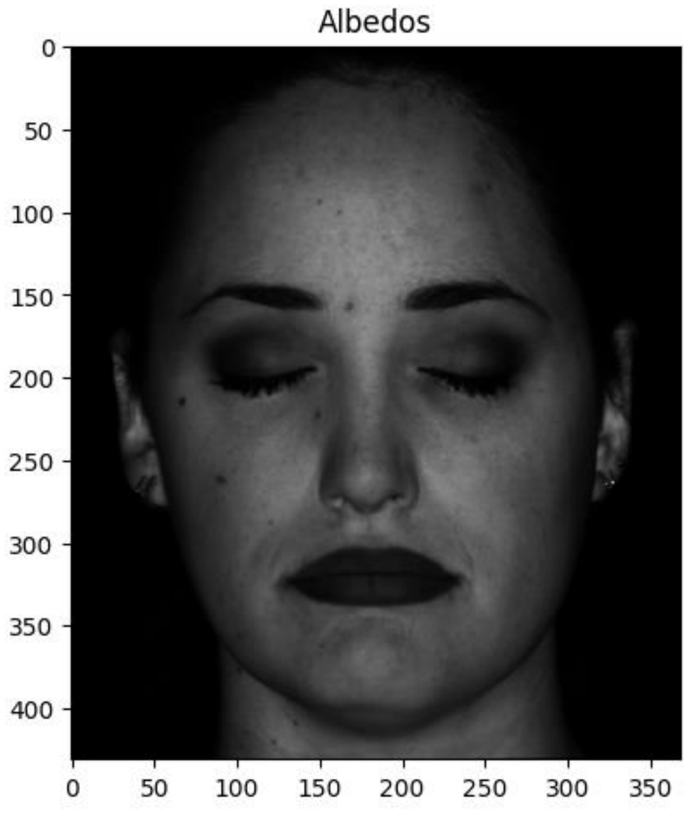
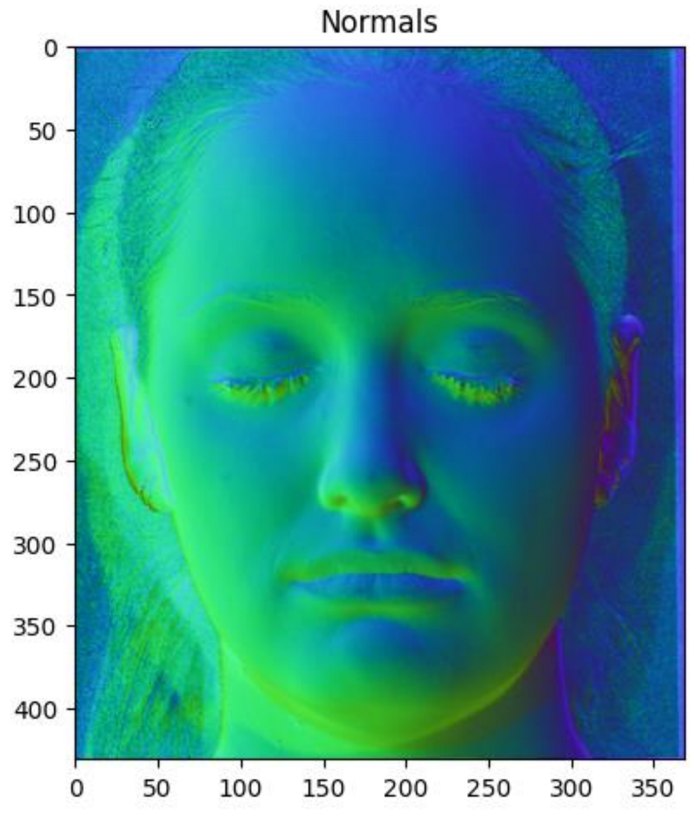
15663 Computational Photography Homework 5

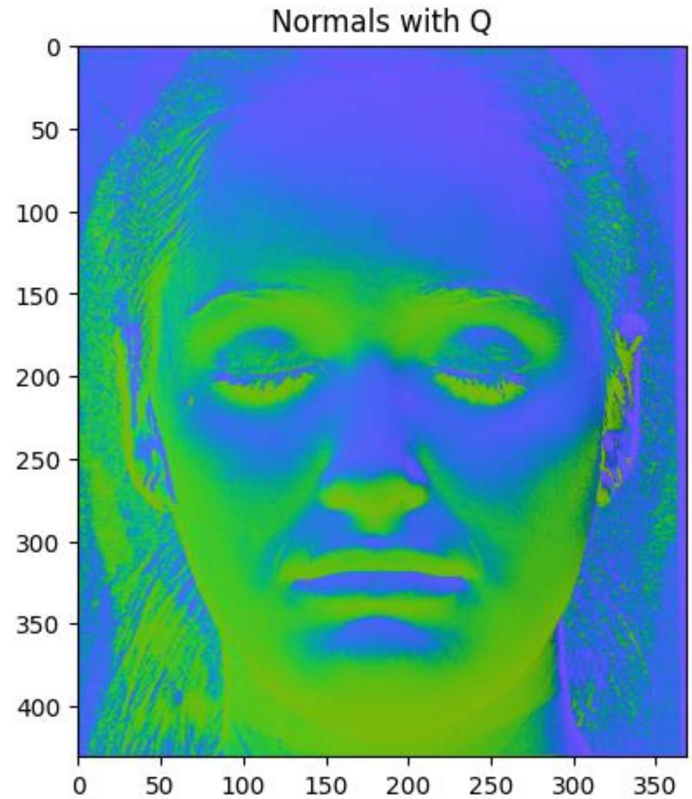
1. Photometric Stereo

1.1. Uncalibrated Photometric Stereo

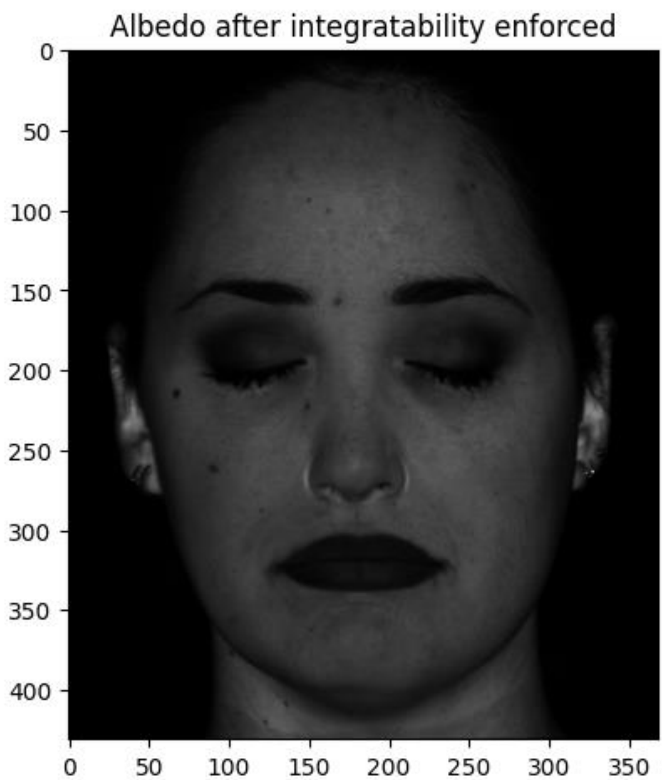
Visualizing Albedos and Normals:

