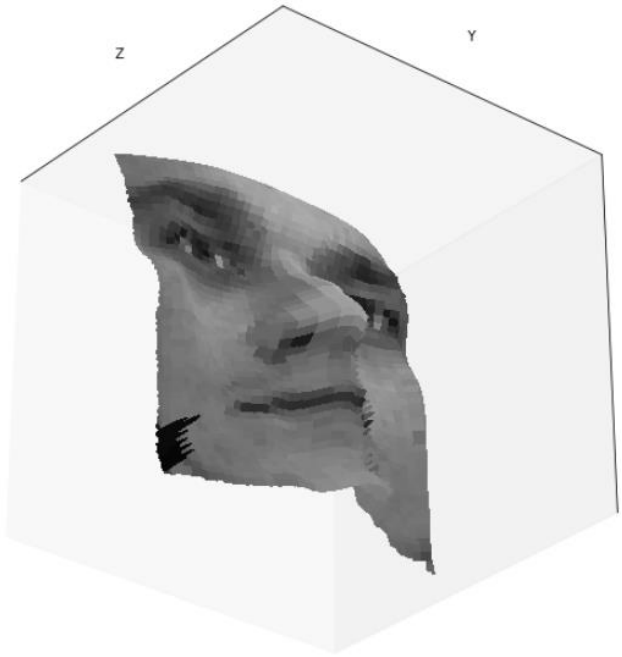
Part-2 : Compute Height Map

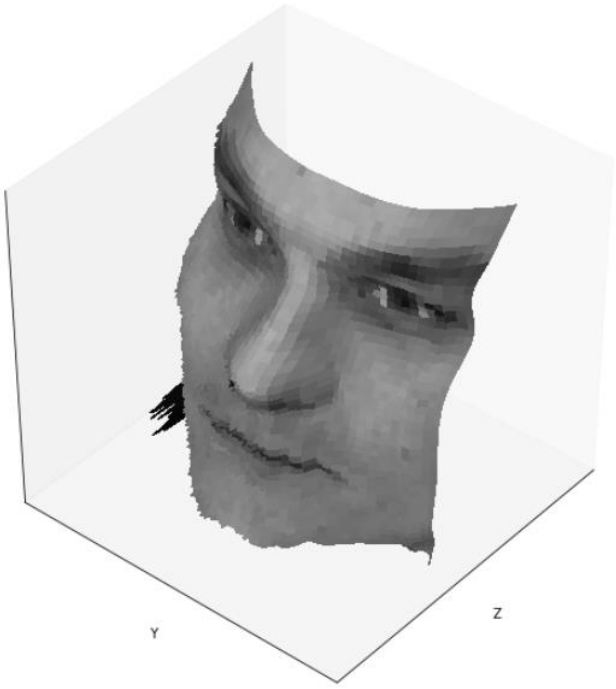
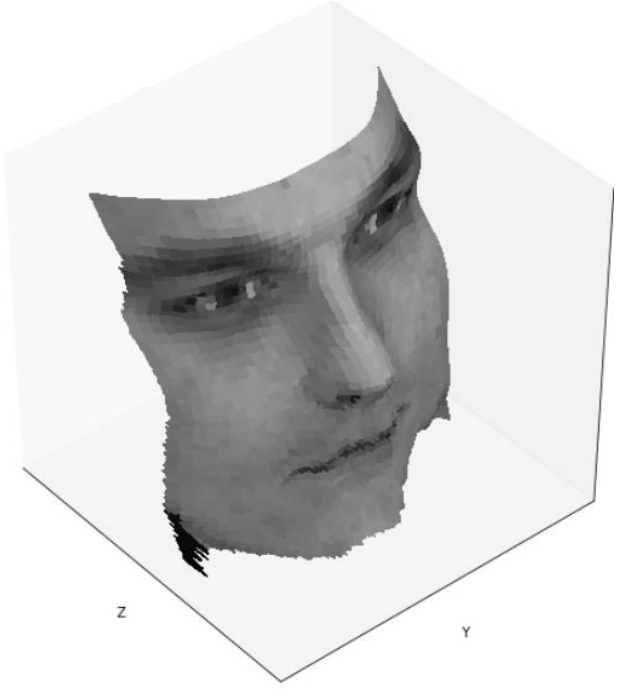
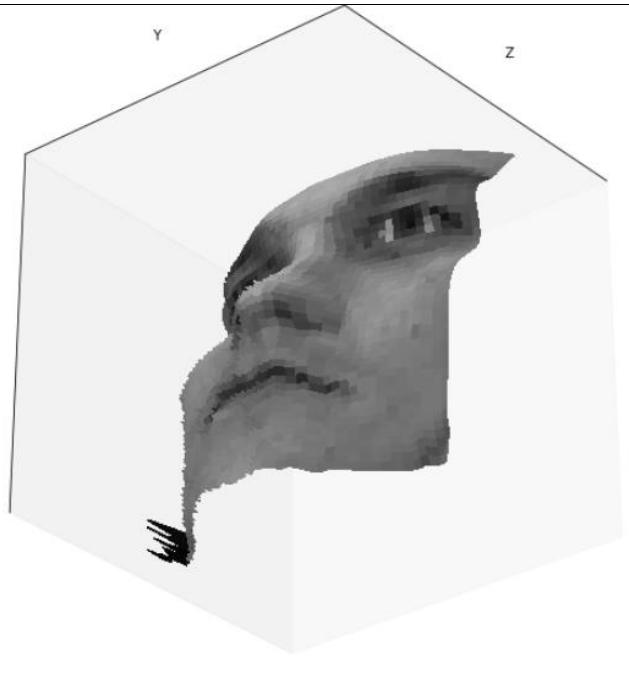
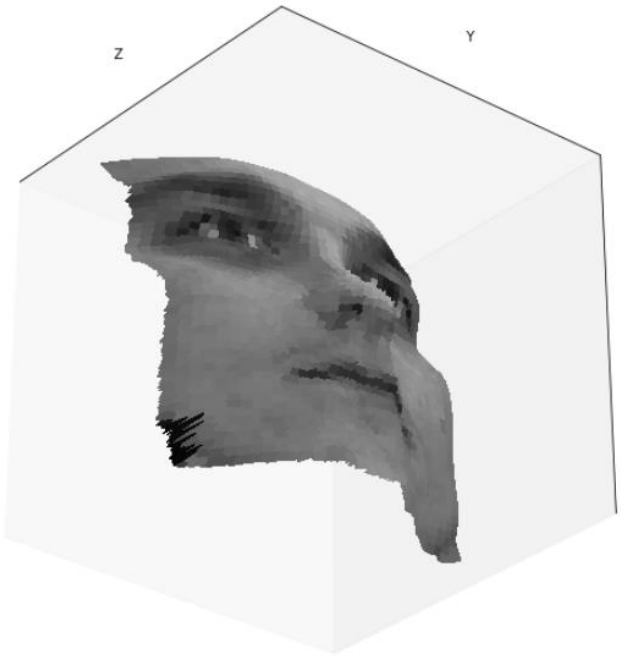
5. For every subject, display the surface height map by integration. Select one subject, list height map images computed using different integration method and from different views; for other subjects, only from different views, using the method that you think performs best. When inserting results images into your report, you should resize/compress them appropriately to keep the file size manageable -- but make sure that the correctness and quality of your output can be clearly and easily judged.

