

AUTOMATIC RECTIFICATION OF IMAGES THROUGH SCALE INDEPENDENT TARGETS

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ABSTRACT:

In the paper, a procedure for the automatic rectification of images is described. The procedure uses some targets fixed to the vertices of a 2 m x 2 m square frame. The frame is positioned on the surveyed surface (e.g. a building facade or a road where an accident occurred). The position of the target vertices is obtained through a correlation between the image we should rectify, and the image of the target. The design of the targets has been made in order to obtain a scale independent correlation; for this reason, the correlation is influenced by a rotation. The target in the stored image, and in the image to be rectified, has different orientations. For this reason an error in the determination of the vertex position occurs. The rough position values of the targets vertices can be used to obtain transformed target images which allow a fine correlation. The description of the procedure and the results of a test are reported. A different colour coded target has been studied and tested, with good results.

1. INTRODUCTION

When objects to survey are positioned on a flat surface (road accidents, crime scenes), rectified images can allow to obtain distance and angle measurements.

In several cases the surfaces to be surveyed can be considered flat (regular facades of buildings, squares and rectilinear roads); rectified images can be very useful and allows to obtain a great part of the information that can be obtained with a three-dimensional survey, but with greater rapidity and facility of execution. Image rectifying can be realized when at least four known points are available in the image (Kraus, 1993); the known points can belong to the object, or materialized with targets, having appropriately studied designs. Such designs can allow the detection of the points, while their disposition, according to a defined pattern, gives their coordinates, respect to a reference system fixed to the same targets; thus both reference system and points can be towed together (Artese, 2007). If the rectifying must be unsupervised, the image coordinates of the known points must be obtainable through automatic procedures.

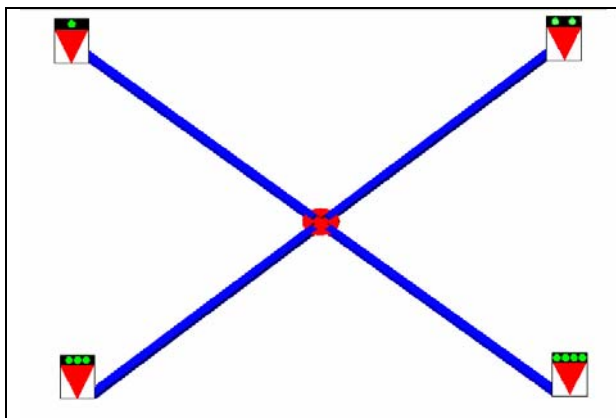


Figure 1. Frame and targets

The technique described in the present paper is based on the use

of a folding aluminium frame (Figure 1); four targets are fixed in the vertices of a 2.00 m x 2.00 m square. The frame should be leaned against the flat surface to survey. The targets are tilted, in order to have a good visibility also for camera stations close to the ground; the target design is studied to detect a point on the surveyed surface, for this reason it is not rotation independent.

For the identification of the points, the matching techniques can be used; among these techniques, Cross Correlation is simple and effective (Jaehne, B., 1989). Cross Correlation allows to get the correspondence between two digital images, and is based on two assumptions: the images geometrically differ only due to translation and radiometrically differ only due to brightness and contrast.

The precision of Cross Correlation decreases rapidly when geometric model is violated, i.e. rotations greater than 20° and/or scale differences greater than 30% are present (Forstner, W., 1984).

2. METHODOLOGY

2.1 The rectifying procedure

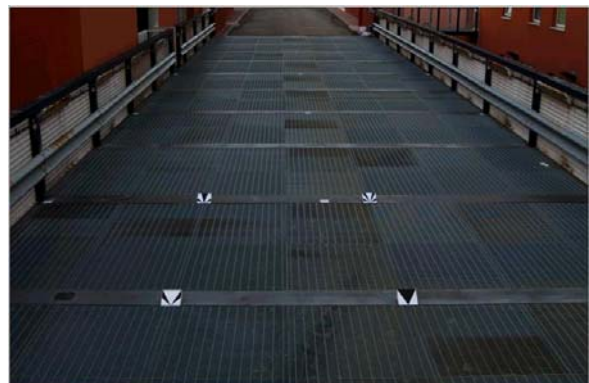


Figure 2. Test site and targets

In a first phase, different target designs have been adopted and a test has been performed at the University of Calabria (Figure 2),

on a bridge we can consider a flat surface.