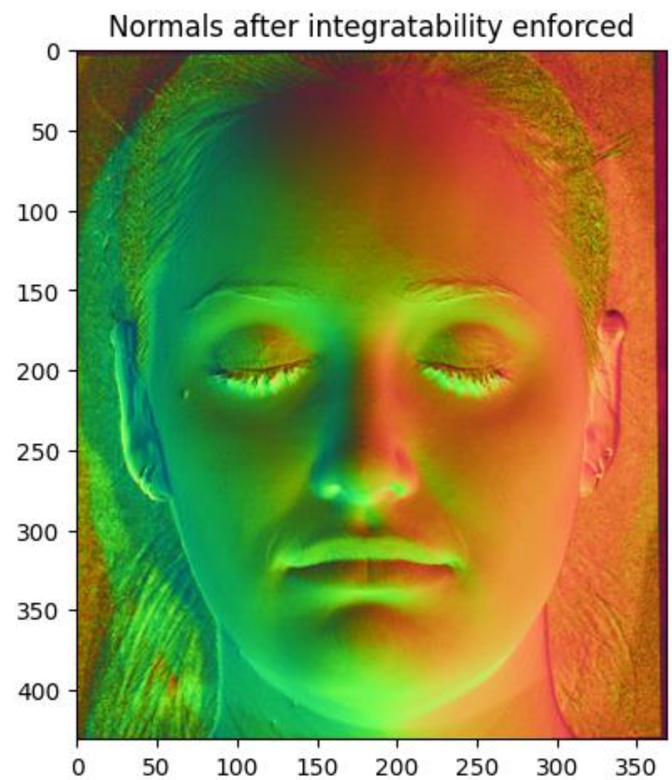






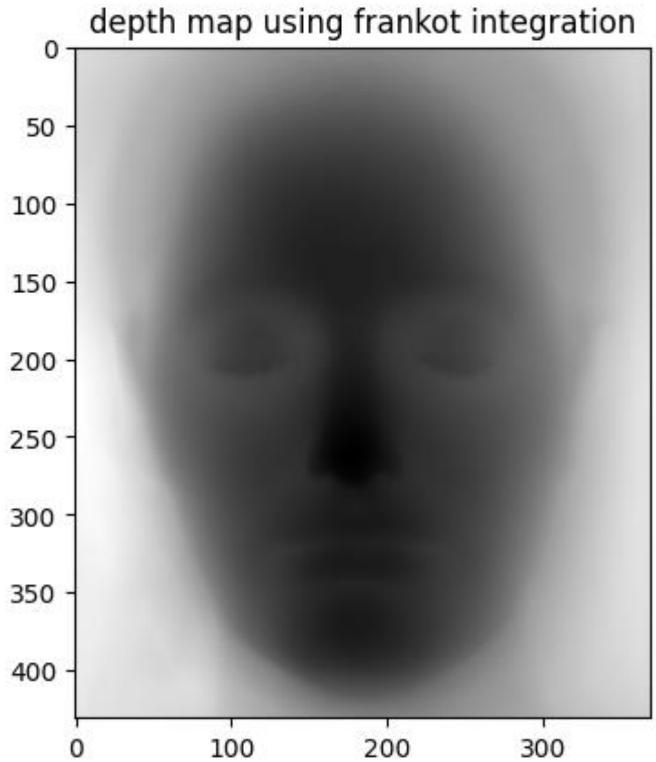
1.2. Enforcing Integrability

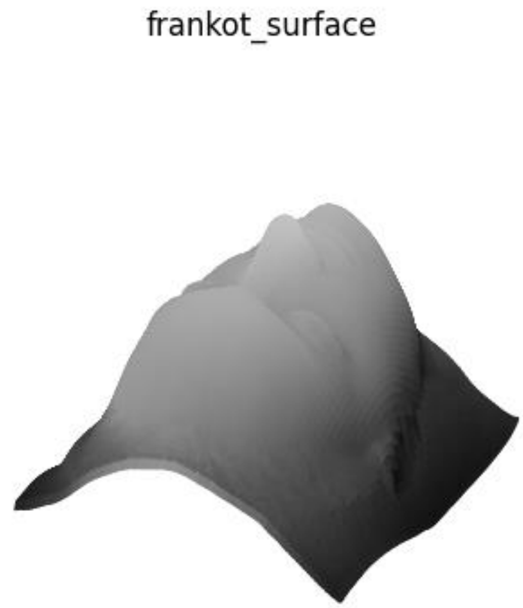




I experimented with various sigma values and found not much variation in my results. I ended up using sigma of 4

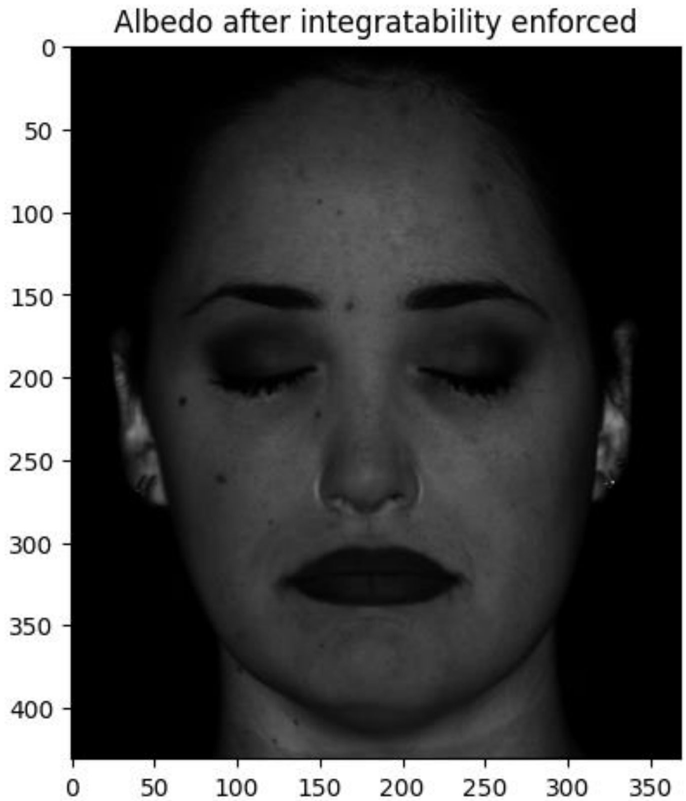
1.3 Normal Integration :

