Yale University
Department of Computer Science
CS475/CS575/EE475: Computational Vision and Biological Perception

Problem Set

Due on Tuesday, April 7

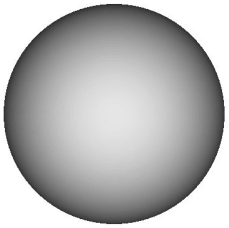
General Instructions

Images available at `http://zoo.cs.yale.edu/classes/cs475/image.html`.

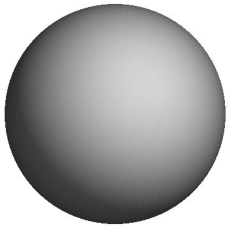
If you would like to submit your answers electronically, please leave a copy in your zoo cs475 directory. Create a subdirectory called `hw4` and name the file `hw4-yourname.pdf` or `hw4-yourname.doc`.

1 Reflectance Map

Consider the images below and assume that they are both Lambertian spheres illuminated by a single light source at infinity. For each of the images, write down a mathematical expression that describes the reflectance map $R(p, q)$ of the object. Briefly explain any extra assumptions that you make. Use MATLAB to draw contour maps of $R(p, q)$ for each image. PARTIAL CREDIT: if you cannot obtain a mathematical expression, provide a hand drawn plot of the $R(p, q)$.



Sphere 1



Sphere 2

2 Shape-from-shading

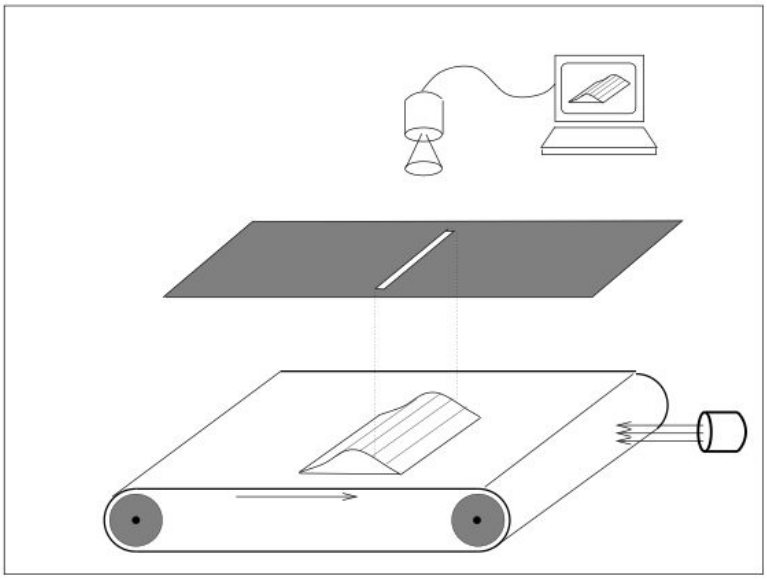


Figure 1: Setup for Problem #2.

Consider an industrial system in which shape is inferred from the shading of folded aluminum sheets, see Figure 1. Each sheet is put on a conveyer belt and slowly progresses toward a line viewed from above by a camera through a very narrow slit. You can assume the following:

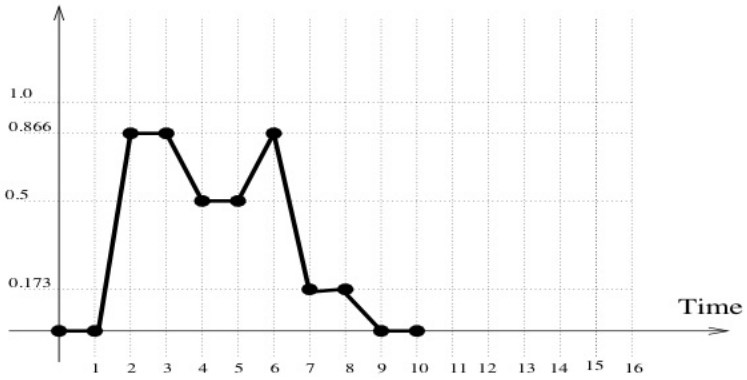
- The object is Lambertian with albedo constant equal to 1.
- The belt is Lambertian as well.
- The object is illuminated from the side by a distant light source so the light rays are parallel to the object's motion.
- The aluminum object curves in one dimension only: its cross section describes it completely. That it, the height function is described by a single parameter.
- The object is carefully positioned so that at any time t the camera records a line of constant intensity $I(t)$.
- The belt is moving with a constant speed.
- The belt is at a known distance which you are free to choose.

Suppose that the system runs for 10 seconds, during which the object moves 10 distance units.

(a) The recorded image intensity is $I(t) = 0.25$. Write down the function of the cross section, i.e. the shape of the object.

(b) Describe the shape as before but assuming that $I(t) = 0.17t$.

(c) Draw the shape of the object by assuming that $I(t)$ is given by the function plotted below.



(d) Assume that you apply the same algorithm to infer shape as in the first previous parts but on a textured object like `Sphere.tiff`: the sphere is on the belt instead of an aluminum sheet. What shape would you obtain? (Qualitative answer.)