The design has been studied in order to confront the image of a part of the targets close to the vertex, with the complete image; the correlation is, therefore, independent from the scale of the photogram.

If the orientations of the target in the stored image and in the image to rectify is almost the same, the correlation procedure gives optimal results. In Figure 3 the result of cross correlation for target 4 (bottom right) is shown; the points with high values of the correlation coefficient are light grey. Figures from 4 to 7 show the results of the fine correlation, performed on areas surrounding each vertex, for the targets from 1 to 4.

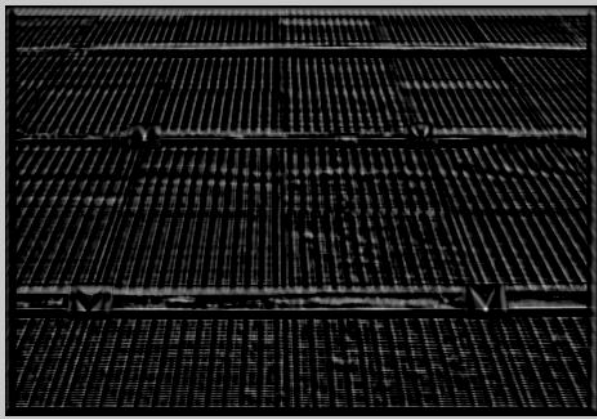


Figure 3. Target 4 cross correlation for figure 2

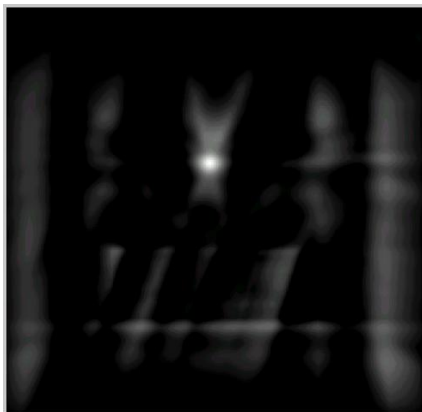


Figure 4. Target 1 fine correlation

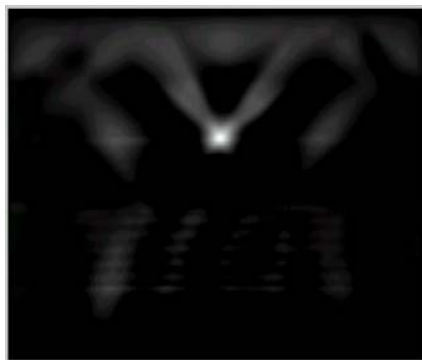


Figure 5. Target 2 fine correlation

It can be observed that the point of maximum correlation is univocally determined, as the centre of a symmetrical area, showing increasing values of the correlation coefficient.

