

# OBJECT RECOGNITION FOR INTERIOR ORIENTATION IN DIGITAL PHOTOGRAMMETRY

H.Karabork<sup>a</sup>, F. Yildiz<sup>a</sup>, E. Coskun<sup>a</sup>

<sup>a</sup> SU, Engineering Faculty, 42031 Kampus-Konya, Turkey - (karabork, fyildiz, emrec)@selcuk.edu.tr

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## ABSTRACT:

In this study, measuring processes of fiducial marks are performed with area based matching method. A computer program in Borland C++ Builder software is developed to find out the image fiducial marks particularly for this project. Ten images were taken by Wild RC 10 camera. They belonged to Selcuk University Campus area. The films were scanned by Zeiss Scai Photogrammetric Scanner (Pixel size is  $21\mu$ ). Four fiducial marks on each image are automatically measured by area based matching method. Both residuals of fiducial marks on each image and root mean square error of transformation between pixel and image coordinate system are calculated. In addition, interior orientations of 10 images are manually achieved by Erdas Imagine Orthobase software. Residuals of fiducial marks and root mean square error of transformation between pixel and image coordinate system are manually calculated. Finally, both manual and automatic measurement techniques are compared with each other in terms of interior orientation accuracy.

## 1. INTRODUCTION

Image orientation is needed for any task such as the generation of a digital terrain model, the computation of orthophotos, and the acquisition of data for geographic information systems. Image orientation relates to the determination of parameters defining particular photogrammetric models for mapping geometric primitives such as points, lines, and areas from one coordinate system to another one. Image orientation has always been a focus on attention in photogrammetry, in view of its importance (Heipke<sup>a</sup> 1996). Conventionally, the measuring of all kinds of points, such as fiducial marks, ground control points, tie points and terrain elevation points, causes the most time-consuming and labor-intensive task in photogrammetric production (Lue 1999). Therefore, it is clear that automation of image orientation for photogrammetry is necessary.

In this study, measuring processes of fiducial marks are performed with area based matching method. A computer program in Borland C++ Builder software is developed to find out the image fiducial marks, particularly for this project.

## 2. INTERIOR ORIENTATION

Interior orientation is an important task for digital photogrammetry. The purpose of interior orientation is to establish a relationship between pixel coordinate system and the image coordinate system (Fig.1). For digital cameras, the relationship between pixel and image coordinates is almost constant. This relationship is determined during calibration procedure. If digitised aerial photographs are used, this relationship must be determined by measuring the fiducial marks. Fiducial marks that have regular shapes are artificial objects on images. They are projected on the film at the time of exposure. Different cameras have different fiducial marks

(Fig.2). The fiducial marks are placed on the upper surface of the inside cone of an aerial camera. Many cameras have their own exclusive fiducial shapes (Lue 1997). They are placed either at the four corners of the frame and/or in the centre of the four sides. Fiducial marks are registered onto the film by projecting an image of the mark through a small lens. Each fiducial is designed and projected separately (Seedahmed and Schenk 2000).

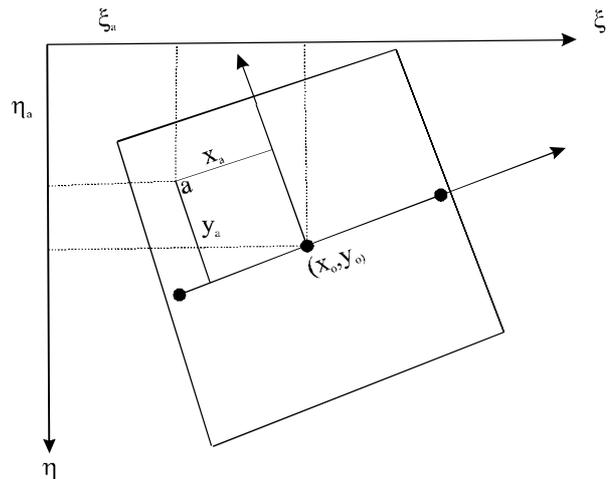
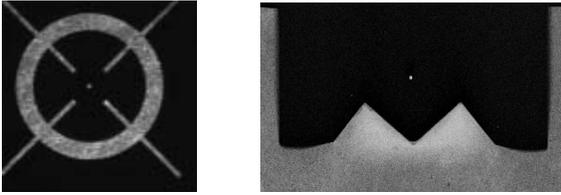
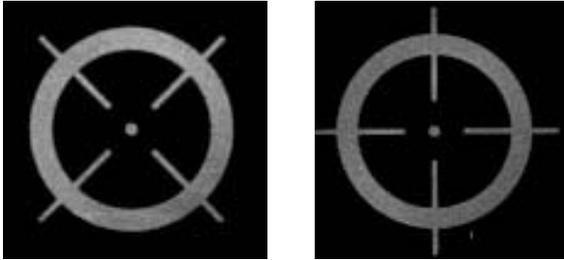


Figure 1. Relationship between pixel coordinates system and image coordinates system



Wild RC10

Zeiss RMK A 30/23



Zeiss RMKA-TOP30

Zeiss RMKA-TOP3050

Figure 2. Subimages of fiducial marks for several models.

