CMSC 426

Problem set 1

Due: Thursday, October 16, 2003
Project: calibration

(a) Use the calibration toolbox: Obtain the calibration toolbox from the web site http://www.vision.caltech.edu/bouguetj/calib_doc (Follow the instructions there : store the matlab files into a folder "Calib" of your toolbox.).

Calibrate the 5 images (calib1.tif – calib5.tif) with this toolbox. In these images the calibration pattern supplied by the web site with 30 mm distance between the corners was used.

Get the file heikkila_data.zip from
http://www.vision.caltech.edu/bouguetj/calib_doc/htmls/example3.html
It contains, as described there, 3 files; we are interested in two of them: the file cademo.mat, which contains the data points for a three-dimensional calibration grid, and the file demo_script_oulu_3D.m which converts the data into the format used in the toolbox and runs the calibration. Run the script demo_script_oulu_3D. Save the estimated internal calibration parameters. The 2D image points and 3D object points are also stored in the file data1.mat, as x and X, in the file supplied here. (You could save these parameters yourself.)

(b) Implement your own calibration: Undergraduates should implement the algorithm described in section 6.3 of Trucco and Verri and graduates should implement in addition the algorithm described in class (1. compute the projection matrix, 2. RQ composition 3. non-linear minimization). Run your algorithm(s) with the data file (data1.mat). That is, load data1.mat. It contains a vector x of size 2*491 (491 image points) and a vector X of size 3*491 (the corresponding 491 scene points). Print the estimated parameters (10 for the first algorithm, 11 for the second). Do your estimates differ significantly from the estimates of the toolbox?

Problems

1. The f-number of a lens is the ratio of the focal length to the diameter of the lens. The f-number of a given lens (of fixed focal length) can be increased by introducing an aperture that intercepts some of the light and thus in effect reduces the diameter of the lens. Show that image brightness will be inversely proportional to the square of the f-number.

2. How many steradians in a sphere?

3. Why is the irradiance of the image of a surface independent of the distance from the surface? After all, when the lens is twice as far from the surface, it collects only one-quarter as much of the light emitted from a given surface patch?

   Show that the irradiance of the image of a surface in a perfectly specular mirror is equal to the radiance of the surface itself, independent of the shape of the mirror.

4. A surface has constant BRDF. What is the maximum possible value of this constant? Now assume that the surface is known to absorb 20 % of the radiation incident on it (the rest is reflected); what is the value of the BRDF?

5. A light bulb of 10 w/sr radiant intensity (radiant intensity is the integral of radiance over the emitting area) illuminates a room. Consider a circular light patch with 10 cm diameter at the floor. The light bulb is 10 m above the patch, 10 m to the left and 10 m behind. What is the solid angle from the bulb to the patch? What is the irradiance of the patch on the floor? (Assume, light is coming only from the light bulb.)

6. What is the image of a sphere?

7. Show that the image of an ellipse in a plane, not necessarily one planar to the image plane, is also an ellipse.

8. Straight lines in the three-dimensional world are projected as straight lines into the two-dimensional image. The projections of parallel lines intersect in a *vanishing point*. Where in the image will the vanishing point of a family of parallel lines lie? When does the vanishing point of a family of parallel lines lie at infinity?

   In the case of a rectangular object, a great deal of information can be recovered from lines in the images and their intersections. The edges of a rectangular solid fall into three sets of parallel lines, and so give rise to three vanishing points. In technical drawings one speaks of one-point, two-point, and three-point perspective. These terms apply to the cases in which two, one, or none of the three vanishing points lie at infinity. What alignment between the edges of the rectangular object and the image plane applies in each case?

9. 2.3 and 2.4 from Trucco and Verri

10. 6.2 from Trucco and Verri