Different methods and views for B07

	Different Views	
Row		
		

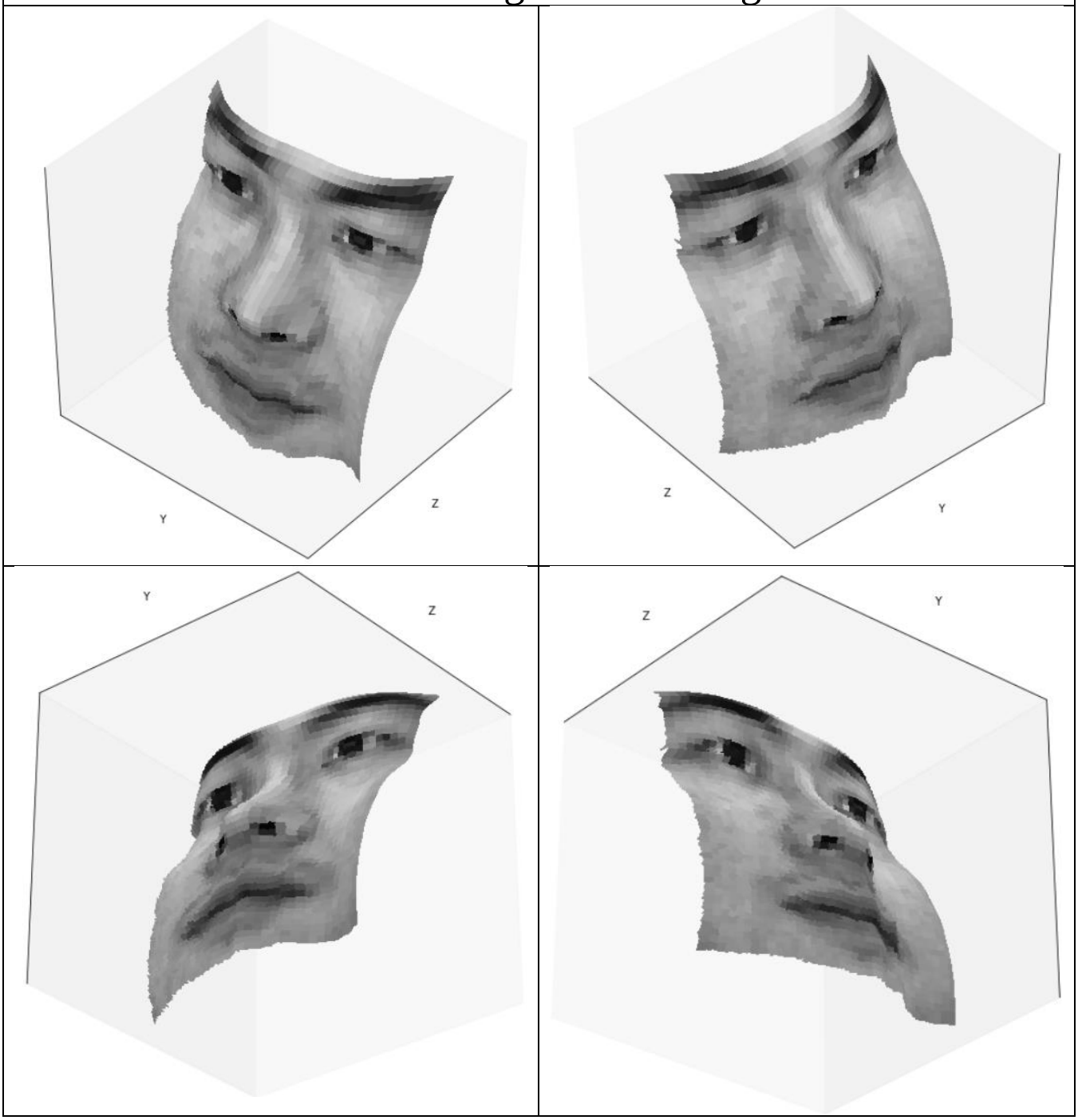
Column		
		

Average		
		

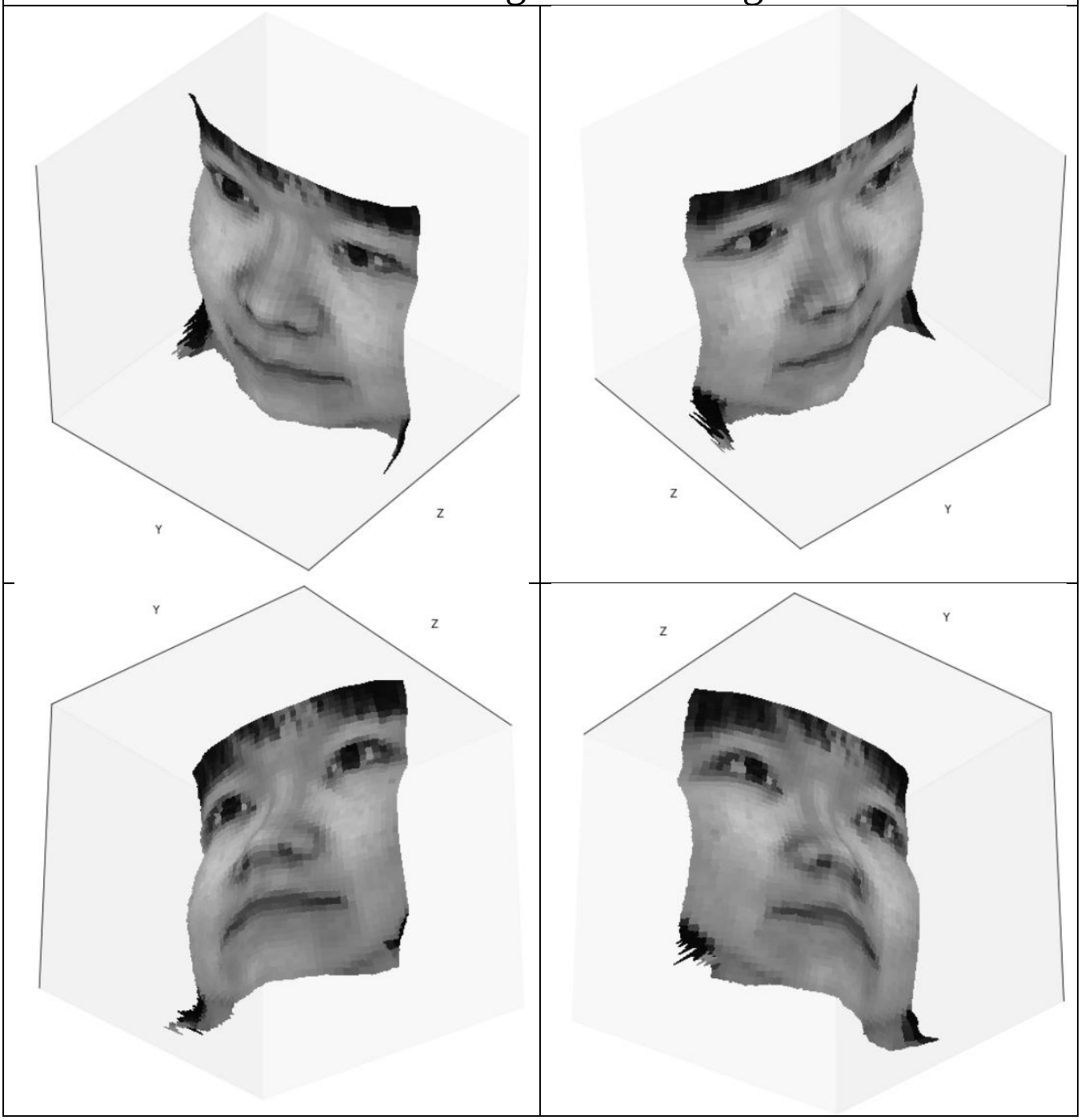
Random		
		

Different views for B01 using random integration method

Different views for B02 using random integration method



Different views for B05 using random integration method



6. Which integration method produces the best result and why?
    A. Taking the average of different random paths on the image produces the best results as

7. Compare the average execution time (only on your selected subject, “average” here means you should repeat the execution for several times to reduce random error) with each integration method, and analyze the cause of what you’ve observed:

Integration method (Subject B07)	Execution time (averaged over 10 iterations)
random	131.361s
average	0.000895s
row	0.000499s
column	0.000596s

Analysis:

The row and column times are close together and set the baseline time taken to integrate over the entire image in the most efficient way possible.