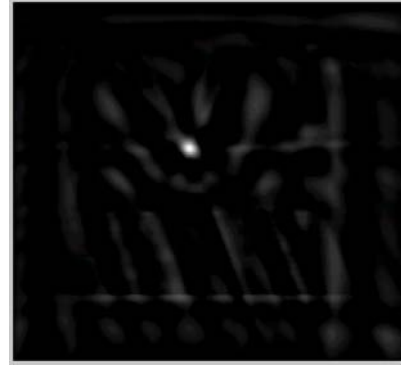


Figure 6. Target 3 fine correlation

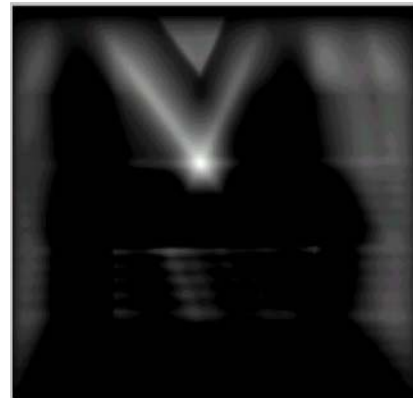


Figure 7. Target 4 fine correlation

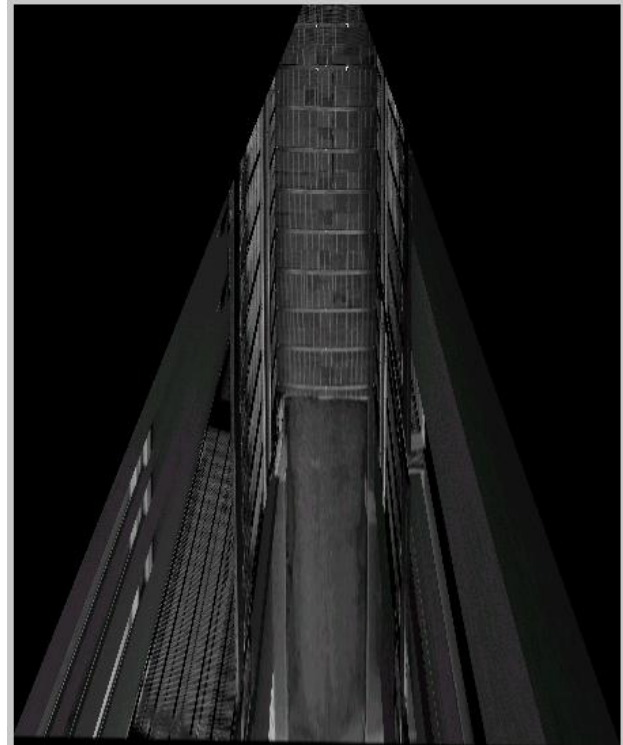


Figure 8. Automatic Rectifying of Figure 2

Figure 8 is the result of the automatic rectifying performed on the image of figure 2. A test on several control points has shown differences less than ten centimetres.

For a rotation of about 10° (Figure 9) the cross correlation allows to detect the targets, but the precision decrement is not negligible. Figure 10 shows the result of the correlation for target 4; we can observe that there are other points far from the target vertex, with comparable values of the correlation coefficient.

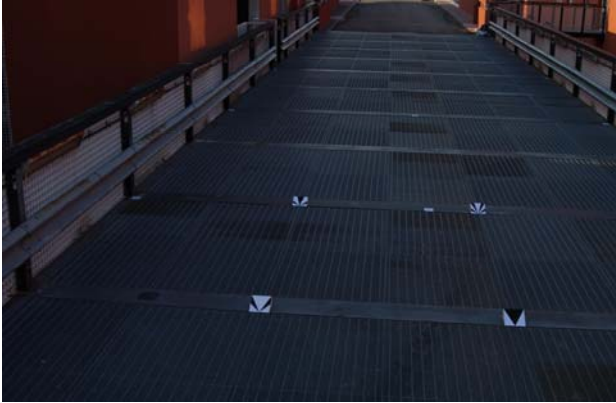


Figure 9. Test site image with rotated targets

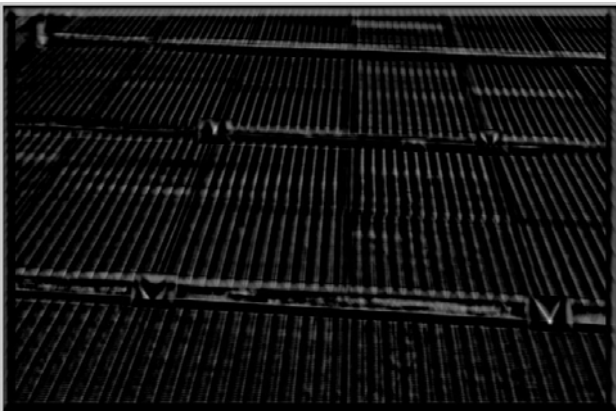


Figure 10. Target 4 cross correlation for figure 9

Figures from 11 to 14 show the results of the fine correlations for the four targets; in this case there are not symmetrical distributions, respect to the points of maximum correlation. The coordinates obtained for the targets vertices are evidently different from those real ones.



