DIGITISING TABLE CALIBRATION USING CLOSE RANGE PHOTOGRAMMETRY

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ABSTRACT

Throughout the surveying and mapping industry there is a proliferation of digitising tables being used to acquire data for Geographic Information Systems. In many work situations the digitising tables receive only a cursory calibration, if they receive one at all. Users generally rely on GIS system software to make the appropriate corrections to the data when fitting to control. To obtain the most reliable and accurate information, however, all phases of a system should be calibrated. The paper describes a method of calibration using close range photogrammetry via the bundle reduction technique and discusses the results of tests carried out.

KEY WORDS: Calibration, Cartographic, Close-range, GIS/LIS, Photogrammetry

1. INTRODUCTION

The question of digitiser calibration arose while the authors were developing a data acquisition system using manually digitised aerial photographs. As the method depended on digitised coordinates, it was essential that the accuracy of the equipment was verified. Of course, this is in keeping with the sound and practical expectations that every piece of equipment used for precise scientific measurement must be calibrated to provide full information on the accuracy attributes of the data.

At the time, the School of Surveying had just acquired a Rollei 6006 metric camera. As all the tools, including analytical plotter and software, were conveniently available, it was decided to use close range photogrammetry to calibrate, or verify, the calibration of the digitiser being used.

This paper is a description of the project and its outcome.

2. DIGITISER CALIBRATION

The digitiser being used was an ARISTOGRID table digitiser MODEL GRT108 with a measuring area of 915mm x 1220mm, and a quoted resolution/repeatability of 0.025mm (1/1000 inch). The measuring process uses the principle of absolute coordinates. The sensor can be lowered or raised from the digitising surface at any time without affecting measurement accuracy. We had never experienced any problems with this digitiser and in fact it had a 'feel' of reliability and accuracy. There were, however, other digitisers within the University which had exhibited a gradual creep in 'size' over a number of years.

The procedure proposed was to manually digitise a reference grid, use close range photogrammetry to coordinate the reference grid, and then relate the digitised coordinates to the photogrammetric coordinates. At this stage the reference grid was more of a convenience as a set of targets and transfer medium than as a calibration grid. The anticipation was that the photogrammetric coordinates would agree with the reference grid coordinates.

3. REFERENCE GRID

A reference grid on film was purchased from a Queensland Government Department. It was a 1cm grid with an overall size of 1m x 1m which did not exactly coincide with the digitiser measuring area. It was decided to carry out the calibration of the digitiser at 100mm intervals even though it extended beyond the recommended measuring area along one side; a total of 121 points. The 100mm grid intersections were high-lighted with marking pen to avoid misidentification.

4. DIGITISER COORDINATES OF GRID INTERSECTIONS

Two sets of digitised coordinates of the grid intersections were acquired for this project. For convenience they were labelled Dig 7 and Dig 10. A description of the data sets follows below.

4.1 Dig 7 Data Set

The XY coordinates of the data set are the arithmetic mean of 7 sequential sets of measurements over the grid. That is, after a grid intersection was measured the cursor was moved to the next intersection, and then the next, until all grid intersections were measured. Then the whole grid was measured again, for a total of 7 times. The arithmetic mean of each grid intersection was determined, giving one set of data.

The precision/repeatability of the measurements was 0.06mm (one sigma).

4.2 Dig 10 Data Set

The XY coordinates of this data set are the means of 10 consecutive measurements over each intersection of the grid. That is, each grid intersection was measured 10 times, with the cursor being moved off the intersection after each individual measurement. When 10 measurements had been made on a particular grid intersection, the cursor was moved to the next intersection, and the procedure repeated. The whole grid was measured once.

The precision/repeatability of the measurements was 0.04mm (one sigma).

5. PHOTOGRAMMETRIC COORDINATES OF GRID INTERSECTIONS

5.1 Outline

The coordinates of the grid intersections were determined photogrammetrically by the bundle method. The reference grid was fixed to the digitising table with tape and three one metre long scales helped keep it flat as well as providing control for the project. The scales were positioned so as not to obscure any of the grid intersections.

