Computer Vision **CS 543 / ECE 549**

Homework 1
Due Feb 16, 2010

Answer the following questions and explain solutions. Numbers in parentheses give maximum credit value. You can work in small groups, but turn in individual solutions and indicate collaborators. Do not use code from the Internet. Turn in hard copies of solutions by 12:15pm (start of class) on Tuesday, Feb 16.

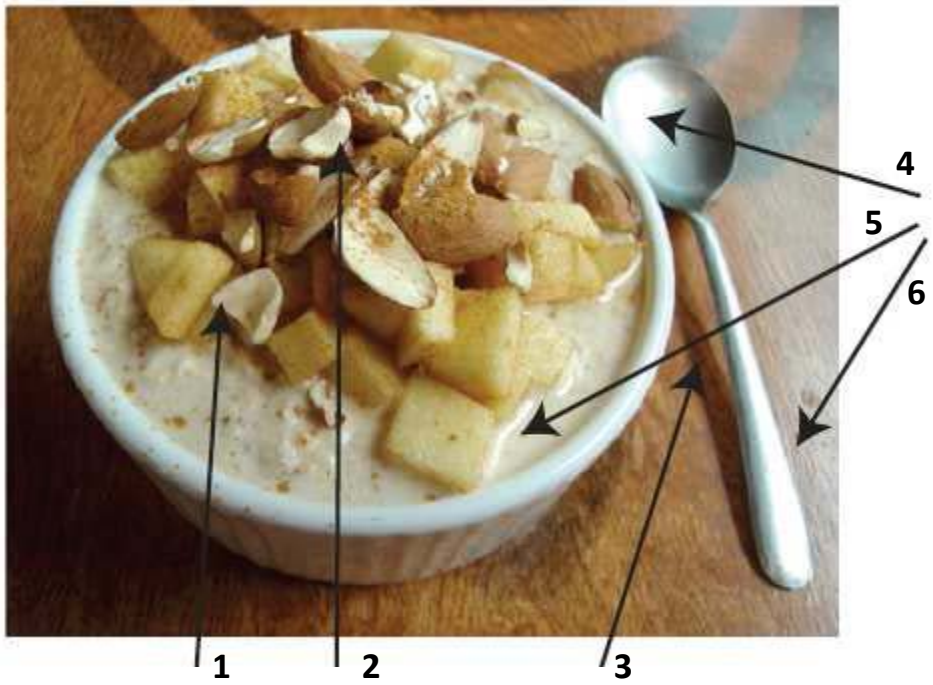
1. Single-View Metrology (55%)

A. For the Kyoto Street image, shown above, estimate the positions (in the image plane) of the three major vanishing points, corresponding to the building orientations. Use at least three manually selected lines to solve for each vanishing point. The included code getVanishingPoint_shell provides an interface for selecting and drawing the lines, but the code for computing the vanishing point needs to be inserted. (15%)
   - Specify the points (u,v).
   - Plot the points and the lines used to estimate them on the image plane.
   - Plot the ground horizon line and specify its parameters in the form au + bv + c = 0.

B. Based on these vanishing points, estimate the camera focal length and optical center. Show all work. (15%)

C. Estimate the camera tilt (rotation about the x-axis) and camera roll (rotation about the z-axis) in degrees. For this, set the XZ plane to the ground plane, so that the Y axis is along the direction of gravity. To estimate the tilt, it may help to obtain the 35mm equivalent focal length (see EXIF data using imfinfo in Matlab). Show work. (10%)

D. The above photo was taken from my office. Estimate the horizon and draw/plot it on the image. Using the height of the sign as a reference, estimate the heights of the post, the building, and the camera. This can be done with powerpoint, paper and a ruler, or Matlab. Turn in an illustration that shows the ground horizon, and the lines and measurements used to estimate the heights, as well as the estimated heights. Measure the height of the sign with a tape measurer. (15%)



2. Lighting (15%)

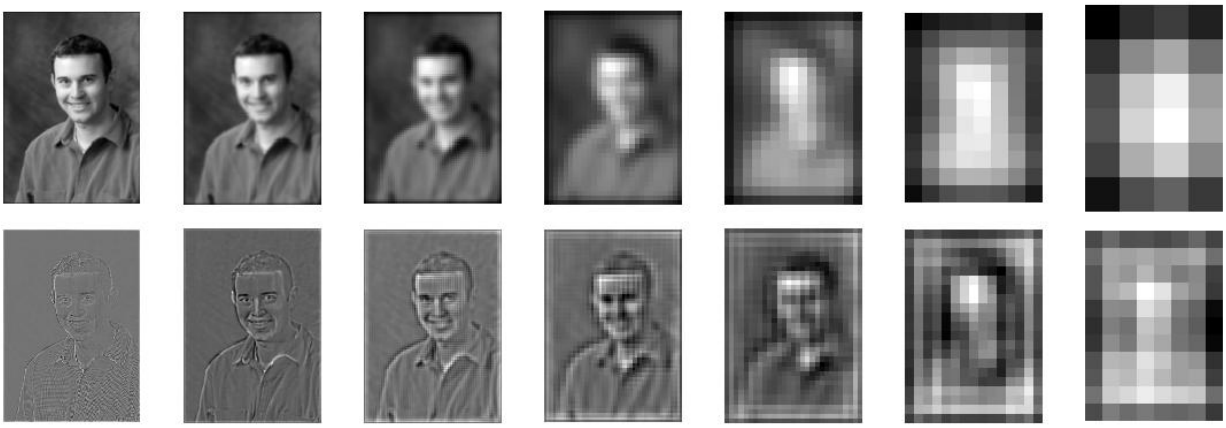
A. For each of the arrows in the above image, name the reasons the pixel near the end of the arrow has its brightness value and explain very briefly. The arrow pointing to milk is pointing to the thin bright line at the edge of the piece of apple; the arrow pointing to the spoon handle is pointing to the bright area on the handle.

3. Image Filtering (20%)

A. Using a grayscale image of yourself (at least 640x480 resolution), create a Gaussian pyramid with eight levels and a scale factor of 2. Hand in: the original image, the filter used and the Gaussian pyramid images (excluding the original), and pseudocode for the algorithm. (10%)

B. Create a Laplacian pyramid using the results from 3A. Hand in, the Laplacian pyramid images and pseudocode for the algorithm. (10%)

Your result may look something like this:



4. **Final Project: Choose a Group and Topic (10%)**
   A. List the group members and a short (1/2 page) description of the goals of the project. Indicate what each group member will work on and how the project will be evaluated. If known, sketch a potential approach. You can change plans later, but we want to make sure that you start planning now. As a guide to scope, you should expect to spend around 30-40 hours per person on the project.

   You're encouraged to come up with your own project, but here are some ideas:
   - **Shadow detection**: Try to find cast shadows in outdoor images
   - **Pedestrian detection**: Build a detector for standing/walking people
   - **Multiview reconstruction**: Build a system to reconstruct an object or a scene from multiple images
   - **Evaluation of object detection**: Run a state-of-the-art detector on a PASCAL VOC dataset and study (quantitatively and qualitatively) which factors make detection difficult.
   - **Material detection**: Try to classify materials on natural objects in images.
   - **Action recognition**: Try to detect when somebody is performing a particular action in a video.
   - **Tracking**: Try to track players and the ball in a sports video.
   - **Photo organization**: Build a system that can organize your photos by the people in them.
   - **Gender/age classification**: Given a face, try to predict the age and gender.
   - **Fake or Real**: Try to predict whether an input image is natural or was generated by a computer.