Figure 11. Rotated target 1 fine correlation



Figure 12. Rotated target 2 fine correlation

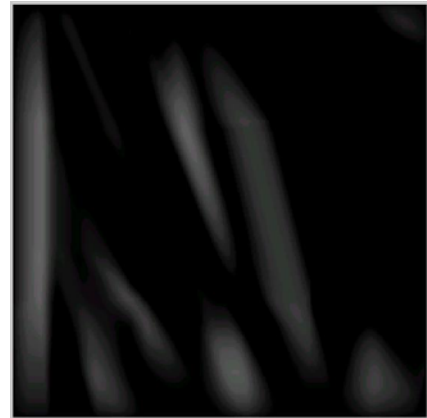


Figure 13. Rotated target 3 fine correlation

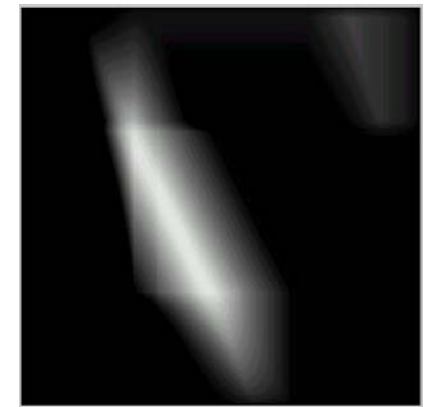


Figure 14. Rotated target 4 fine correlation

Figure 15 shows the original image, with an overlapped red quadrilateral emphasizing the points obtained with the procedure of cross correlation. Figure 16 is a blow-up of target 4: it can be observed that the error in the determination of the vertex is of approximately 2 cm. A such uncertainty is not acceptable in order to proceed to the rectification, that would have too much great errors to be useful.

2.2 Target transformation

The rough position of the targets allows to execute a projective transformation. The red quadrilateral of figure 15 represents, with good approximation, the transform of the rectangle obtained by connecting the four targets vertices. Two vanishing points can be located and it is possible to build up the projective transformation of the targets images, thus obtaining the view of

the targets with the same perspective of the image to be rectified, if the dimensions of the targets and their relative positions are known (Figure 17).

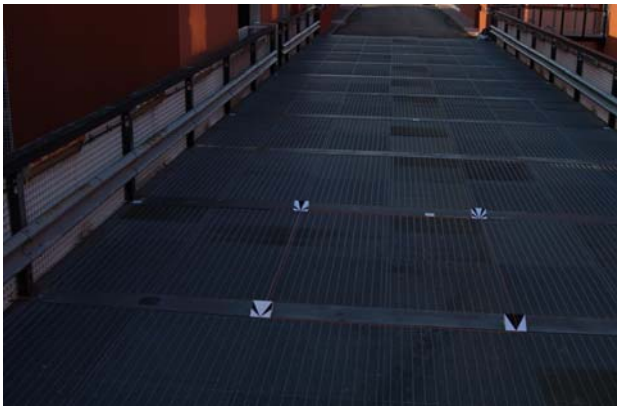


Figure 15. Vertices detected by correlation

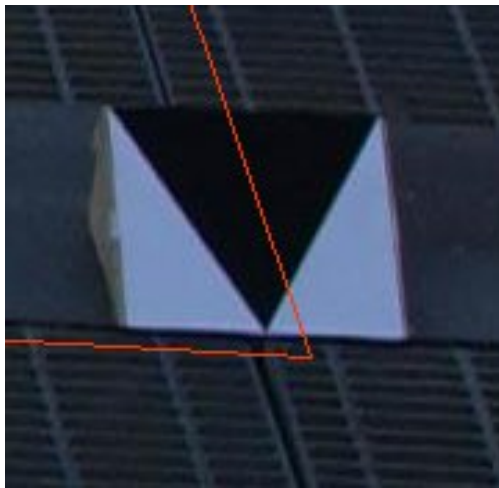


Figure 16. Enlargement of the wrong correlation

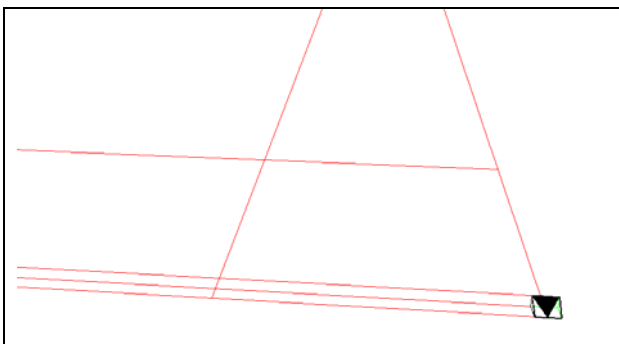


Figure 17. Projective transformation of target 4

The third vanishing point, relative to the vertical lines, can only be obtained if vertical elements are present in the image, but, excluding particular points of view, good results are obtained by considering parallel vertical lines.