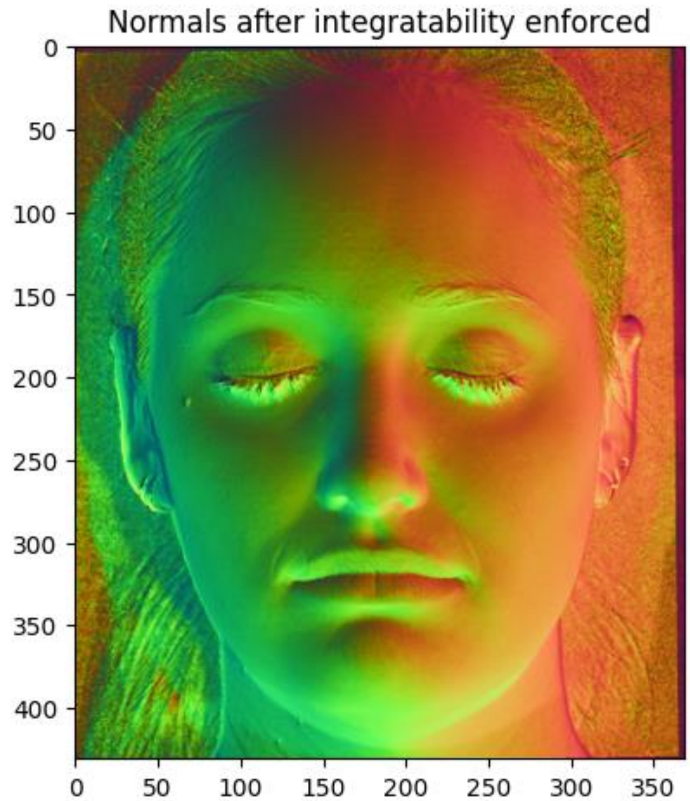


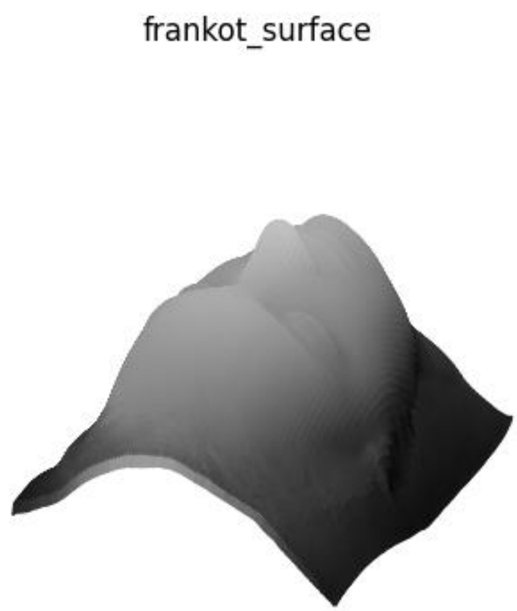


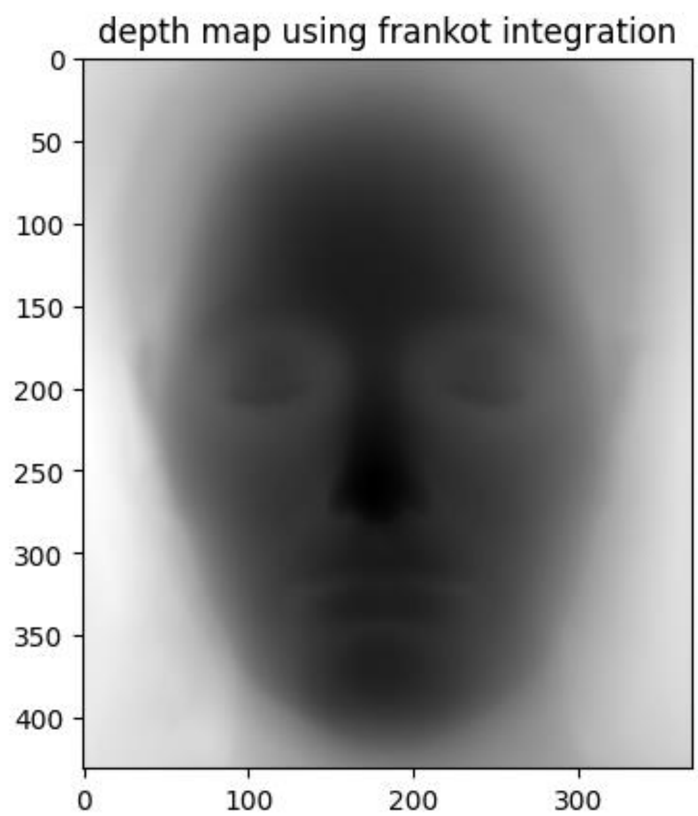
Between Poisson and frankfot integration methods, I observed that the depth estimation is more precise in frankfot method. The above results are generated with u=v=0, lambda = 1

Experimenting with different GBR :



