CSC 477 HW6

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Part A

Problem 1

Using photometric stereo and the given images and light directions, we can calculate the surface normals based on the shading of the different images, using

$$\vec{C}(x, y) = V\vec{n}(x, y)$$

where $\vec{C}(x, y)$ is a Nx1 vector that contains the brightness of the pixel at (x,y) for each of the N point light sources. V is a Nx3 matrix of the directions of the N light sources, and $\vec{n}(x, y)$ is the normal vector at point (x, y), which is what we want to calculate. Since we have seven light sources we need to use non-homogeneous least squares to solve for the surface normal vector. Doing this for every point, and using Lambertian shading in order to generate a 'canonical view' of the image, witha constant albedo we get the following image

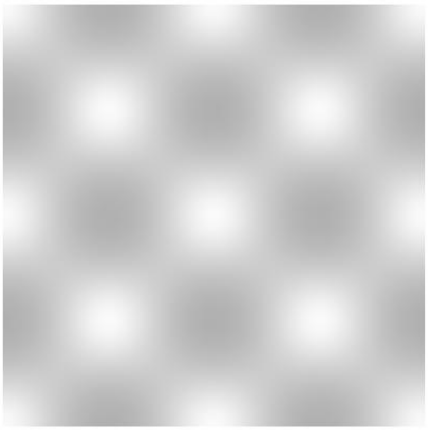

Figure 1: Shape from shading of the given images, with a constant albedo, shaded using Lambertian shading

Problem 2

We can now use the surface normal vectors in order to calculate a depth map of the surface. Setting the origin to a height of 0, we can then use the normals to estimate the partial derivatives using

$$f_x = \frac{-n_x}{n_z} \text{ and } f_y = \frac{-n_y}{n_z}$$

which, when done for each point gives us a depth map we can visualize.

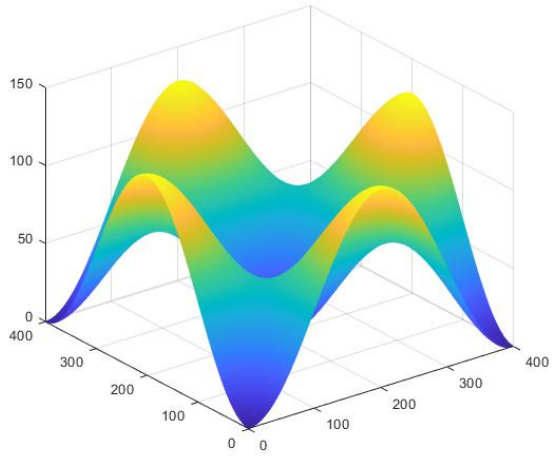

Figure 2: Depth map from partial derivatives using surface normal vectors

Problem 3

Looking at the surface shown above, we can first note a few things: the highest points are bright yellow, the lowest are dark blue, and any point in between those are a shade of green/cyan. With this in mind we can compare the surface with the canonical view we generated to see how the minima and maxima of the canonical view are related to this image.

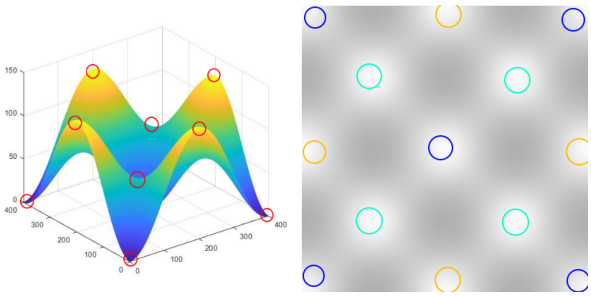

Figure 3: Side by side of the surface from above (left) and the generated canonical view (right)

Keeping in mind that the bright points from the canonical view are points where the surface has a normal vector parallel to the light source (in this case, parallel to $\langle 0, 0, 1 \rangle$), then we can see that each of the bright points correspond to not only to highest and lowest points of the surface, where it is flat in certain areas, but also in the saddles in between those points where it also temporarily becomes flat. The red circles on the surface correspond to bright points on the canonical view, and the color of the circles on the canonical view correspond to the height of that point on the surface (the color matching the colorscale used on the surface)

Problem 4

Given that we now have the depth map, we can now use the partial derivatives to recompute the canonical view by recalculating the surface normals in order to use the Lambertian shading to verify that we get the same image as before (or roughly the same, factoring in noise caused by rounding in steps in between). Doing this results in this image

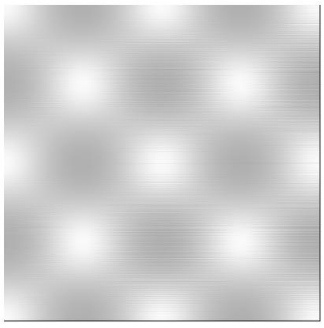

Figure 4: Reconstructed canonical view of the surface with constant albedo