Figure 18 shows the automatic rectification of figure 9.

2.3 The coded targets

If the difference between the orientations of the targets in the stored image and in the image to be rectified exceeds 20° , the cross correlation does not allow to detect, even approximately, the targets. The use of different targets has been then

abandoned and it has been chosen to use a single kind of coded target, in order to obtain both their detection and the approximate localization.



Figure 18. Automatic Rectifying of Figure 15

The codes used in close range photogrammetry are generally geometric arrangements of white dots or shapes on a black background (Fraser, 1997), but, recently, coloured targets have been used. By using an arrangement of 5 red and green dots on a black background, 32 distinct codes can be generated. The use of colours allows a more effective procedure for codes detection and identifying (Fraser, 2005).

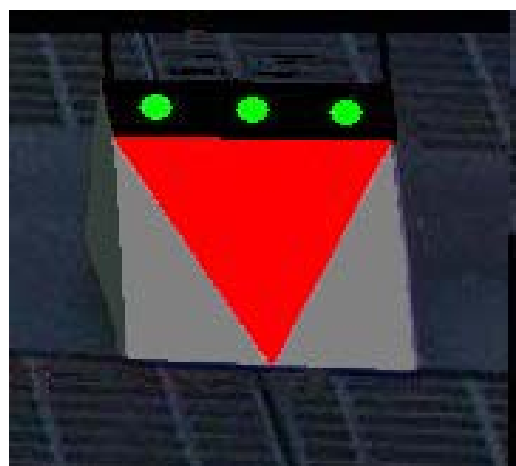


Figure 19. Coded colour target

Figure 19 shows a new target. It is characterized by the same design of the old target 4, but the triangle is red on a grey background; on the upper part of the target, a black stripe has been obtained, on which some green dots are printed, the number of dots being the target code.

Figures 20 and 21 show, respectively, the green and the red channel of figure 19. Applying non maxima suppression to the green channel of the image, it is possible to easily isolate the codes, and to get the coordinates of their centroid. The quadrilateral obtained by connecting the four centroids can be used in order to perform the projective transformation of the targets and, subsequently, to execute the cross correlation between the transformed targets and the image to be rectified; the use of the red channel facilitates the procedure and improves the accuracy of the results (Figure 22). A test performed with a target rotation of about 35° has given differences of few centimetres on the control points.

known. Finally, we must underline that no compressed image files should be used, to avoid errors in the results of cross correlation.

