

ECE 5460 Image Processing AU2018
Project #2
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1 Introduction

In this project, we implement illumination cone algorithm for finding the surface normals and reflectance of an object from a set of images obtained under different lighting conditions. This set of images, assuming a Lambertian object, can be approximated by a three dimensional linear subspace, under an orthographic camera model and without shadows and specularities.

2 Experimental Results

2.1 Evaluation results on Image Set A

We first evaluate standard illumination cone algorithm on the first dataset: Image Set A. As shown in Fig. 1, the first image is illuminated from atop. The other sources are rotated 60 degree from the z-axis and toward the xy -plane (the image plane), and located at 45 degree (mid point) in each of the quadrants. The 3D positions of these light sources are further illustrated in Figure 2.

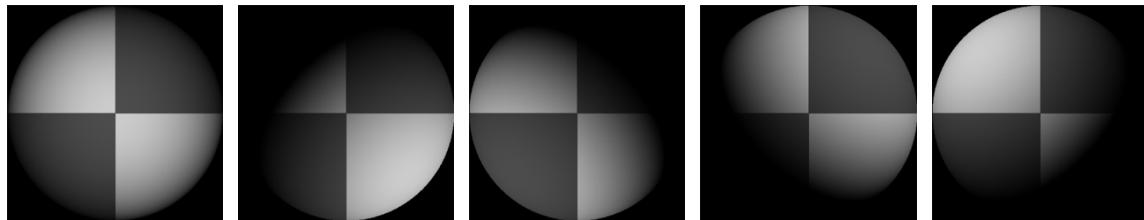


Figure 1. Image Set A.

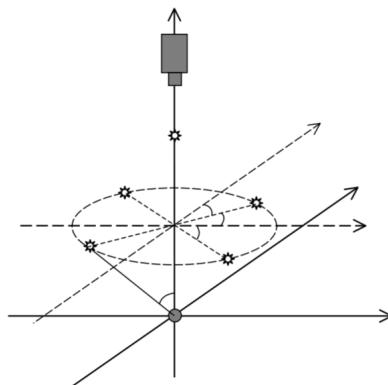


Figure 2. 3D positions of the light sources

We use the images shown above and the matrix of source vectors \mathbf{V} , recover the albedo and shape of the original object. The results are shown below. Fig. 3 shows recovered reflectance, which is the albedo. Fig. 4 shows recovered normals field while without depth information. Finally, the shape can be recovered from the normals as in Fig. 5 and Fig. 6. New generated samples are shown in Fig. 8.

Please refer the Matlab source code and generated video (***circle.avi***) for more intermediate results.

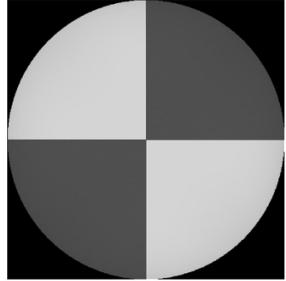


Figure 3. Recovered reflectance (albedo)

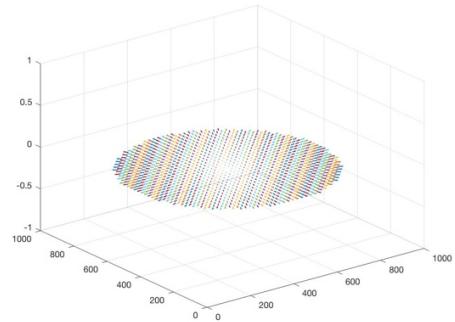


Figure 4. Recovered normals field.

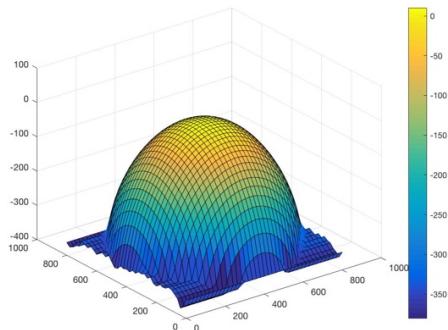


Figure 5. Surface recovered by integration (shape). **Figure 6.** Recovered 3D reflectance.

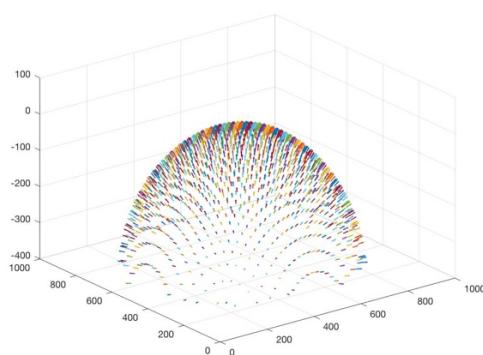
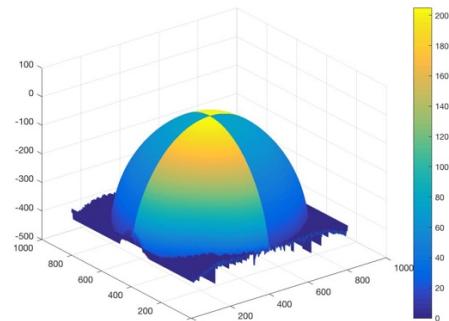


Figure 7. Recovered normals on shape.