### 3. IMAGE MATCHING

Matching can be described as the establishment of the correspondence between various data sets, such as images, maps or GIS data in photogrammetry. Moreover, the matching problem can be described as correspondence problem. A number of photogrammetric tasks is related to matching. Some of these are following: the reestablishment of the interior orientation, relative orientation and point transfer in aerial triangulation, absolute orientation, generation of digital terrain model (DTM) and interpretation step. The image of a fiducial mark is matched with a two-dimensional model in the reestablishment of the interior orientation. Parts of one image are matched with parts of other images in order to generate tie points for relative orientation and point transfer in aerial triangulation. Parts of the image are matched with a description of control features in absolute orientation. Parts of an image are matched with parts of another image in order to generate a three-dimensional object description in the generation of DTM. Features extracted from the image are matched with object models in order to identify and localize the depicted scene objects in the interpretation step (Heipke<sup>a</sup> 1996).

Matching algorithm is generally categorized as area based and feature based matching. The area based matching aims to shift and possibly warp one of the images such that its intensities best fit to the intensities of the other image. Area based matching consist of cross correlation and least squares matching. Cross correlation is a powerful technique to have the correspondence between digital images. It is based on two assumptions:

1. the two images geometrically differ only due to translation.
2. the two images radiometrically differ only due to brightness and contrast (Lang and Förstner 1998).

In order to compute the cross correlation function of two windows, a reference window (Fig3) is shifted across a larger search window (Fig4). In each position the cross correlation coefficient between the reference window and the

corresponding part of the search window is computed according to Equ.1 (Heipke<sup>b</sup> 1996).

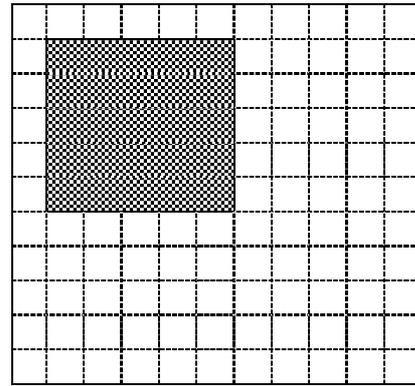


Figure 3. Reference Window

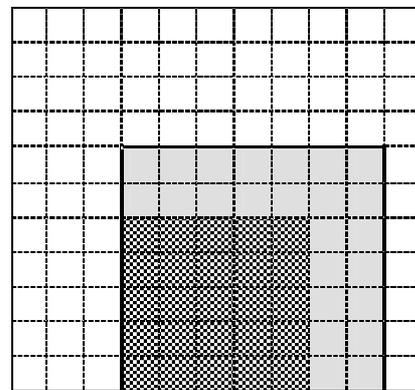


Figure 4. Search Window

$$\rho = \frac{\sum_{\xi=1}^m \sum_{\eta=1}^n (f(\xi, \eta) - \mu_1) * (g(\xi, \eta) - \mu_2)}{\sqrt{\sum_{\xi=1}^m \sum_{\eta=1}^n (f(\xi, \eta) - \mu_1)^2 * \sum_{\xi=1}^m \sum_{\eta=1}^n (g(\xi, \eta) - \mu_2)^2}} \quad (1)$$

$$-1 \leq \rho \leq 1$$

where

- $f(\xi, \eta)$  = individual grey values of reference window
- $\mu_1$  = average grey value of reference window
- $g(\xi, \eta)$  = individual grey values of corresponding part of search window
- $\mu_2$  = average grey value of corresponding part of search window
- $m, n$  = number rows and columns of reference window

Least squares matching is a generalization of cross correlation. It has the following fundamental features:

- any parametric type of mapping function can be assumed,
- any parametric type of radiometric relation between the two images may be dealt with,

- the estimation process is efficient,
- the evaluation tools from least squares estimation are available.

Feature based matching uses symbolic descriptions of the images for establishing correspondence. It is assumed that such a symbolic description can replace the original image suitably well and all information that is necessary for matching is contained in the attributes of the features and possibly their relations. Using features instead of the original intensities permits to select a representation that is much more invariant with respect to distortions such as illumination, reflectance or geometry (Lang and Förstner 1998).

#### 4. EXPERIMENTS AND RESULTS

Ten photographs, which belonged to Selcuk University Campus area, were taken by Wild RC 10 camera. Fig.5 shows subimages and locations of fiducial marks for Wild RC 10 camera. Table 1 shows calibrated data of fiducial marks for Wild RC 10 camera. The focal length is 153.29 mm and photographs scale is 1:10000. The films were scanned by Zeiss Scai Photogrammetric Scanner. They were scanned with a pixel size of 21  $\mu$ m, 8 bits per pixel, yielding a ground resolution 21.0 cm. Total scanned image size is 10956 pixel\*10956 pixel.

