# Politecnico di Milano - Courses on Photogrammetry
# Laboratory report

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| CFU group: | 10 | Date: | 02/01/2023 |
| Lab Topic: | 03 - Photoplane (building façade) | | |

## Description of the performed activity *(max 50 lines)*

**T**he main objective of this lab was to create the photoplace of a building façade. For the purposes of this lab, the façade of Politecnico's building 3 internal courtyard was used. Starting from a single photo with image coordinates (csi, eta), the aim is to retrieve a photoplane. The transformation applied from one system to the other is an omography (fig. 1). Knowing both sets of coordinates, we need to estimate 8 parameters.

**A**s a first step, the acquisition of the image had to be planned. This was done by acknowledging some basic principles to optimize the quality of the results. For example, standing as much as possible central to the façade, and parallel to it would minimize distortions at the border of the image. This was only partly obtainable, keeping in mind that the person taking the photo didn't have the aid of instrumentation to aid centering oneself on the vertical direction; the photo, while centered in the horizontal direction, was certainly not so in the vertical one. A total station was then used to produce and measure the coordinates of 35 GCP pertaining to the façade, with set GSD = 0.01 m. The points were identified by markers to be easily detectable on photo and had to be well-spread on the entire façade. The data collected and the subsequent computations performed can be found in the attached document *points_and_calculations.xlsx.*

**A**s stated earlier, the transformation equation had to be computed to transform the object coordinates (fig.2) to image ones. For this aim, two points (7, 8) were chosen to compute the inclination angle with respect to the horizontal, which was 136.8°. The left-most point of the two was set to be the fictitious new origin with coordinates $X_0$ and $Y_0$. Under the hypothesis of two-dimensionality, the z-axis stayed untouched, and we proceeded to compute the new coordinates X', Y', Z' for all the points. For our next calculations, we filtered points based on the hypothesis of the maximum protuberance acceptable, which was a value highly dependent on the camera parameters. By recalling the worst-case scenario error and the minimum detectable displacement, we chose a range of acceptability of about three times $DZ_{max}$, which made us neglect 19/35 points that had y values > 3.5 cm (with y being the direction of extrusion of the façade).

**F**inally, on the RDF software we imported the image and its object coordinates (gcp3.ogg) and collimated the image points to retrieve the image coordinates (coords1.imm). To later perform some statistics on the dataset, we chose 3 points (ca. 20% of the dataset) to be Check Points. The two sets were then joined, and their residuals were computed, by choosing the direct parameters – going from object coordinates to the image ones. These 8 parameters were exported onto excel to compute the mean, dev.st and rms of both GCP and CP. Some important considerations are to be made at this point: firstly, the results of the GCP and CP have the same order of magnitude, which indicates that we don't expect outliers in the GCP. This comparison is very important to check the general outcome of the job performed. Indeed, there are no points with singular residuals higher than some millimeters. The statistical values are not comparable with the GSD of the camera, nor with the precision of the total station, for what concerns the mean and standard deviation values, as they are smaller by a couple of orders of magnitude. To check if any error incurred during the procedure, we check the RMS error, which instead is comparable to the GSD of the camera (0,0058 m). Eventually, through RDF it was possible to create the rectified image – the *photoplane*. By creating a file with the union of object and image coordinates, devoid of the check points, selecting the resampling area in a clockwise fashion and selecting a bilinear resampling algorithm with pixel values of 0.01, we obtained the rectified image as seen in fig.3.

**A**s a last point, we had to check whether the initial consideration (exclude any point higher than 0.035 m in the Y direction) still held and proved truthful. Thus, we check with the DXF tool all the points previously exempted from the calculations, such as windows, extruding columns, and so on. The statistics computed are, to say the very least, worse, and less precise than the previous ones, ranging in the order of tens of centimeters in the X direction, to some meters in Y. The error magnitude is mostly due to the residuals on points (1, 4, 6, 16, 22), which lie in the first-floor windows, on columns, or outside of the façade wall, while the rest come from the lower floor, closer in distance to the position of the camera. By considering these as outliers and rejecting them, we get better results (fig.4). This goes at the expense of the redundancy of the points, as by removing the outliers, we remove half of the points considered. **I**n the end, we can safely state that by also choosing points outside of the façade, the overall resolution would have greatly decreased.

*Final Line Count: 50 lines*.

## Attachments

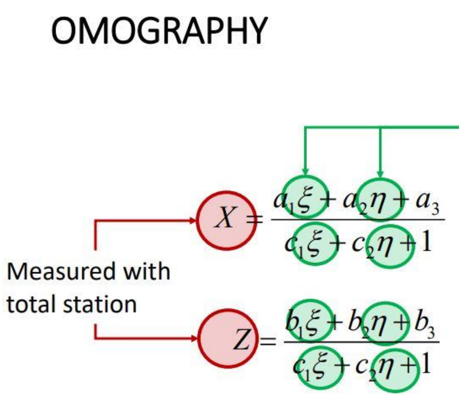


Fig. 1

Fig. 2

Fig. 3

| Point | residualsX | residualsY | | X | Y |
|---|---|---|---|---|---|
| 12 | -0.02983515 | 0.49743326 | mean | 0.0154 | 0.39867 |
| 11 | -0.00540365 | 0.401685706 | devst | 0.02817 | 0.06757 |
| 14 | 0.03280761 | 0.433703242 | RMS | 0.08774 | 0.44647 |
| 21 | 0.038060526 | 0.365444619 | | | |
| 9 | 0.041354019 | 0.295058977 | | | |

| Point | residualsX | residualsY | | X | Y |
|---|---|---|---|---|---|
| 22 | -0.02949233 | 8.675771984 | mean | 0.15413 | 5.08412 |
| 6 | -0.01692449 | 6.226359672 | devst | 0.35319 | 3.2243 |
| 4 | 0.006481067 | 5.795450101 | RMS | 0.32846 | 1.8865 |
| 1 | 0.047815886 | 5.768162345 | | | |
| 16 | 1.016704411 | -2.44051385 | | | |

| Point | residualsX | residualsY | | X | Y |
|---|---|---|---|---|---|
| 1 | 0.047815886 | 5.768162345 | mean | 0.00725 | 3.16403 |
| 4 | 0.006481067 | 5.795450101 | devst | 0.02866 | 2.77056 |
| 6 | -0.01692449 | 6.226359672 | RMS | 0.06595 | 1.37783 |
| 9 | 0.041354019 | 0.295058977 | | | |
| 11 | -0.00540365 | 0.401685706 | | | |
| 12 | -0.02983515 | 0.49743326 | | | |

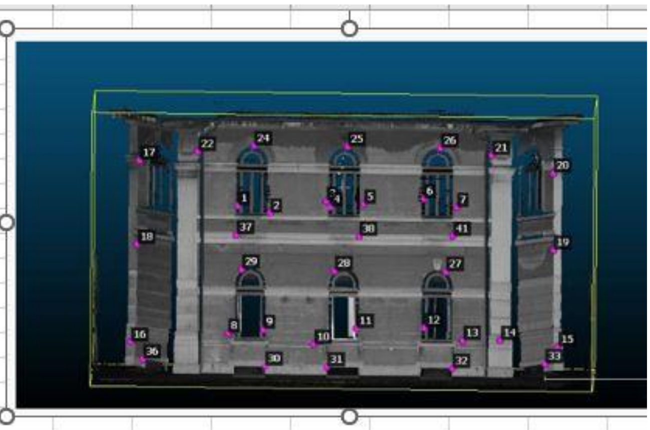

Fig. 4