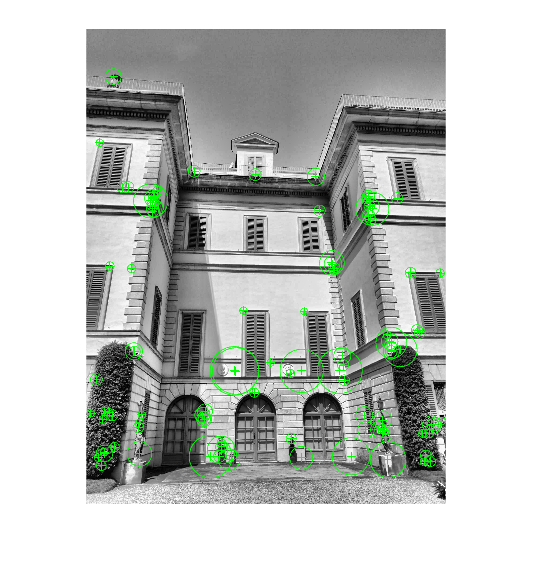
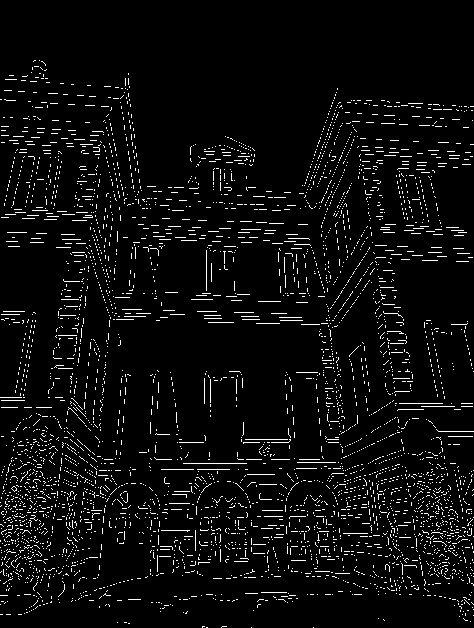
IACV Homework 2021  
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Introduction  
For this homework we have an image of the back side of Villa Melzi. We know that facade 1 and 5 are  
coplanar, facade 2 and 4 are perpendicular to facade 1, 3 and 5. We also have to position of the sun  
in the real world (a point at infinity in 3D); We know that the camera is 1.5 meters above the ground.  
Natural camera cannot be assumed. We know only that skew factor can be assumed to be 0.

Immagine che contiene testo, interni, giocattolo

Descrizione generata automaticamente  
F1 - Feature Extraction  
To extract relevant features from the image, I first applied a grayscale, taking into account all the 3  
color channels, and then histogram equalization. Then I used Canny edge detection algorithm. This  
algorithm returns a binary image composed by lines, this result simplify the application of the lines  
detection exploiting the Hough transformation. In order to detect the lines in the image I used the  
Hough transformation. Finally, I retrieved the segments lines setting a max gap between two points  
on the same line and the minimum length of a segment line of 25 pixels. For the feature extraction  
step, I used the SURF algorithm which produces the best result.

For the next steps, i saved some of the extracted lines in .mat files to reuse them subsequently.

G1 – Horizontal Plane Reconstruction

To recover the affine properties of the images we have to put back the line at infinity in the image to its canonical position [001]T. I extracted the line at infinity using vanishing points from horizontal lines of facade 2 (or 4) and of facade 3.

The projective transformation to restore affine properties is:

Applying this transformation to the image gives this result:

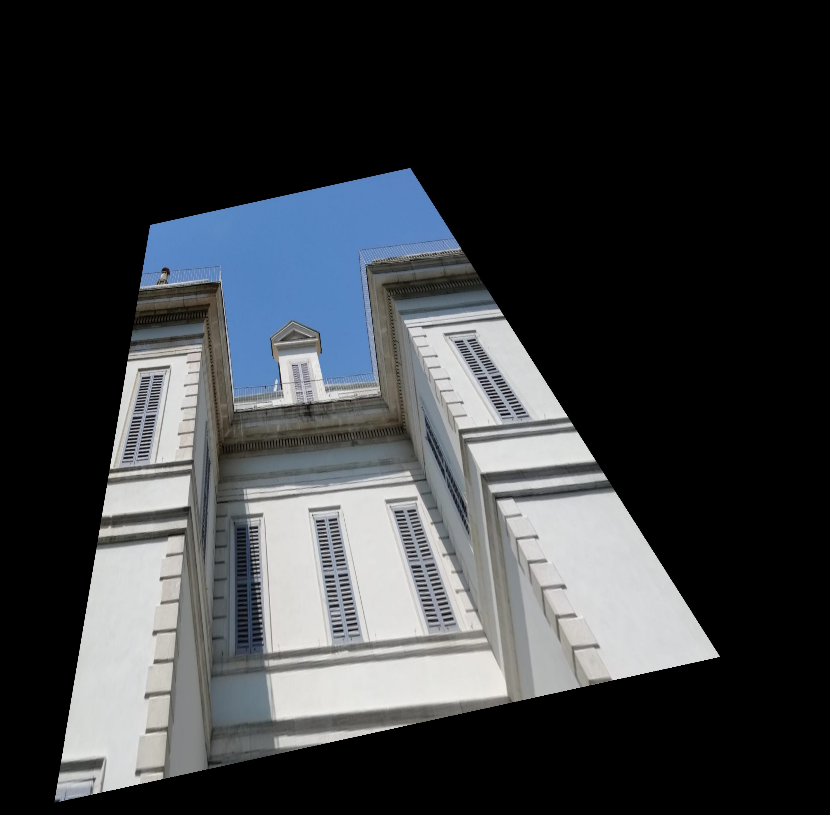


In order to recover also metric properties, i defined an affine transformation like this:

where variables a and b are to be estimated. For this purpose, i used two additional informations from the image:

* 90 degree angle between facade 3 and 4
* 75.6 degree angle between the horizonal line on facade 3 and the shadow projection of the left edge on facade 3. I computed this angle using the location of the sun in the real scene. In the initial image i noticed that the shadow of the edge was aligned with the right side of the left windows on facade 3.