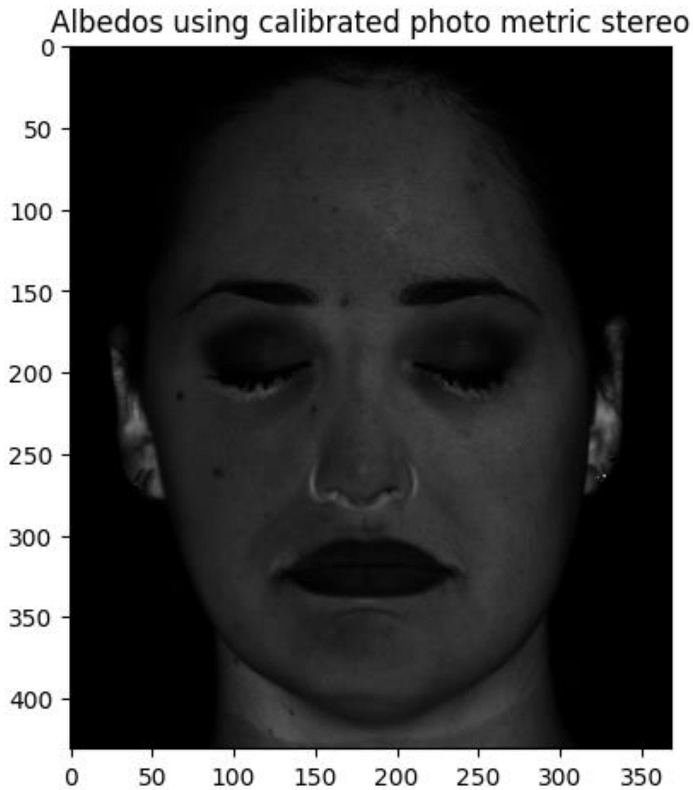


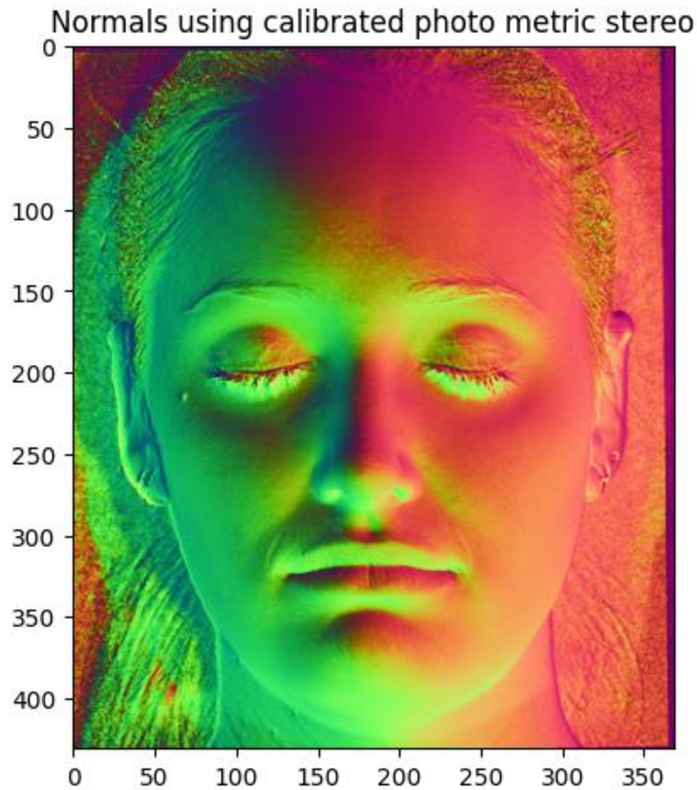


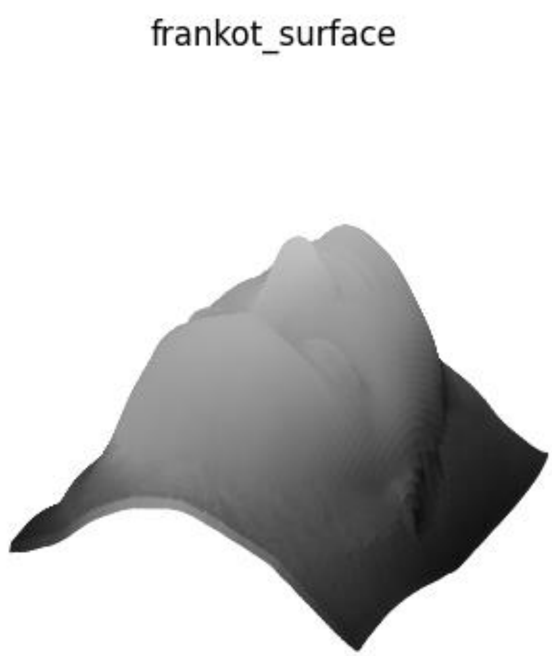


The above results are generated with u=v=l=2, and by varying these values, I can only observe the slight change in thickness of this surface, either becoming flat or elongation. The best results observed are shared above with u=v=0, l =1.

1.4. Calibrated Photometric Stereo :







Calibrated versus uncalibrated photometric stereo. The calibrated results look sharper and better contrast. Although we can match uncalibrated one with calibrated, it takes more hyperparameters tuning. We apply blur to the uncalibrated PS which makes it less accurate in estimating depth and reconstructing the surface.

2. **Capturing your own Photometric Stereo :**

Result with the image captured that violates ideal photometric stereo :

