ICS 683: Advanced Computer Vision (Fall 2013)

Homework Assignment #4
(Due: Thursday, Nov. 14)

- To help the grader (and also yourself), please be neat, document your code properly, and answer the questions in the order they are stated.
- Typed work is preferred. But if you submit work written by hand, make your handwriting as clear and recognizable as possible. You are solely responsible for any consequences resulting from poor handwriting.
- **Make a report describing implementation details, resulting outputs, and your observation of program/algorithm behavior and results.**
- Create a subfolder 'Homework-4' in your drop box folder at Laulima and upload your homework files (**a report (pdf or MS word file) + a single zip file of your code and a README file**) in that folder. The README file should explain how to run your code, and necessary software or system set-up if your code is not written in MATLAB. In the code, make sure you type in your name and any necessary comments.
- If you submit your homework in person, staple all pages together and be sure to write your name on the front page.

Photometric Stereo

The goal of this assignment is to implement a standard photometric stereo algorithm. Assume Lambertian reflectance function, but the albedo is unknown and nonconstant in the image. Your program will take in multiple images as input along with the light source direction for each image.

NOTES:

- You should divide the image intensities by 255 to scale them from [0,1] before any computation.
- In all images, assume that the strength of the light sources was a constant 1.0.
- Assume that the camera parameter k is 1, i.e. each row of matrix **S** consists of the corresponding light source direction.
- Assume that the intensity is zero for points in shadow and use the method discussed during the class to zeros out any equations from shadow points.

- You need to solve a linear equation $\mathbf{Ax} = \mathbf{b}$ using pseudoinverse. The solution is $\mathbf{x} = \mathbf{A}^{+}\mathbf{b}$ where $\mathbf{A}^{+}$, the pseudoinverse matrix of $\mathbf{A}$, is defined as: $\mathbf{A}^{+} = (\mathbf{A}^{T}\mathbf{A})^{-1}\mathbf{A}^{T}$.
- Set the integration constant – the height of the surface at the start point – as 0.

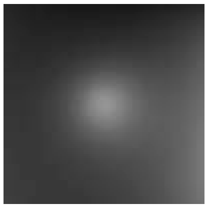
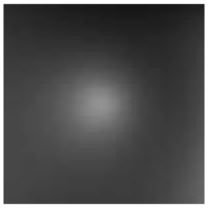
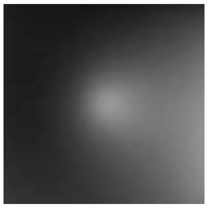
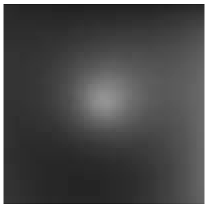
Your program should have two parts:

- Read in the images, and estimate the surface normals and albedo map using corresponding light source directions.
- Reconstruct the height map from the surface normals.

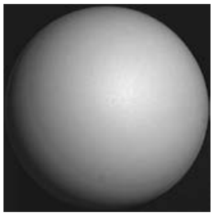
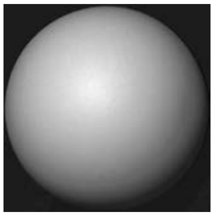
DATA SETS:

All images for this assignment are provided in a zip file "hw4-images.zip", which you can download from the course webpage.

1. SYNTHETIC DATA

Images:				
Filename:	im1.png	im2.png	im3.png	im4.png
Light source direction:	$\begin{bmatrix} 0 \\ 0 \\ -1 \end{bmatrix}$	$\begin{bmatrix} 0 \\ 0.2 \\ -1 \end{bmatrix}$	$\begin{bmatrix} 0 \\ -0.2 \\ -1 \end{bmatrix}$	$\begin{bmatrix} 0.2 \\ 0 \\ -1 \end{bmatrix}$

2. REAL DATA

Images:				
Filename:	real1.bmp	real2.bmp	real3.bmp	real4.bmp
Light source direction:	$\begin{bmatrix} -0.38359 \\ -0.236647 \\ 0.892668 \end{bmatrix}$	$\begin{bmatrix} -0.372825 \\ 0.303914 \\ 0.87672 \end{bmatrix}$	$\begin{bmatrix} 0.250814 \\ 0.34752 \\ 0.903505 \end{bmatrix}$	$\begin{bmatrix} 0.203844 \\ -0.096308 \\ 0.974255 \end{bmatrix}$

OUTPUTS:

- Estimated albedo map: a grayscale image
  - Since $0 \leq$ albedo ≤ 1, multiply 255 to albedo to generate a grayscale albedo map
- Estimated surface normals: three images showing three components of surface normal
- Estimated surface height map either as
  - a grayscale image: for this you need to scale the height values between 0 to 255

    (i.e. scale the resulting height values so that the minimum height value maps to 0 and the maximum height value to 255)
  - 3D surface plot: for this, you should use the actual height values