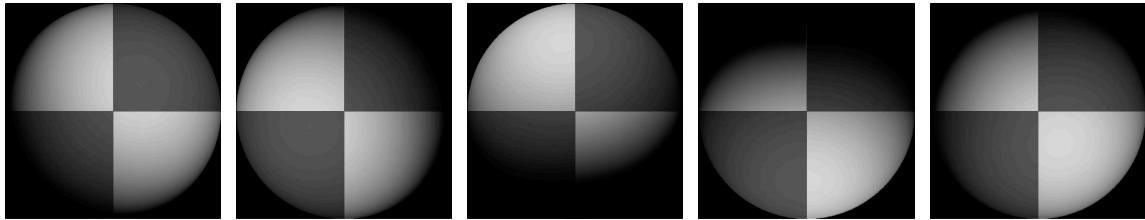


Figure 8. New generated samples. See *circle.avi* for more results.

2.2 Evaluation results on The Extended Yale Face Database B

Next, we use The Extended Yale Face Database [1] to compute the illumination cone of a face and generate new samples. Similarly, as shown in Fig. 9, we select a single identity in our experiment. The first image in Fig. 9 is illuminated from atop. The other images are under different illumination angles.

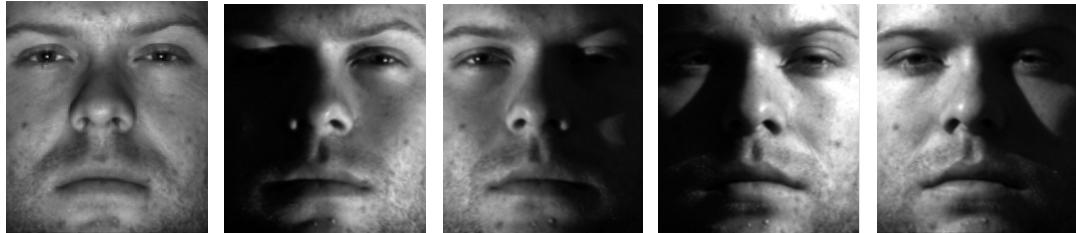


Figure 9. yaleB01 subject. From left to right: yaleB01_P00A+000E-20.pgm, yaleB01_P00A-060E-20.pgm, yaleB01_P00A+060E-20.pgm, yaleB01_P00A-060E+20.pgm, yaleB01_P00A+060E+20.pmg



Figure 10. Albedo

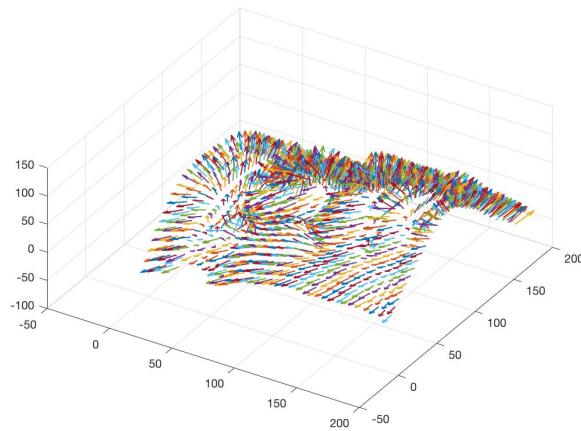


Figure 11. Recovered normals on shape

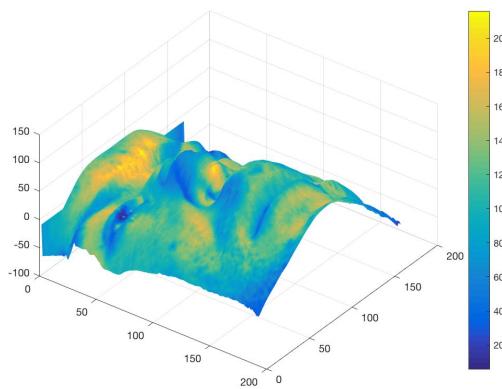


Figure 12. Surface recovered by integration

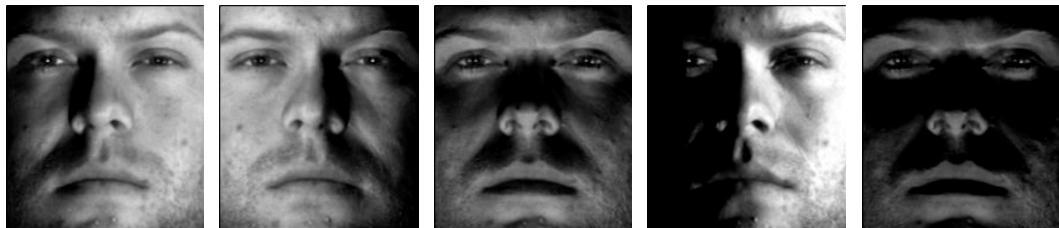


Figure 13. Generated new samples

Please refer to source code and the generated video (*face.avi*) for more intermediate results.

Reference

- [1] Georghiades, Athinodoros S., Peter N. Belhumeur, and David J. Kriegman. From few to many: Illumination cone models for face recognition under variable lighting and pose. IEEE TPAMI 23.6 (2001): 643-660.