

# CS 223b: Introduction to Computer Vision

## Assignment #2: Camera Calibration

(out of 25 points)

**Due date:** Monday, January 26th, 2003 (no extension)

**N.B.:** You are not allowed to work in teams on this assignment.

**Recommended readings:** *Trucco and Verri* Chapter 6

### 1 Calibration with MATLAB (20 pts.)

(a) (20 pts.) You are given the locations of known points:

<http://robots.stanford.edu/cs223b/homework/hw2/points3d.txt>

on a 3D calibration target depicted below in Figure 1. Your job is to create a MATLAB function of the

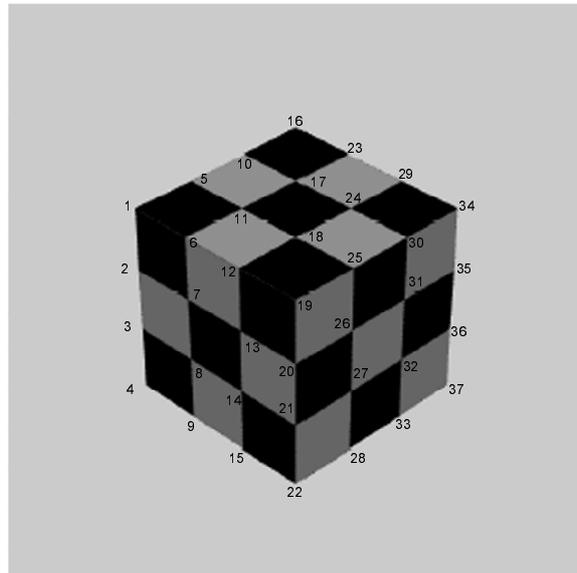


Fig. 1: Three dimensional calibration phantom.

form:

```
function [R,T,fx,ox,oy,alpha] = calibrate(pts3d, pts2d);
```

which takes as input the  $[37 \times 3]$  matrix of 3D point locations together with their corresponding 2D image locations (in [column, row] format) and derives the camera's calibration parameters.

Specifically, compute:

- (i) the rotation matrix  $R$  and translation vector  $T$  in equation (6.1) from the textbook
- (ii) the horizontal focal distance  $f_x$  (focal length in effective horizontal pixel size units)
- (iii) the image center  $(o_x, o_y)$
- (iv) the pixel aspect ratio  $\alpha$ , assuming the image is free of distortion.

What you need to do:

1. Download the original calibration image from the class website:

**<http://robots.stanford.edu/cs223b/homework/hw2/calib.pgm>**

2. Localize the feature corners in the image *in [column, row] format*. You may **either** do this manually or utilizing your previous corner-finding code (**N.B.** you will almost certainly have to make changes to your code for this real world example.) You should write a function called:

**function pts2d = localizeCorners(Im);**

Which takes the calibration image matrix as input and returns the  $[37 \times 2]$  matrix of locations of its corner pixels *in [column, row] format*. If you choose to localize these pixels manually, just hard code your values into this function.

3. Using **localizeCorners** and following Trucco and Verri, write the **calibrate** function as defined above.

(b) **To hand in:** you are responsible for handing in the following:

1. A text file called **answers\_hw2.txt** with your calibration results obtained from running your **calibrate** function on the target data we have provided.
2. An electronic copy of your MATLAB m-file for calibration called **calibrate.m**.

The code must be emailed to **cs223b@cs.stanford.edu** before midnight on the day the assignment is due.

## 2 Short answer (5 pts.)

To answer the following questions and to help understand the intuition behind edge detection and filters, you are encouraged to experiment with the following MATLAB functions: **edge** (type 'help edge' for instructions on how it works), **filter2**, **medfilt2**. MATLAB comes equipped with images to use for testing purposes. Some examples:

```
I1 = imread('rice.tif');
I2 = imread('eight.tif');
I3 = imread('pout.tif');
```

Add your answers to the **answers\_hw2.txt** file you created earlier.

- (a) (1 pt.) **Explain why median filtering performs well in images corrupted by impulse noise.**

(b) (2 pts.) Explain the importance of hysteresis thresholding and non-maximal suppression in the Canny edge detection process. How do these two concepts influence the resulting edge image?

(c) (2 pts.) Is a ball better than a circle painted on a plane for determining a camera's aspect ratio? Provide a convincing argument (2 sentences) why your answer is the right one. How would you place the object in order to minimize the effects of lens distortion?

(d) **To hand in:** you are responsible for handing in the following:

1. The text file called **answers\_hw2.txt** with your answers to the previous questions.

This work must be emailed to **cs223b@cs.stanford.edu** by midnight on the day the assignment is due.