Homework 2020-2021

Scene. The Castello di Miramare in Trieste. In the bottom view below, all lines lie on a same horizontal plane ∏. In addition the lines 1 and 2 are orthogonal, as well as lines 4 and 5, and lines 5 and 6 (hence lines 4 and 6 are parallel).
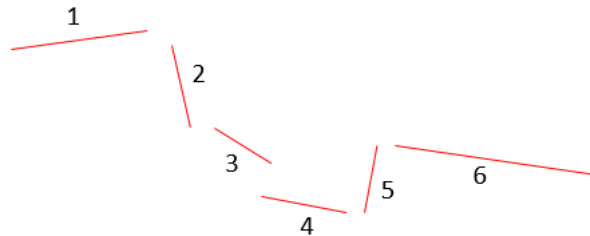

Image. An image of the Castello di Miramare is taken by a digital camera. The camera skew factor is assumed to be null; the aspect ratio is unknown (thus natural camera can not be assumed), as well as the principal point and the focal distance.

ASSIGNMENT

Write and test a Matlab program that analyzes the given image in order to extract the informatin items listed below.

Image Processing.

F1. **Feature extraction**. Combining the learned techniques, find edges, corner features and straight lines in the image. Then manually select those features and those lines, that are useful for the subsequent steps.

Geometry

G1. **2D reconstruction**. Rectify (2D reconstruct) the horizontal plane ∏ from the useful selected image lines and features, i.e., fix a suitable reference frame solid attached to the horizonal plane ∏, and determine the coordinates of points and lines relative to the chosen reference frame.

Suggestion. It is suggested to divide the rectification into two steps.

(i)   affine rectification: use images of lines parallel to the above mentioned ones (even if not on the same plane ∏) to affinely rectify the image of the plane ∏;

(ii)   affine to metric: use above mentioned orthogonality contraints to upgrade the affine reconstruction to Euclidean reconstruction. While doing this try to take accuracy issues into account.

Hint: use normalized coordinates to reduce numerical errors (e.g. set image size = 1)

G2. **Calibration**. First extract a vertical vanishing point and then use it together with useful information extracted during the rectificatino step, in order to estimate the calibration matrix **K** containing the intrinsic parameters of the camera, namely. focal distance, aspect ratio and position of principal point.

G3. **Localization**. Determine the relative pose (i.e. position and orientation) between the reference attached to the horizontal plane ∏ and the camera reference.

G4. **Reconstruction**. Use the knowledge of **K** to rectify also a vertical facade, as, e.g., facade containing line 1 or 4 or 6.

Design suitable techniques to solve the indicated steps and implement the designed solutions in Matlab. For each intermediate steps include experimental results obtained by applying the chosen techniques to the given image. Write a well written report including the explanation of the followed approach and the obtained results (both numerical and graphical) for each step.