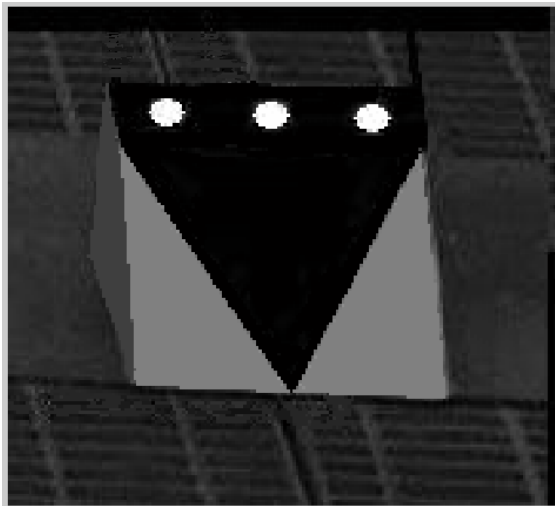


Figure 20. Green channel of Figure 19

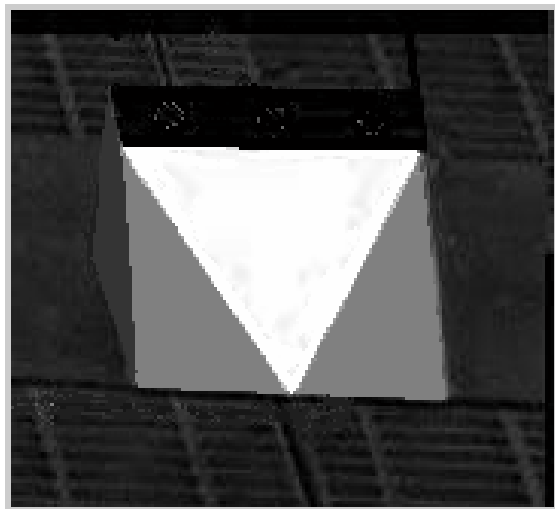


Figure 21. Red channel of Figure 19

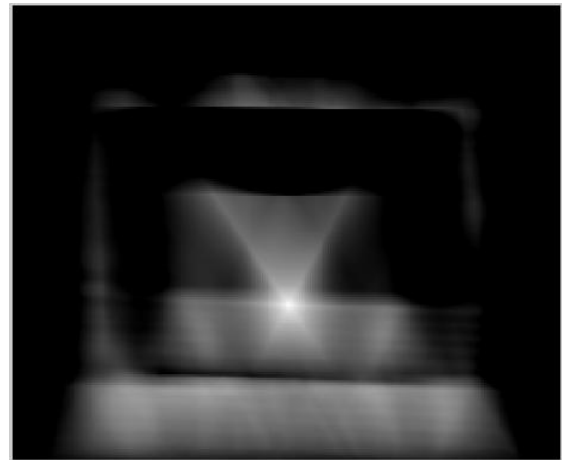


Figure 22. Red channel fine correlation

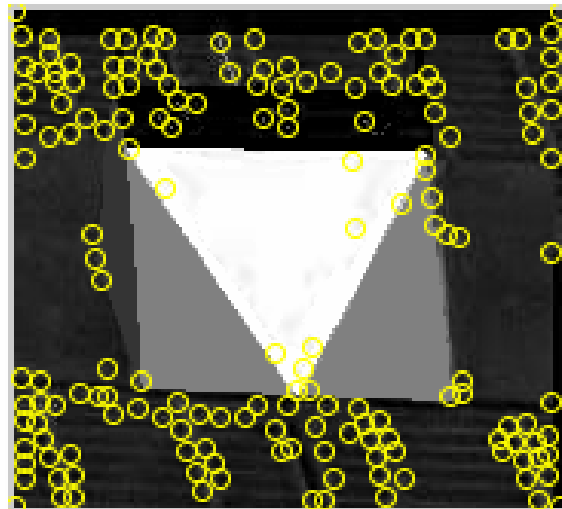


Figure 23. Points detected by Harris operator

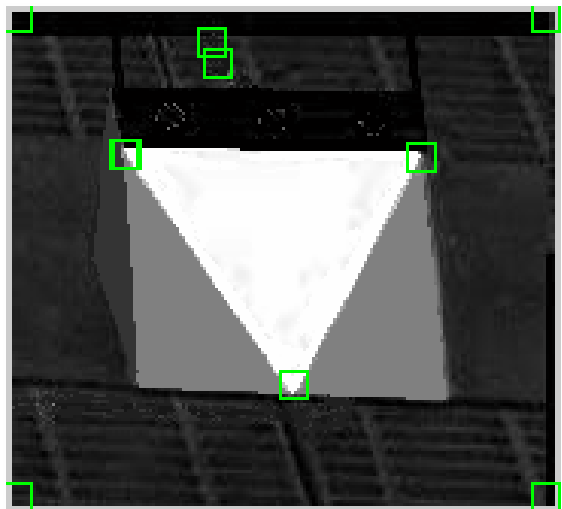


Figure 24. Points detected by Moravec operator

After the location of the codes, a second way can be followed. By extracting a portion of image around each target, a corner detection operator can be applied. The operator of Harris (Harris C.G., Stephens, M., 1989) gives a high number of interest points (Figure 23). In our case we obtained good results using the operator of Moravec (Moravec, 1979).

It must be observed that the result is remarkably influenced by the texture of the area surrounding the targets. In Figure 24 we can see that they have been detected the vertices of the triangle, and two more points on the ground; the location of the correct point can be obtained since the approximate position of the target vertex, respect to the centroid of the relative code is

3. CONCLUSIONS

A method for the automatic rectification of images has been described. The procedure uses targets with a design independent from the scale. The problems due to a rotation of the targets, respect to the image to rectify have been discussed. A solution for small rotations has been proposed. New codified targets, taking advantage of the colour, have been adopted with good results.

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