Computational Photography Assignment 5

Sagnik Ghosh

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1 Photometric stereo

1.1 Initials

```
# Load images
I = [tiff.imread(os.path.join(args.data_dir, f'input_{i}.tif')) for i in range(1,8)]
I = np.array(I) / (2**16 - 1)

# Extract luminance
I = np.array([lRGB2XYZ(I[i])[:,:,1] for i in range(I.shape[0])])

# Reshape
_, h, w = I.shape
I = I.reshape((I.shape[0],-1))
```

1.2 Uncalibrated photometric stereo

Figure 1: Albedo

Figure 2: Normals

The matrix Q used is:

```
Q = np.array([[1,0,1],
              [0,1,0],
              [0,0,1]])
```

Figure 3: Albedo with Q transform

Figure 4: Normals with Q transform

1.3 Enforcing integrability

Figure 5: Albedo

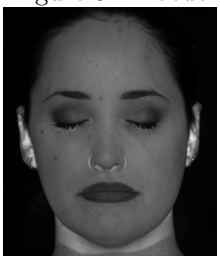


Figure 6: Normals

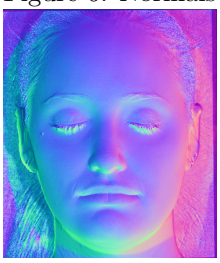


Figure 7: Depth

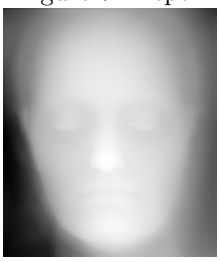
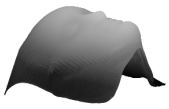


Figure 8: Surface



After experimenting with different GBR matrices, I found that using $\mu = 0$, $\nu = 0.1$, and $\lambda = -1$ works the best. Here are the results:

Figure 9: Albedo

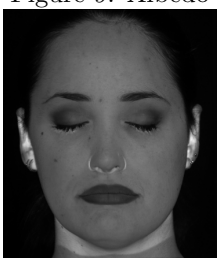


Figure 10: Normals

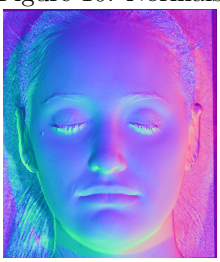


Figure 11: Depth

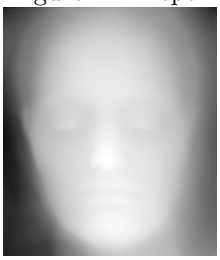


Figure 12: Surface

1.4 Calibrated photometric stereo

Qualitatively, the surface looks very similar to the uncalibrated case. An advantage of the calibrated case is that I did not have to vary the σ parameter or the GBR parameters to get a decent looking surface.

Figure 13: Albedo

Figure 14: Normals

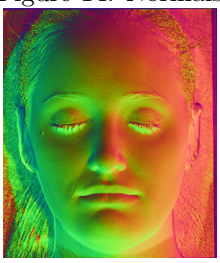


Figure 15: Surface

2 Capture and reconstruct your own shapes

2.1 Object 1 - Obeys most assumptions

The object I chose is a paper roll with some text on it. It is a simple cylindrical surface. The albedo looks great before enforcing integrability but looks off after it. This seems to suggest that some assumptions were violated while capturing the data. The surface was perfectly lambertian with no concavities. Noise was probably not an issue because I averaged 10 images for every light source direction. The only other explanation could be that the camera and the light sources were not far enough from the object (tried 1-2 meters, but it probably wasn't enough). The new rendered image looks a bit off because of the same reasons. Fortunately, the surface looks close enough to the target, although the curvature of the cylinder could have been softer.

Figure 16: One of the images captured

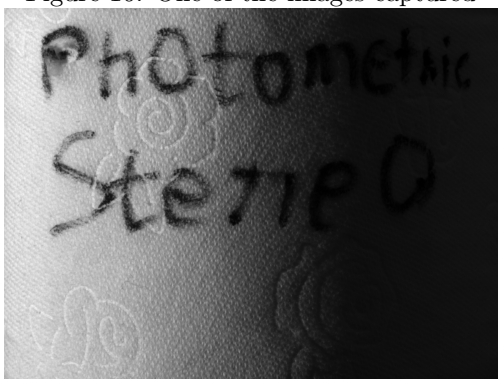


Figure 17: Albedo before enforcing integrability

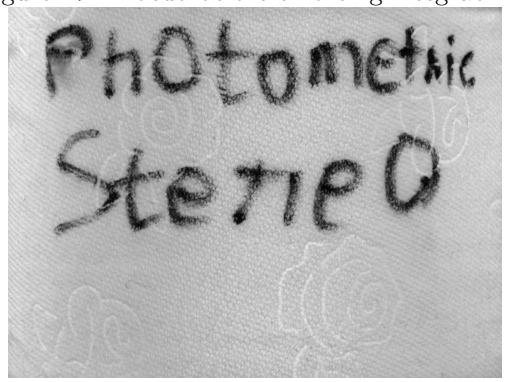


Figure 18: Albedo after enforcing integrability

Figure 19: Normals

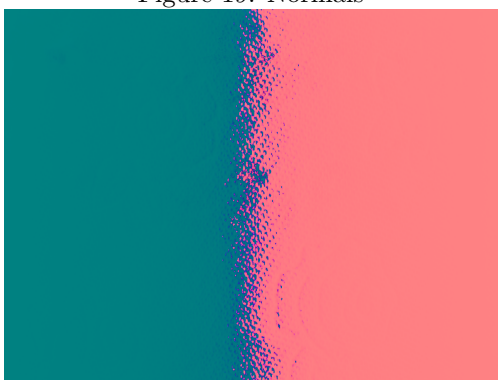


Figure 20: Surface

Figure 21: Rendered from new light direction

2.2 Object 2 - Violates some assumptions

I chose a sunscreen bottle that's not fully lambertian. This violation clearly breaks down photometric stereo based on the results obtained. The surface obtained does not even resemble the true surface (after experimenting with multiple σ values), unlike in the previous case with the paper roll.

Figure 22: One of the images captured

Figure 23: Albedo after enforcing integrability

Figure 24: Normals

Figure 25: Surface

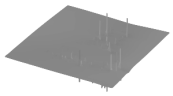


Figure 26: Rendered from new light direction