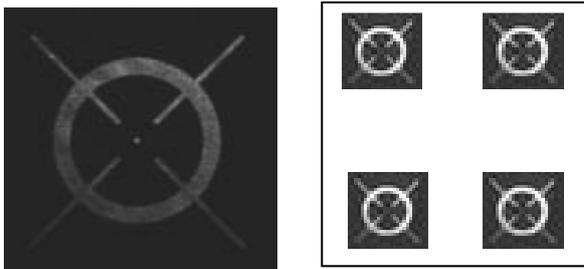


Figure 5. Subimage and locations of fiducial marks for Wild RC 10 camera

Table 1. Calibrated data of fiducial marks for Wild RC 10 camera

Fiducial marks	Calibrated data of fiducial marks	
	x(mm)	y(mm)
1	-106.007	106.004
2	106.009	106.005
3	106.005	-106.002
4	-106.007	-106.004

A computer program in Borland C++ Builder software is developed to find out the image fiducial marks, particularly for this project. The program has manual and automatic interior orientation module, bundle adjustment module and automatic digital elevation module (Karabork 2002).

Cross correlation matching method is used for measuring of fiducial marks (Fig.6). Four fiducial marks on each image in this project are automatically measured by cross correlation. Both residuals of fiducial marks on each image (Table.2) and

root mean square error of transformation between pixel and image coordinate system are calculated.

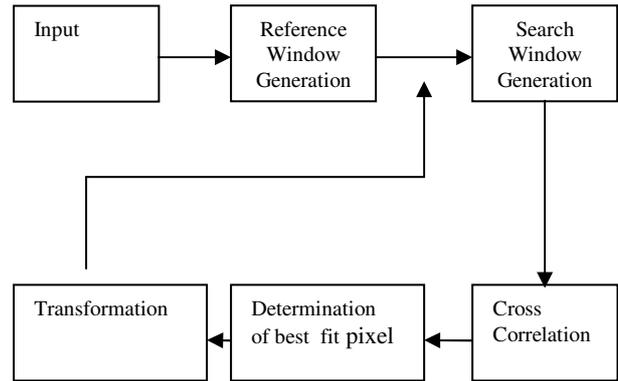


Figure 6. Workflow of interior orientation

Table.2 Residuals of fiducial marks on each image

Image No		Fiducial No			
		1	2	3	4
9061	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	-0.01	0.01	-0.01	0.01
9062	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	-0.01	0.01	-0.01	0.01
9063	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	-0.01	0.01	-0.01	0.01
9064	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	-0.01	0.01	-0.01	0.01
9065	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	0.24	-0.24	0.24	-0.24
9066	$v_x$ (pixel)	0.55	-0.55	0.55	-0.55
	$v_y$ (pixel)	-0.26	0.26	-0.26	0.26
9067	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	0.49	-0.49	0.49	-0.49
9068	$v_x$ (pixel)	0.30	-0.30	0.30	-0.30
	$v_y$ (pixel)	0.24	-0.24	0.24	-0.24
9069	$v_x$ (pixel)	0.05	0.05	0.05	0.05
	$v_y$ (pixel)	-0.01	0.01	-0.01	0.01
9070	$v_x$ (pixel)	0.54	-0.54	0.54	-0.54
	$v_y$ (pixel)	0.49	-0.49	0.49	-0.49

In addition, interior orientation of 10 images are manually achieved by Erdas Imagine Orthobase software. Both residuals of fiducial marks on each image and root mean square error of transformation between pixel and image coordinate system are manually calculated. Finally, both manual and automatic measurement techniques are compared with each other in terms of interior orientation accuracy (Table 3).

Table 3. Root mean square error of both automatically and manually

Image No	Automatically Int. orient. r.m.s.e (pixel)	Manually int.orient. r.m.s.e(pixel)
9061	0.37	0.22
9062	0.37	0.25
9063	0.37	0.33
9064	0.71	0.35
9065	0.46	0.22
9066	0.81	0.25
9067	0.73	0.33
9068	0.46	0.26
9069	0.06	0.28
9070	0.89	0.35

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## 5. CONCLUSIONS

In this study, we showed that the positions of fiducial marks were found using cross correlation method, which is one of the area based matching techniques. Transformation parameters are obtained from two different coordinates of fiducial marks that are pixel coordinate system and image coordinate system at the end of the fiducial mark searching process. The value of the root mean square error of the affine transformation is used as a confirmation criterion for the accuracy. The values of the root mean square error of the affine transformation are 0.06 to 0.89 pixel. Furthermore, manually the values of the root mean square error of the affine transformation are 0.22 to 0.35 pixel. The root mean square errors derived using cross correlation are bigger than the root mean square error derived by human operator (approximately twice the other values). The reliability of the algorithm depends on mainly on the radiometric and geometric quality of the digitised images.

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## 6. REFERENCES

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