HOMEWORK 2017

A bandoneon is a musical instrument, consising in two rigid wooden parts connected by a deformable bellow. The assignment is to reconstruct the bandoneon shape from a single image of it, using additional information described below.

Given image and scene information:

An image of a bandoneon is taken by a zero-skew camera (natural camera can NOT be assumed).
In the given image, the bandoneon is placed on a horizontal floor. Four rectangular faces are visible in the image: two coplanar horizontal faces, and two non-coplanar vertical faces. The long side of the horizontal faces is 243 mm, and it is slightly longer than the long side of the vertical face.
For each horizontal face, two groups of parallel lines can easily be identified. The two groups of lines are mutually perpendicular. One of the (short) lines on each horizontal face is also common to a vertical face.
Part of the horizontal floor is also visible: we can assume to see groups of parallel lines (the groups are also mutually orthogonal): These lines can be used to help in robustly find, e.g., the image of the horizontal vanishing line (i.e. the image of the line at the infinity of the horizontal plane). We can NOT assume square patterns on the floor.
In addition, the long lines in the vertical faces are vertical (i.e. orthogonal both to the horizontal faces and to the floor).

Assignment:

1. **Image feature extraction and selection:**

   Use the learned techniques to find edges and lines in the image. Then manually select those lines which are useful for the subsequent steps.

2. **Geometry**

   2.1 Using constraints on the horizontal lines, and their images, reconstruct the shape of the horizontal faces, and determine their relative position and orientation.
   2.2 Using also the images of vertical lines, calibrate the camera (i.e., determine the calibration matrix K) assuming it is zero-skew (but not assuming it is natural). See the Hint reported below.
   2.3 Localize the camera with respect to (both) horizontal faces. From the image of the (short) horizontal segments common to a horizontal face and its neighboring vertical face, reconstruct the shape of the vertical faces

Hint1: verify the for a zero-skew camera the image of the absolute conic is given by

$$\omega = (KK^T)^{-1} = \begin{matrix} a^2 & 0 & -u_0 a^2 \\ * & 1 & -v_0 \\ * & * & f_Y^2 + a^2 u_0^2 + v_0^2 \end{matrix}$$

where a= f_y /f_x is the aspect ratio of the pixels

Once the four nontrivial elements of ω have been found (remember the matrix is symmetric), the intrinsic parameters can straightforwardly be determined.

Hint 2: to find vanishing points, prefer long lines rather than short lines, as to reduce errors.

Hint 3: normalize image coordinates to reduce numerical errors. E.g. set the image size to 1. If you use pixel number instead, your matrixes will be ill-conditioned.

HOMEWORK DELIVERY:

Submit a compressed file (or separate files within a personal directory) containing the items listed below to the Image Analysis and Computer Vision page on the Beep Platform, (Homewok page, Delivery folder) by February the 5th, 2018, 12:00 a.m., Milano time. Also, send a notification via e-mail to vincenzo.caglioti@polimi.it within February 5, 2018, 13:00 a.m. Milano time: The submission must include:

- the used input image
- the above images with extracted features (edges, vertexes and corners)
- computed results (vanishing line, 2D relative coordinates for planar shape reconstruction, calibration parameters, 3D camera poses, 3D relative coordinates for 3D reconstruction)
- well written report including problem formulation, well-explained solution approach for the various steps, experimental results (including comparison with same results obtained on the test image) and their analysis
- commented Matlab code.

ATTENTION: Submission of multiple files in the Delivery folder is NOT ALLOWED: Please submit either a single compressed file or construct your own directory