The execution time for the averaging method is a sum of the row and column methods as they are both executed and then averaged to obtain the result.

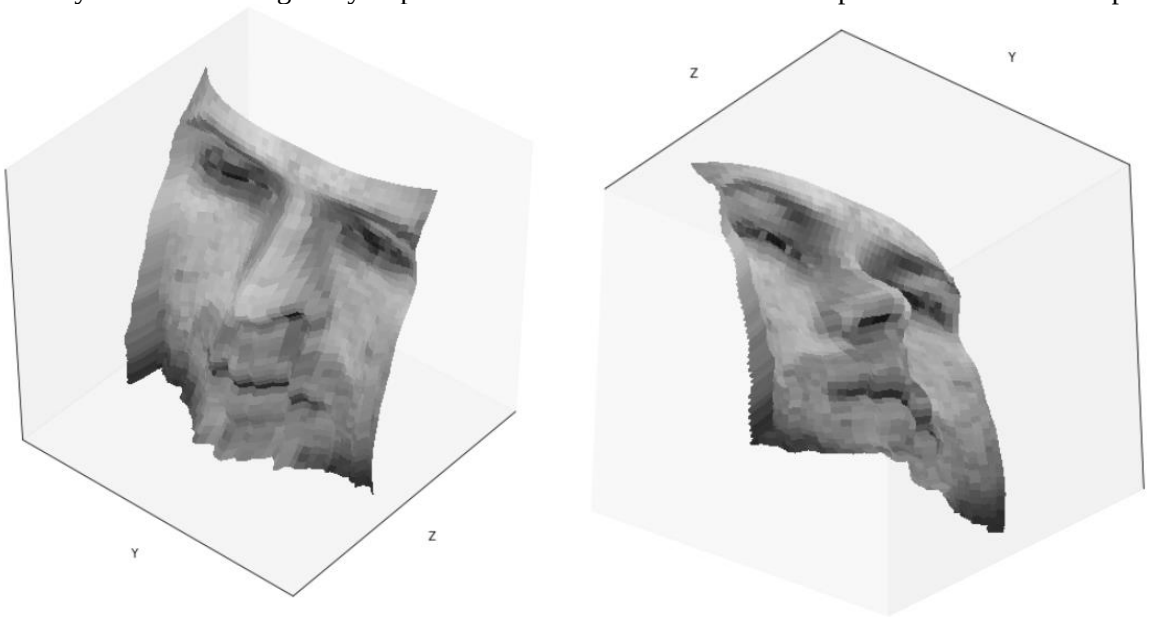
The random integration method takes a much higher order of runtime as the implementation I used consists of 5 nested for loops including 15 paths to each pixel to calculate the integral.

Part-3 : Violation of the assumptions

8. Discuss how the Yale Face data violate the assumptions of the shape-from-shading method covered in the slides.
    1. The texture of faces violates the Lambertian object assumption that Photometric Stereo makes as it does not have a uniform reflectance.
    2. The images captured across subjects will never be consistent as there will always be discrepancies in the shapes of different features on the person's face.

9. Choose one subject and attempt to select a subset of all viewpoints that better match the assumptions of the method. Show your results for that subset.
    1. For subject B01 while using the column integration method, there is a valley that forms near the right side of the lip that may be due to the presence of s stubble on the upper lip of the subject. To mitigate the errors caused by this, I will take out some of the viewpoints where there the stubble causes some irregularities that would not exist without it.

10. Discuss whether you were able to get any improvement over a reconstruction computed from all the viewpoints.



1.
2. There does seem to be some reduction in the depth of the valley present in the height map for the column integration method

Part-4 : Bonus

Post any extra credit details/images/references used here.