Image 1

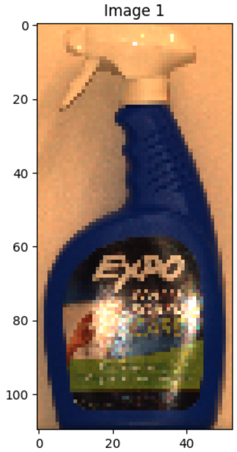


Image 2

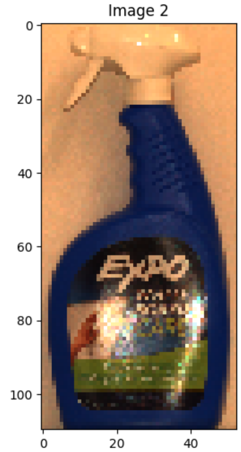


Image 3

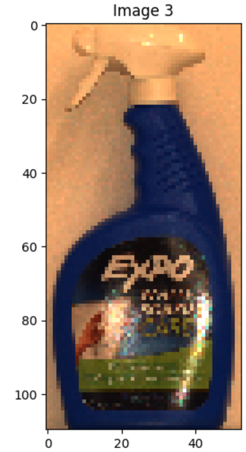


Image 4

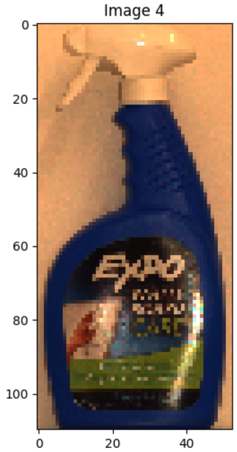


Image 5

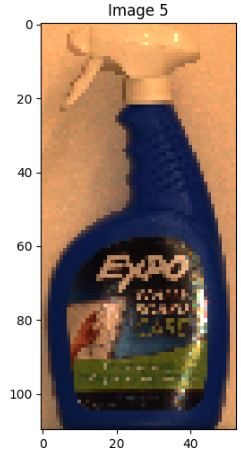


Image 6

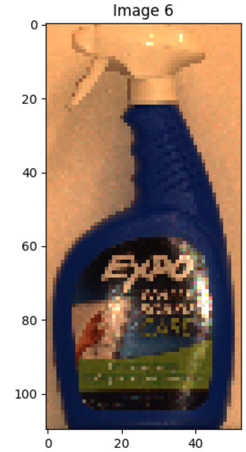
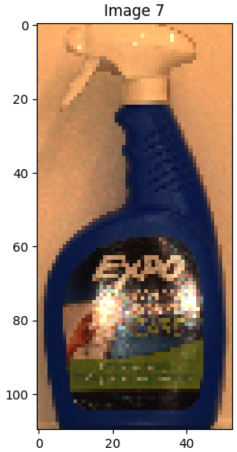
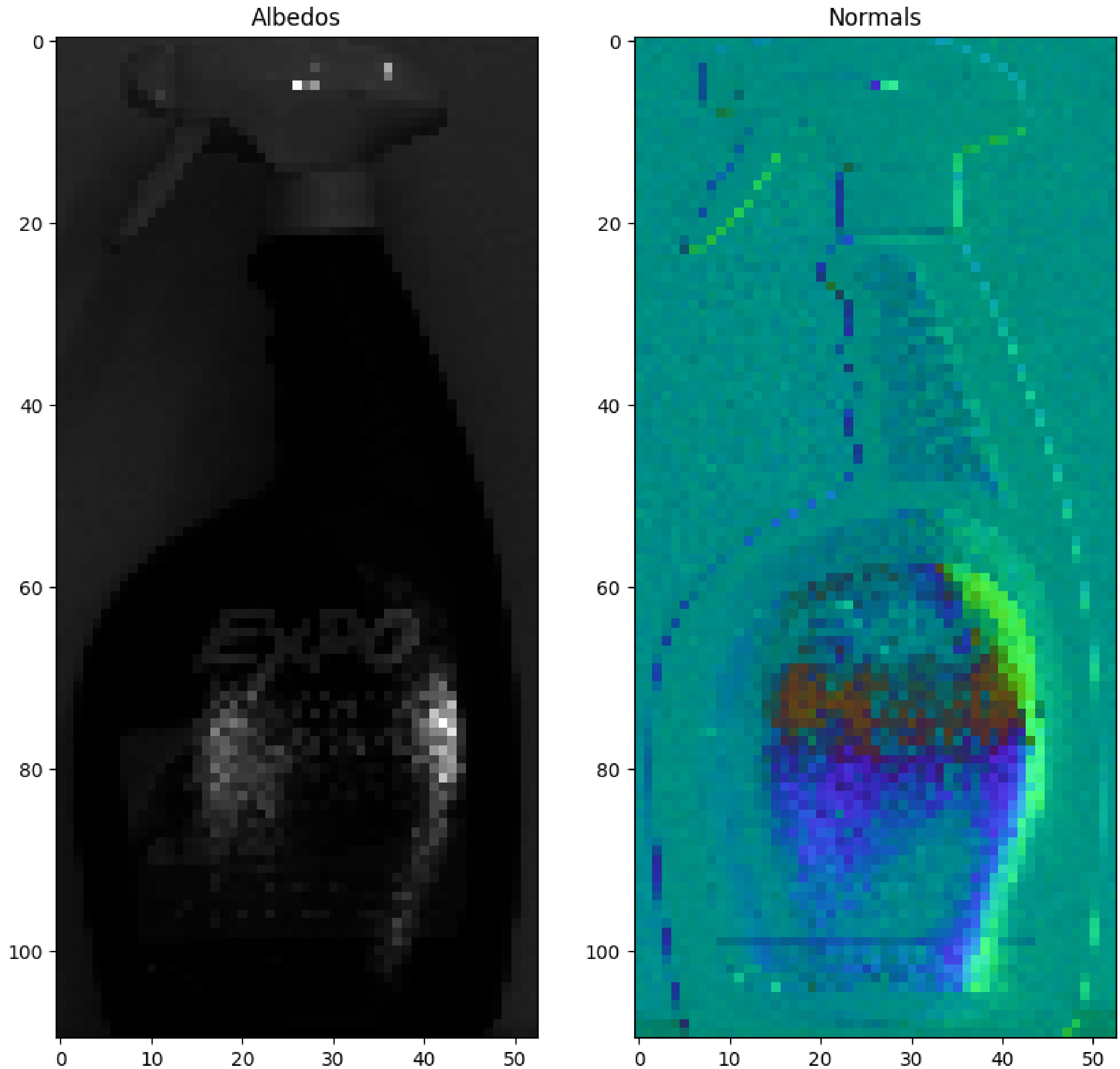
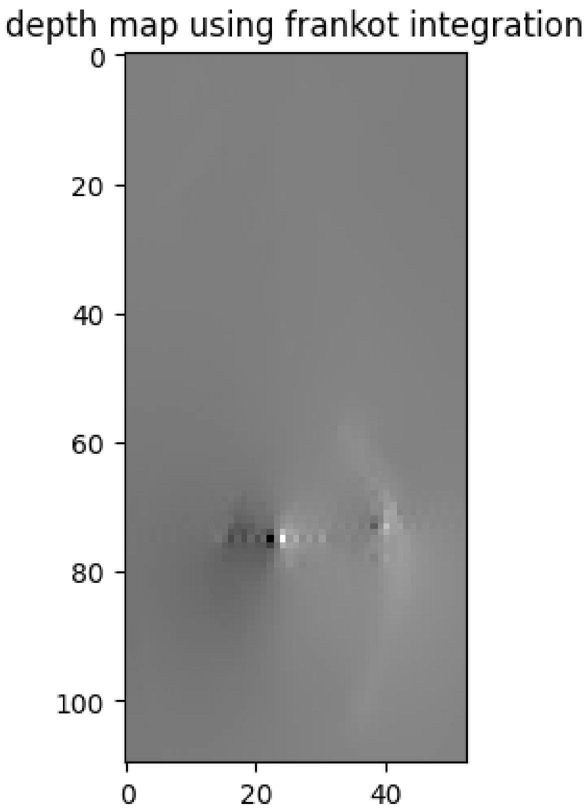
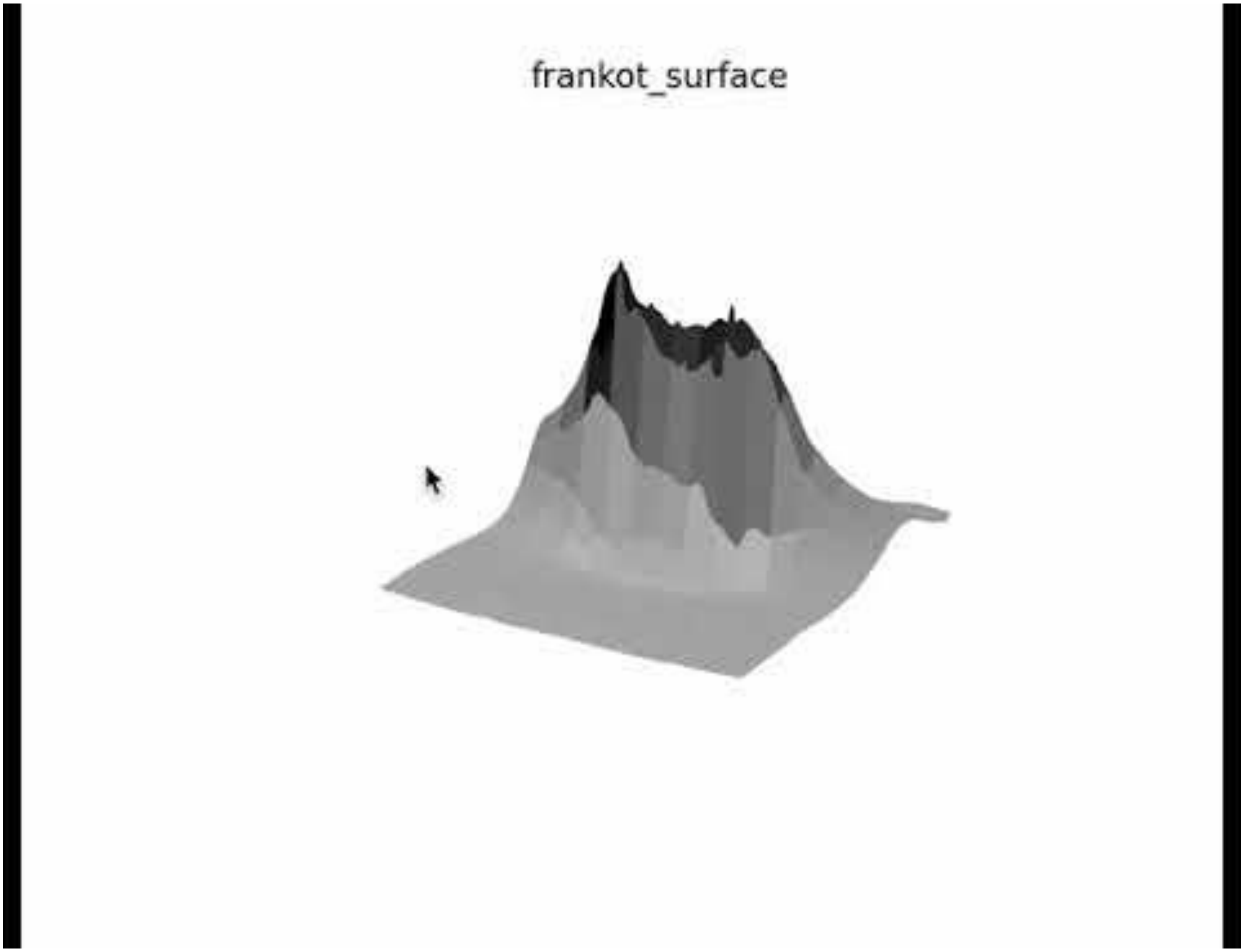


Image 7



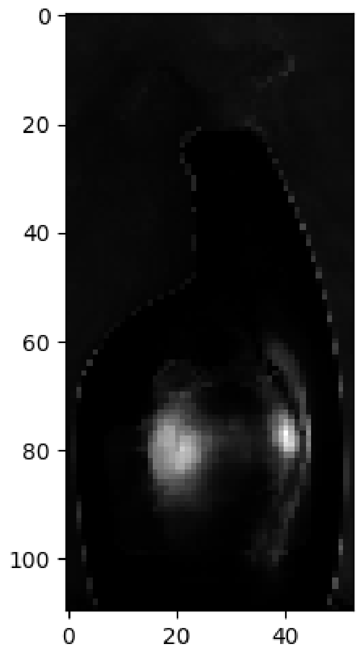

Albedos
Normals
0
20
40
60
80
100
0
10
20
30
40
50
EXPO


depth map using frankot integration
0
20
40
60
80
100
0
20
40



Click on this to see the 3d view

Rendering under a new light direction:



The object used is non-diffuse at the label part, which violates the photometric stereo assumption. But still we can see a close surface reconstruction result.