5.2 Photography

Photography was taken with a Rollei 6006 metric camera with a 50mm lens using black and white film. Lighting was normal room lighting consisting of standard fluorescent lights. Reflections obscuring the grid intersections were not a problem, except in only a couple of instances. Nine regularly spaced camera stations in classical configuration approximately 2 metres from the digitiser were used to acquire full coverage over the grid (refer to Diagram A). The camera was mounted on a stand, and coverage confirmed before exposing the film. The film was processed through a public commercial laboratory.

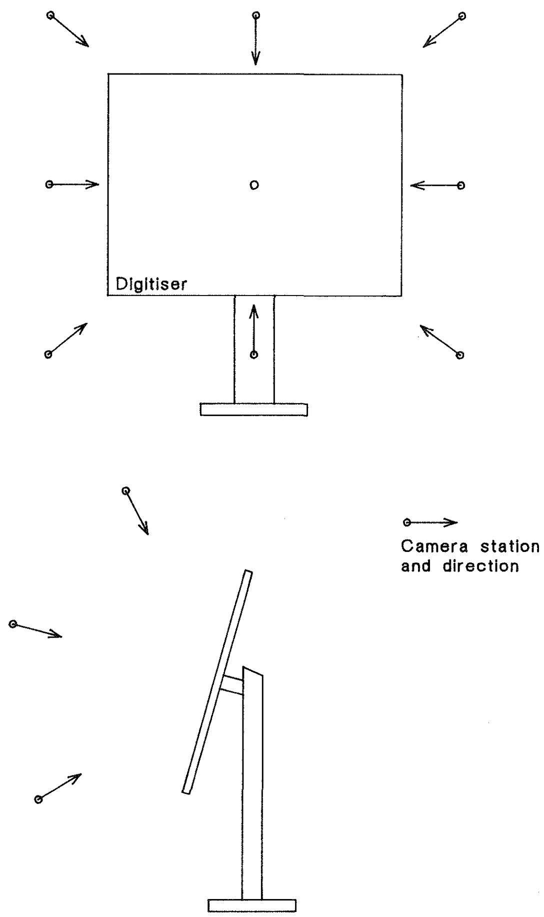

Diagram A: Camera-Digitiser Geometry

5.3 Image Coordinates

Image coordinates of the grid intersections were measured on a Zeiss Planicomp C100 analytical plotter using the black and white negatives. Lens distortion, but not film unflatness, was allowed for during the measuring procedure.

5.4 Bundle Adjustment

Grid intersection coordinates were determined by bundle technique using the image measurements of the nine photographs. The adjustment was constrained by holding the central grid point fixed together with one other point for "azimuth". The digitising table was assumed to be reasonably flat and a number of height points were loosely held. Scale control was provided through measurement on three one-metre scales.

5.5 Results

The result of the bundle adjustment was a set of coordinates for the grid intersections. The one sigma level of accuracy for XY (in the plane of the digitiser) was about 0.1mm while for Z (perpendicular to the plane of the digitiser) was about 0.2mm. Sigma nought for image measurements was 5 microns, which was considered satisfactory for this project.

6. ANALYSIS OF COORDINATES

The digitised coordinates (Dig 7 and Dig 10) were shifted and rotated, but not scaled, to fit the nominal values (even 100mm) of the reference grid. The X and Y differences between the transformed coordinates and the nominal grid values were determined and 0.1mm contours of the separate X and Y differences plotted. These results are shown in Figures 1 to 4.

As can be seen from the plots, the two manual digitiser results are similar to each other, but differ from the reference grid by a considerable amount; some half a millimetre in both X and Y directions. At this stage it appeared there was a simple uniform scale error in the digitiser.

Next the photogrammetric coordinates of the intersection points were compared with the nominal values of the reference grid. 0.1mm contours of the X and Y differences are shown in Figures 5 and 6. The differences are similar to the manual digitiser results; some half a millimetre in both X and Y directions.

Contours of the X and Y differences between the manual digitiser coordinates and the photogrammetric coordinates are shown in Figures 9 to 12. As could be expected, the results are in agreement with the differences, and more or less consistent with the photogrammetric accuracy of 0.1mm.