So, solving this system of 2 equations gives the affine transformation to recover metric properties:



Here the result of the metric reconstruction.

The ratio between the lenght of facade 3 and facade 4 is (lenght directly measured in pixels on the rectfied image):

473 px / 663 px = 0.71

G2 – Camera Calibration

To estimate the intrinsic parameters of the camera, i set up this matrix of four unknown variables, corresponding to the image of the absolute conic. .

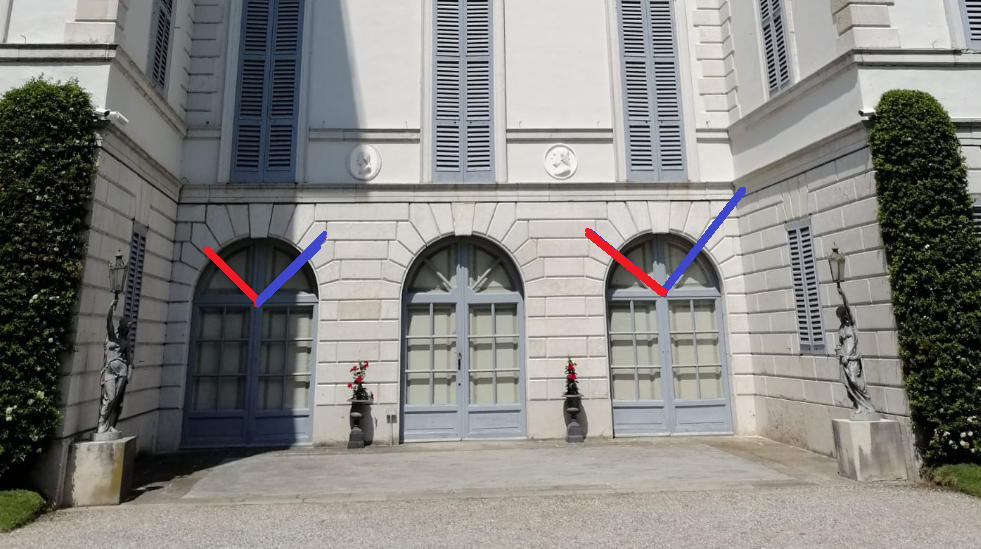
The calibration matrix K can then be calculated applying cholesky factorisation to the IAC matrix.

To estimate the unknown variables, i tried two similar approaches:

* I first tried the method using the vanishing points of the scene and imposing an angle of 90 degrees between their line at infinities (this gives 2 independent constraints). For the other 2 constraints i took the rectification matrix from the previous step (Hrect \* Haff), inverted it, and took the first two columns h1 and h2 of this matrix. Then i used this two equations (from the theory).

However, the result was not enough satisfying in the next steps.

* In the second approach i used the same first two equation as before, while for resolving the other 2 constraints i took some lines from the arcs above the doors on facade 3, noticing that there is a 90 degree angle between them. The results in the next steps was better than before with the IAC calculated in this way.



I estimated this calibration matrix K:

G3 – Vertical Facade Reconstruction using IAC

To reconstruct facade 3, i took the previously estimated Image of the Absolute Conic and found its intersections with the line at infinity extracted from the initial image. To extract this line, i used vanishing points from vertical and horizontal lines of facade 3.

So i obtained the image of the circular points I’ and J’.

I calculated and applied singular value decomposition to this matrix. From the output of svd, i extracted the rectifying homography Hrect2.

Here is the result:

G4 – Camera Localization

To localize the camera in the 3D scene, i used the matlab function fitgeotrans(…), taking the four points as the corners of facade 3 from the initial image.

Then, imposing the height of the camera from to gound to 1.5 meters, I estimated the camera position as:

x = 3.6249 m

y = 1.5000 m

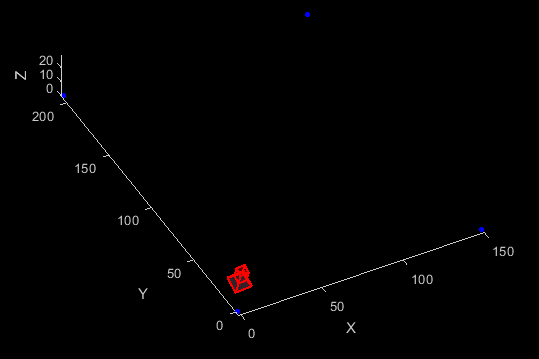
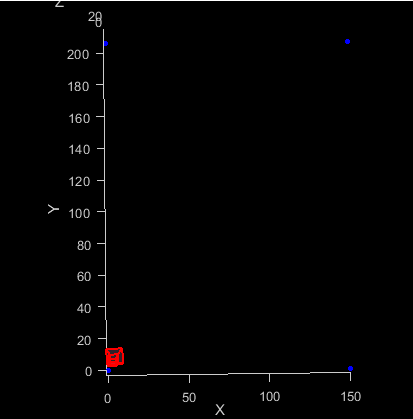
z = 23.1578 m (distance from facade 3)

Camera orientation :

x-axis: 25.3101°

y-axis: 5.6561°

z-axis: 1.4751°

In the images below, the blue points are the corners of facade 3.