Results with an object close to lambertian surface :

Image 1

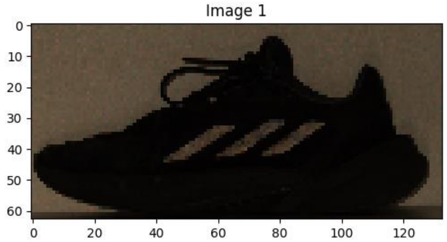


Image 2

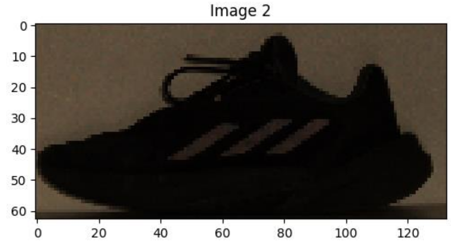


Image 3

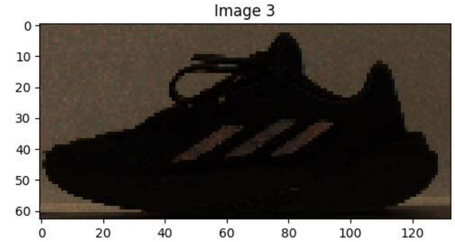


Image 4

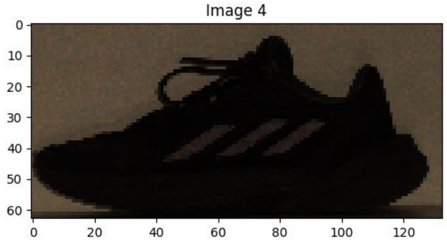


Image 5

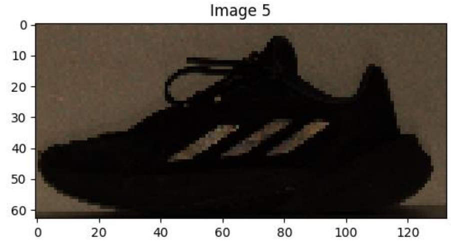


Image 6

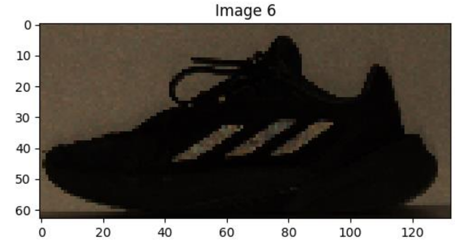
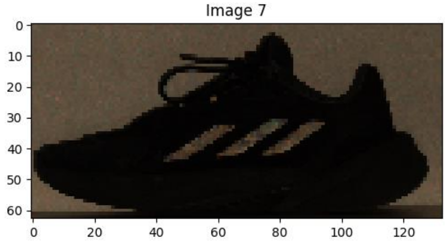
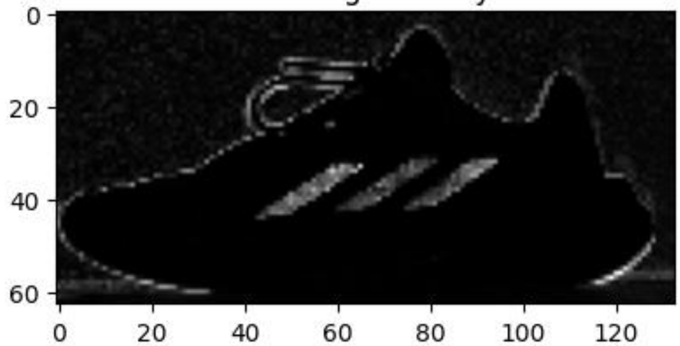