The scale for the photogrammetric coordinates was derived independently from metal scales and not from the reference grid. The conclusion to be drawn is that the reference grid contains a scale error.

Finally, the nominal grid coordinates were conformally transformed to fit the photogrammetric coordinates. The scale of the grid was calculated as 1:0.9993. Contours of the X and Y differences are shown in Figures 7 and 8.

At this stage the project appeared to change from one of digitiser calibration to one of reference grid calibration.

7. CONCLUSIONS AND RECOMMENDATIONS

The project was successful in that we verified to 0.1 millimetre, the measuring accuracy of our digitising system.

However, the project highlighted a problem with our "standard" reference grid. Had we adopted the reference grid as correct then we would have mistakenly thought the digitiser to be in error.

A solution to the calibration problem for a large table digitiser would be for the manufacturer to mark a grid on the table itself in addition to boundary marks, similar to the grid etched on a photo carrier of an analytical plotter. The calibration of the permanent grid could then be done efficiently and conveniently by close-range photogrammetry.

8. ACKNOWLEDGMENTS

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9. REFERENCES

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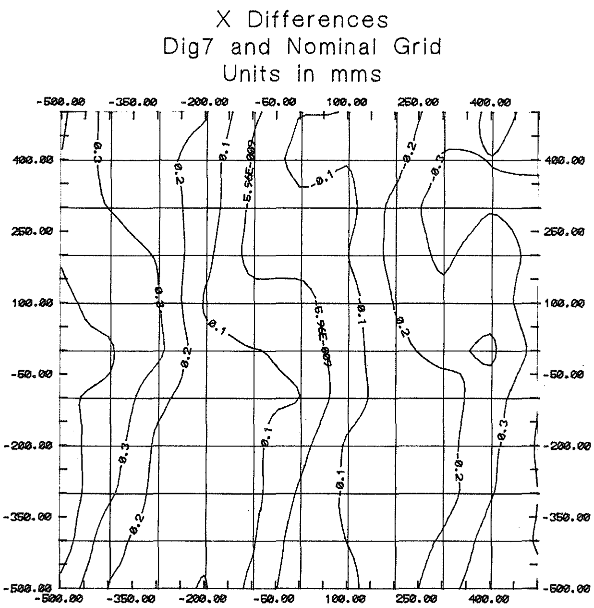

Figure 1: X Differences : Dig7 - Grid

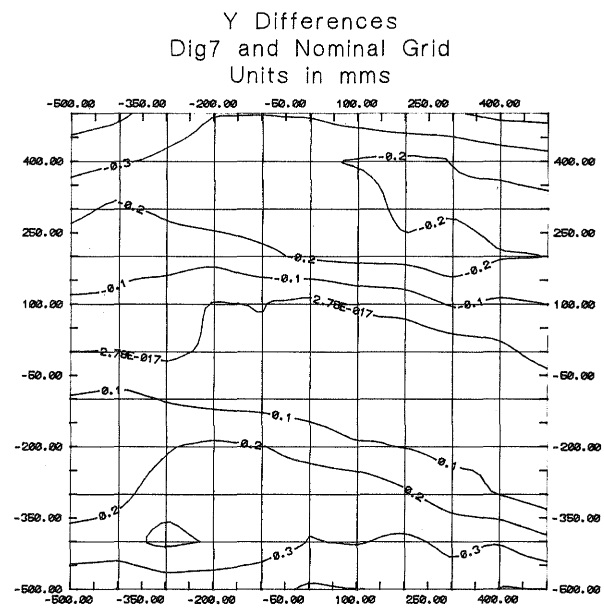

Figure 2: Y Differences : Dig7 - Grid

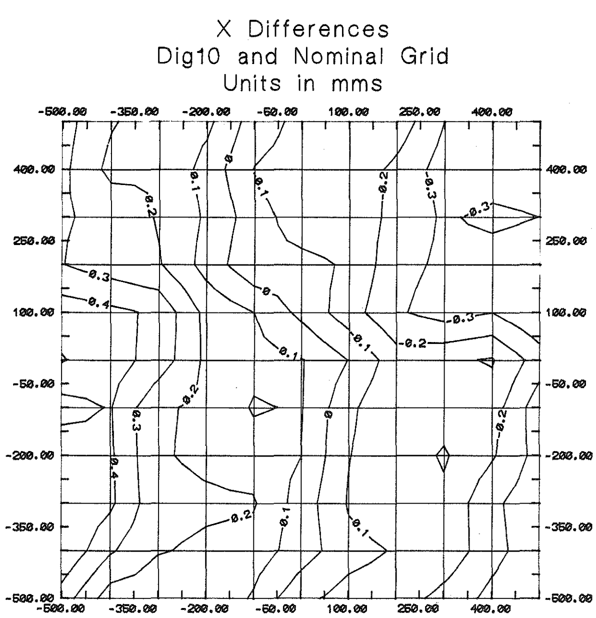

Figure 3: X Differences : Dig10 - Grid

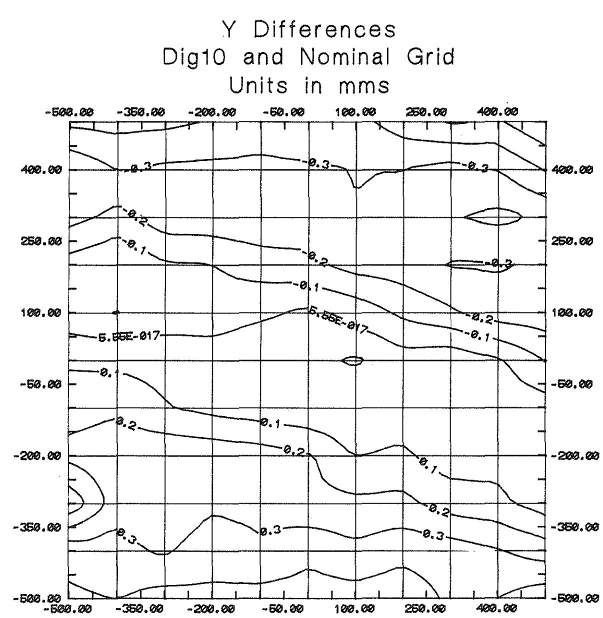

Figure 4: Y Differences : Dig10 - Grid

X Differences
Photogrammetry and Nominal Grid
Units in mms

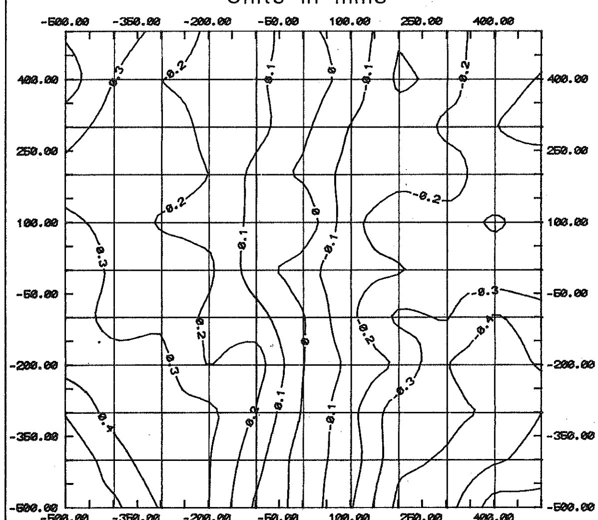

Figure 5: X Differences : Photogrammetry - Grid