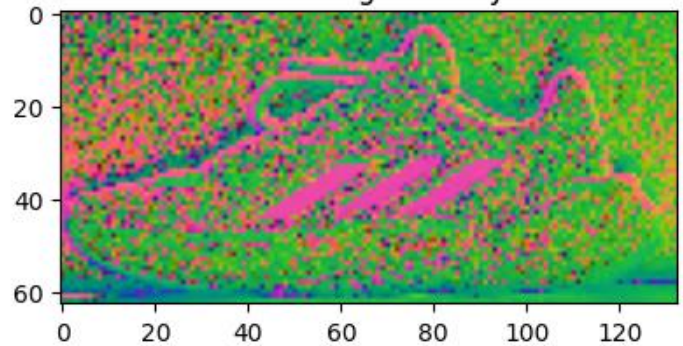
Image 7



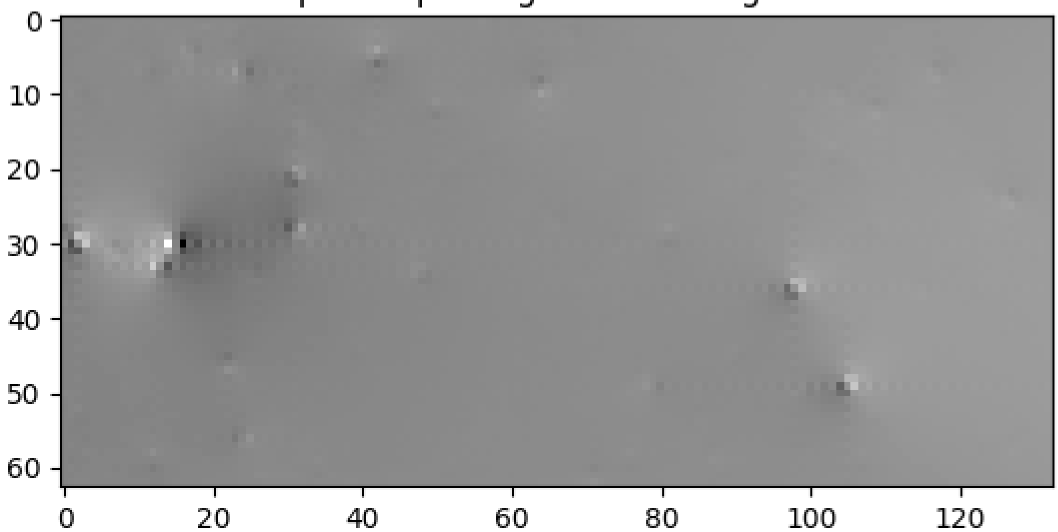
Albedo after integratability enforced



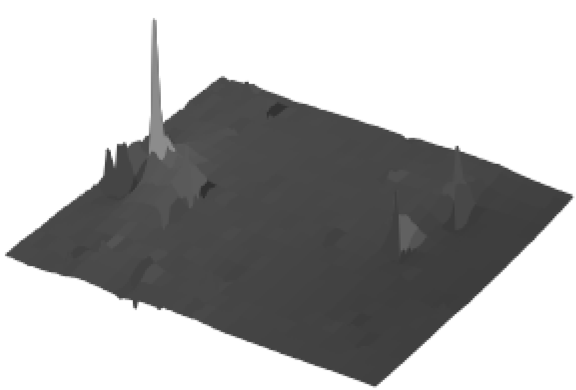
Normals after integratability enforced



depth map using frankot integration

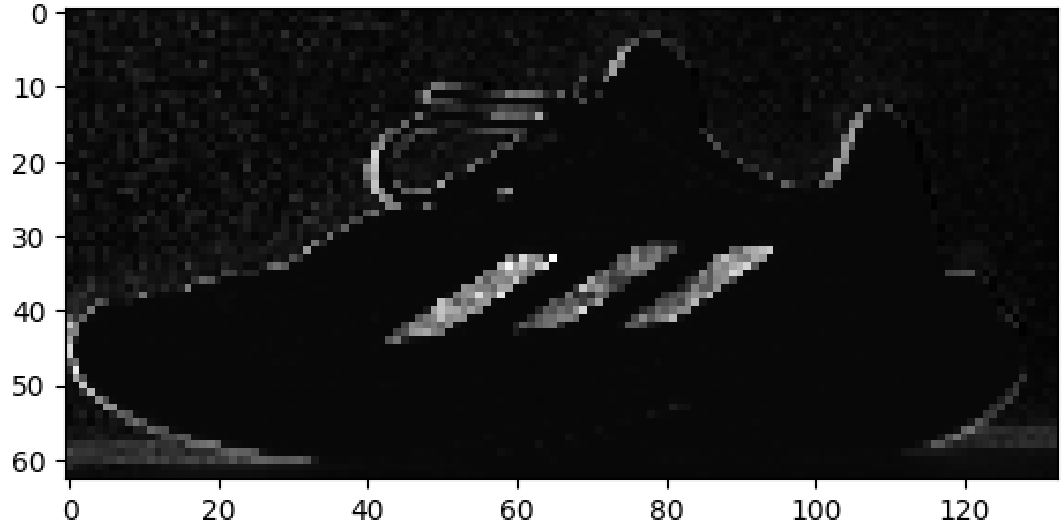


frankot_surface



As you can see, the results are not great with this object. I tried reconstructing the surface with 6 different objects under different distances from the camera. I guess I am making mistakes with either shadows appearing around the processed image or the flash light I am using is less intense and hence I am using shutter speed of 10s, which is a source for more noise.

Rendering under a new light condition:

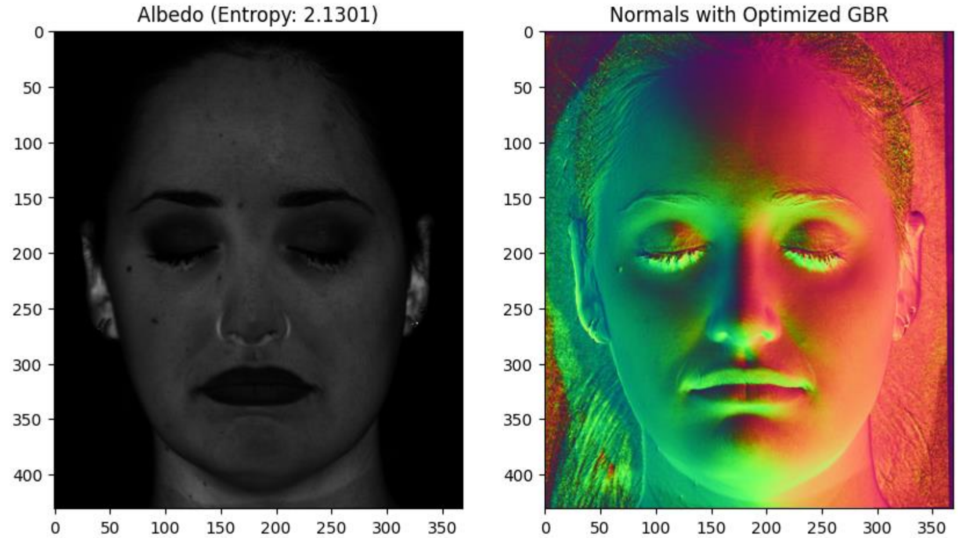


3. **Entropy Minimization :**

Image 1 :

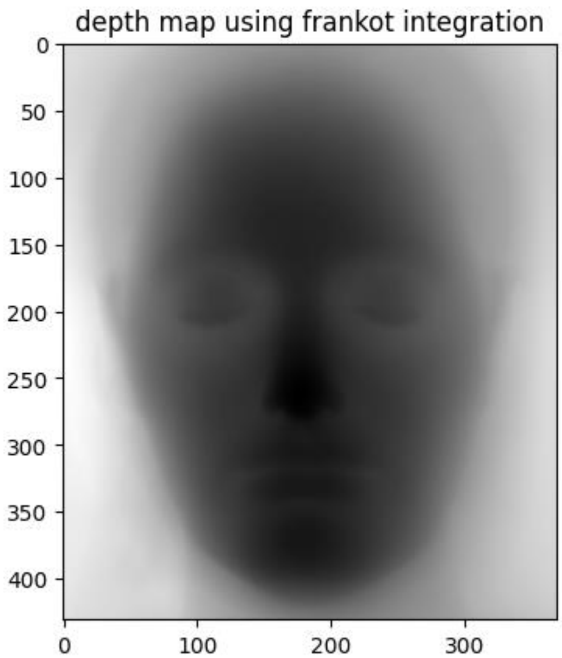
Optimal GBR :

```
[[1.         0.         0.        ]
 [0.         1.         0.        ]
 [0.0177214  0.24175874 0.26782841]]
```



Minimum entropy is 2.13 obsevred at lambda = 0.2, u = 0.01, v = 0.24

By increasing the number of trials, I am reaching closer to the calibrated Photometric Stereo results. This method didn’t work for the images I captured, probably because of the earlier computation error.



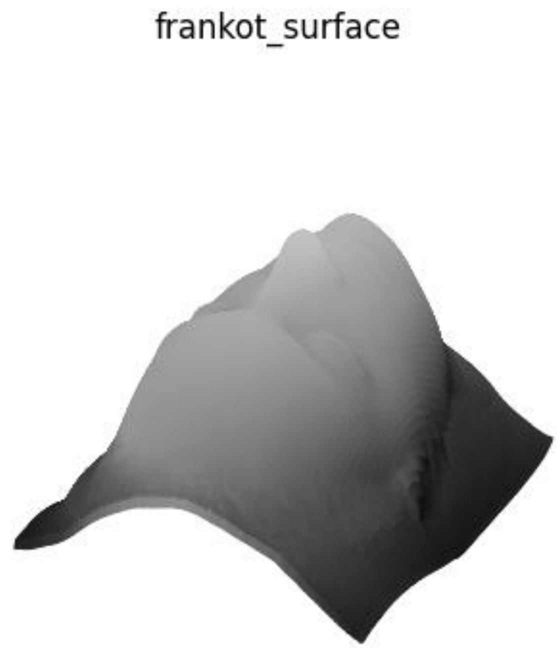
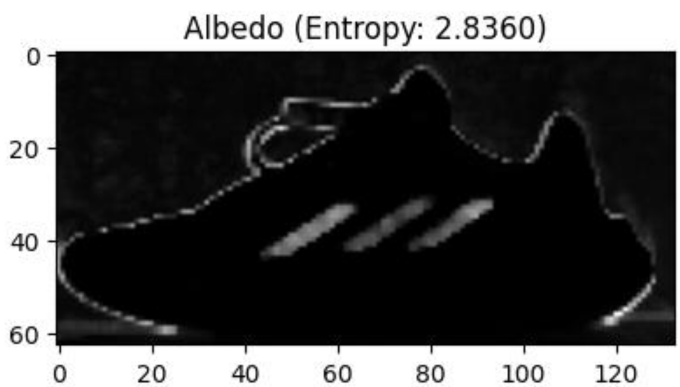
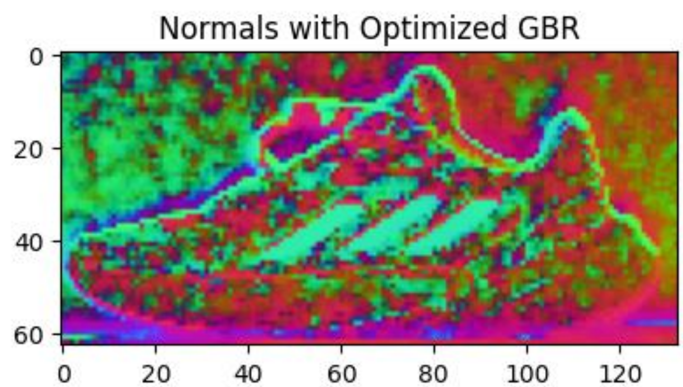
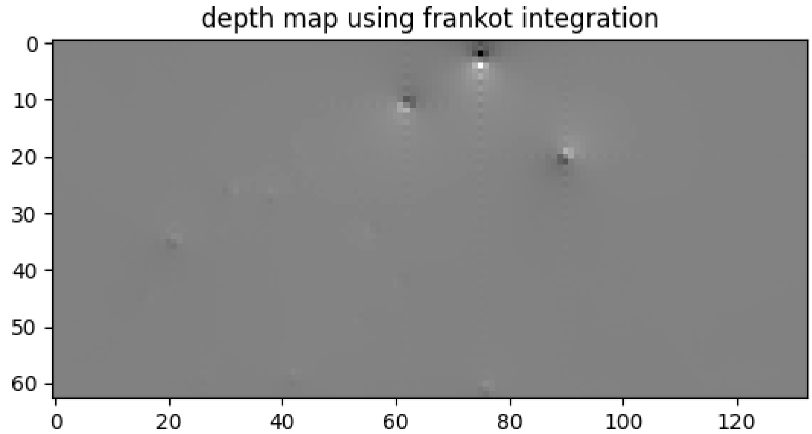