Y Differences
Photogrammetry and Nominal Grid
Units in mms

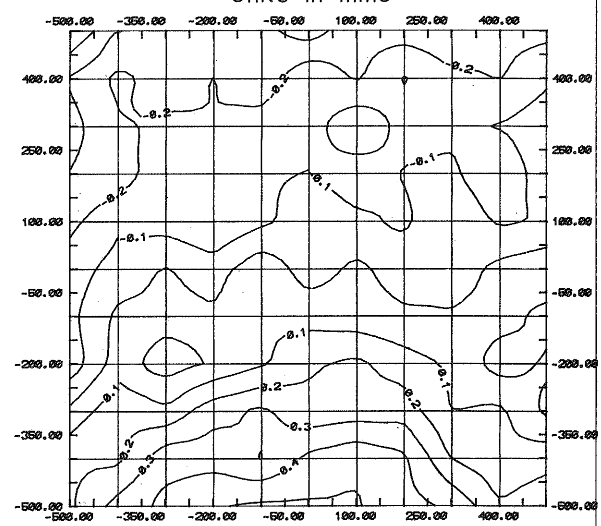

Figure 6: Y Differences : Photogrammetry - Grid

X Differences
Transformed Grid and Photogrammetry
Units in mms

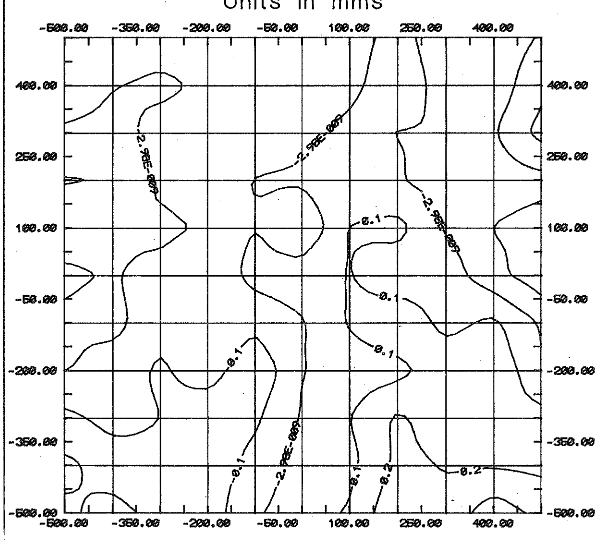

Figure 7: X Differences : Grid - Photogrammetry

Y Differences
Transformed Grid and Photogrammetry
Units in mms

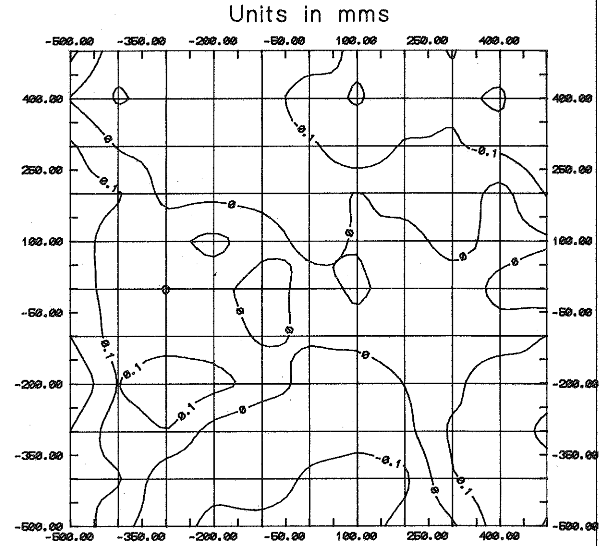

Figure 8: Y Differences : Grid - Photogrammetry

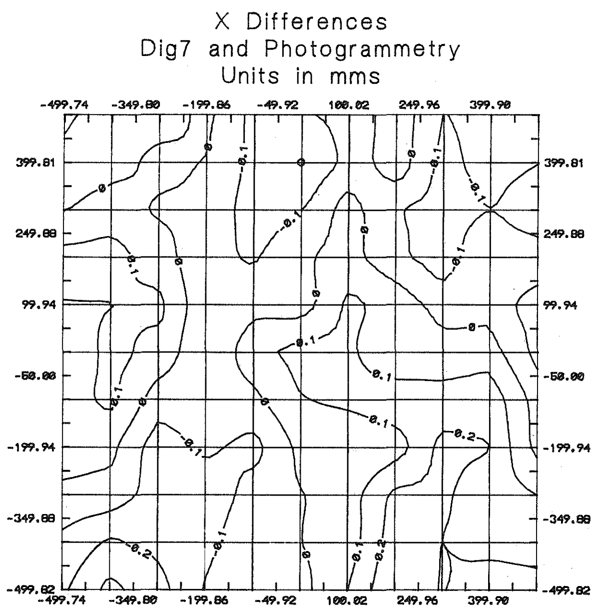

Figure 9: **X Differences : Dig7 - Photogrammetry**

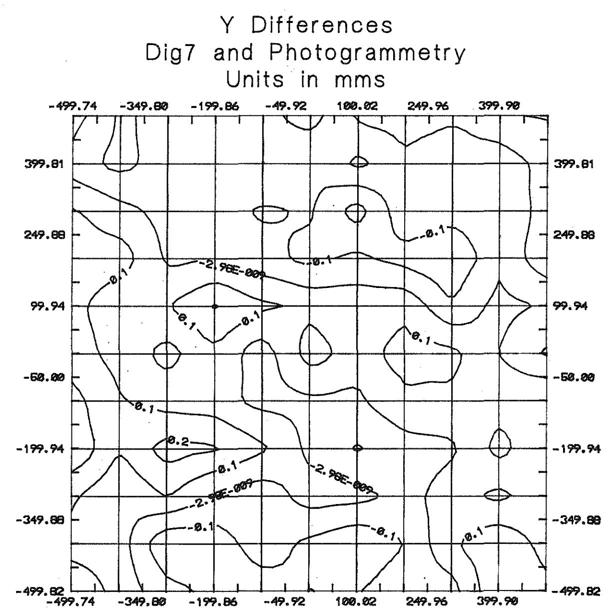

Figure 10: **Y Differences : Dig7 - Photogrammetry**

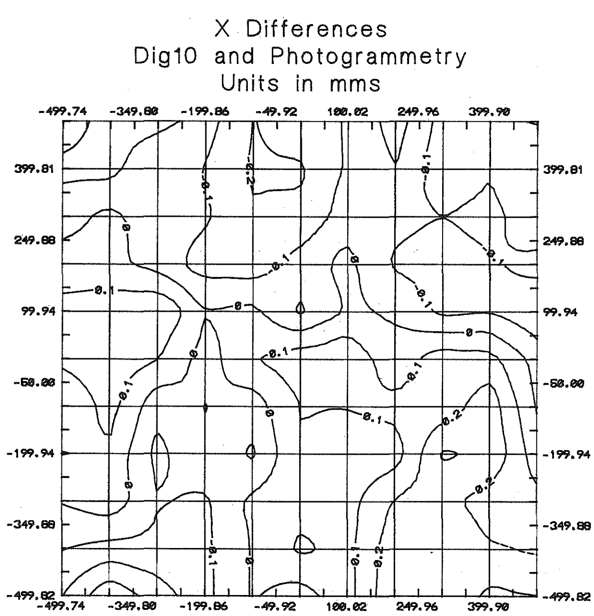

Figure 11: **X Differences : Dig10 - Photogrammetry**

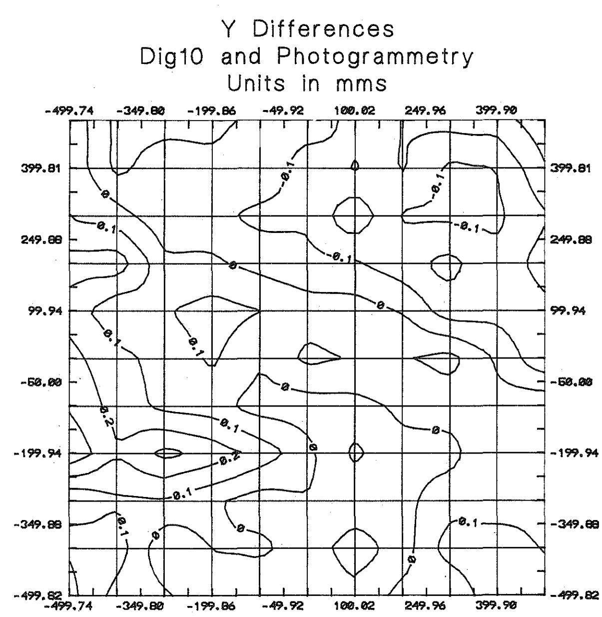

Figure 12: **Y Differences : Dig10 - Photogrammetry**