Image 2 :






depth map using frankot integration
0
10
20
30
40
50
60
0
20
40
60
80
100
120

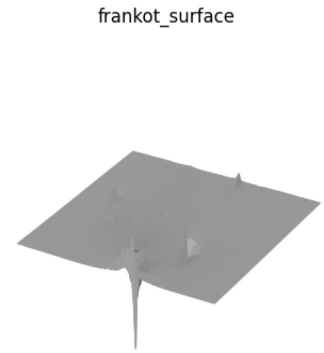
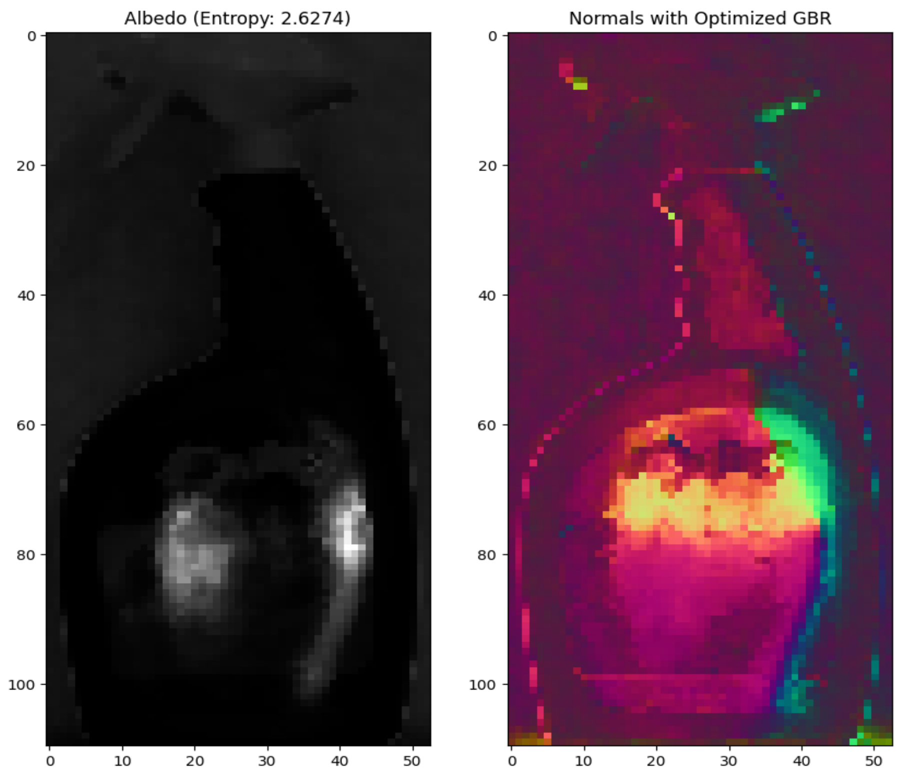
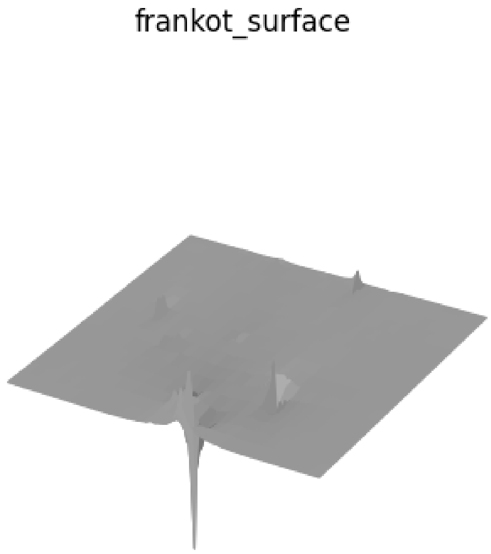
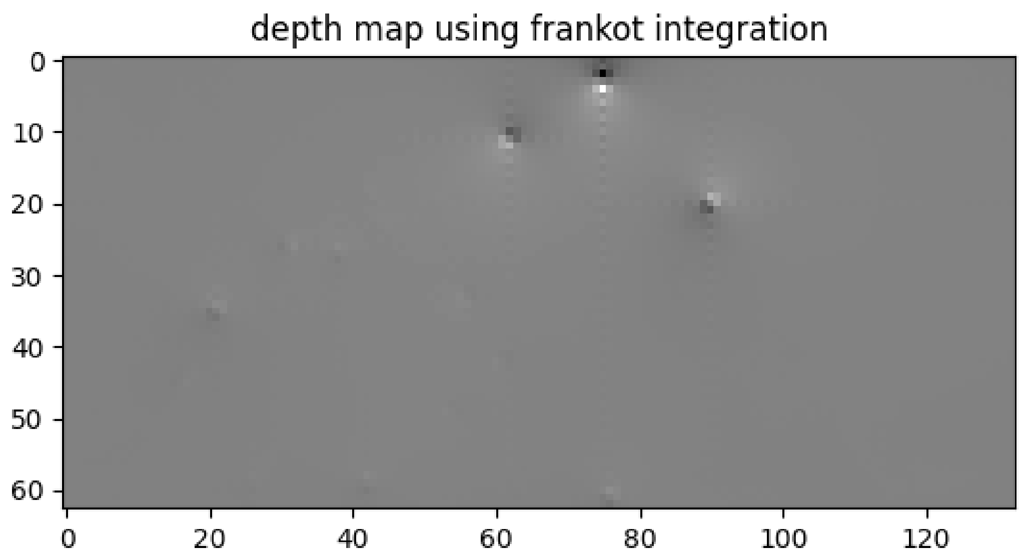

frankot_surface

Image 3 :


Albedo (Entropy: 2.6274)
Normals with Optimized GBR
0
20
40
60
80
100
0
10
20
30
40
50


frankot_surface


depth map using frankot integration
0
10
20
30
40
50
60
0
20
40
60
80
100
120