A COMPARISON BETWEEN TWO COMPARABLE ANALYTICAL METHODS OF DATA REDUCTION FROM NON-METRIC PHOTOGRAPHY

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Abstract

This paper discusses, contrasts and studies theoretically and experimentally the accuracies obtained from two comparable analytical methods of data reduction from non-metric photogrophy .
Both methods depend mainly on the perspective theorem.
These methods are(1)the Artificial photo perspective Transformation (APPT) developed by Thompson (1962), and(2) the metric photo perspective Transformation (MPPT) developed by Gruen (1985).
We can say that the comparison is between :
(1) The surveying technique wherein an imaginary camera (theodolite) is used for measurements; and
(2) The photogrammetric technique wherein a real camera is used for measurements., Three different cameras (Zeiss Jena)UMK,Wild P32 and Galileo Santoni metric cameras were used in the comparison between the above two methods. A non-metric camera was also used (Nikon FM 35 mm),as well as a Wild T2 one second theodolite. A set of analysis of results , concluding remarks and recommendations was achieved.

1 . INTRODUCTION

In the APPT method we transform the image co - ordinates from the non-metric photograph to image co - ordinates on imaginary metric photographs by using perspective transformations . In the MPPT method we transform the image co - ordinates from the non -metric photograph to image co - ordinates on real metric photographs by using the same transformations.

In our comparison between the two methods , either theoretically or experimentally ,we shall assume that: (1)the non - metric camera used with both of the methods was the same ;
(2) the object dimensions (W,H) observed by both the methods were the same ;
(3)the base distance (B) and the object distance (D) for both the imaginary camera or theodolite and the metric camera were equal and
(4)the condition for photography should be standarised as far as possible

2. THEORETICAL COMPARISON

The comparison between the APPT and MPPT methods
will be now concentrated in the following main factors :

(1)the accuracy of the image co-ordinates of the metric and fictitious photographs ;
(2)the accuracy of the operator in orienting the metric camera and the theodolite in the field (w,ø,k) and measuring their co-ordinates (X_s,Y_s,D_s) and
(3)the pointing accuracy of the operator .

2.1The Accuracy of the Image Co-ordinates of the Real and Fictitious Photographs

The accuracy of the image co-ordinates achieved from the surveying technique (artificial photographs) is generally better than that achieved from the photogrammetric technique (metric photographs) .

The accuracy of the fictitious photographs is a function of the accuracy of measuring and computing the control points and the horizontal and vertical distances between the two stations ($B_x$and B_y), e.g if the chosen focal length (f) of the imaginary camera is 100 mm , the mean object distance (D) is 100 m and the accuracy of computing and measuring the control points ,B_x and B_y is 0.5 mm , in this case we can achieve an accuracy in the co-ordinates of the fictitious photographs of 0.5 µm . This level of accuracy cannot be achieved by using metric photographs.

2.2 The Accuracy of the Operator in Orienting the Imaginary Camera(or theodolite) and the Metric Camera in the Field.

The accuracy of measuring the spac co-ordinates(σXs,σYs and σDs)of the metric camera , imaginary camera and/or theodolite stations should be nearly the same, and that is because we used the same stations and the same co-ordinate system , while the accuracy from setting the orientation parameters(w, ø , k) in the field for the metric camera depends mainly on the type of camera .

In artificial cameras or theodolites , we can achieve accuracy in setting the orientation parameters σw , $\sigma ø$ and σk between 0".0 in the imaginary cameras to 1".0 or less in the theodolite which cannot be achieved by using metric cameras .

2.3 The Pointing Errors of the Operator

There is no need for a comparator to measure the fictitious image co-ordinates , and consequently there are no pointing errors for the artificial photographs . In the metric photographs the pointing accuracy of a photogrammetric operator is a function of many parameters such as the model scale , the operator experience and the model`s photographic contrast . The pointing accuracy can be estimated from the repeated measurements of different points .

2.4 Aspects of Results

As a result , we can expect that the accuracy obtained theoretically by using (APPT) method is better than that obtained by using (MPPT) method .

3. EXPERIMENTAL COMPARISON

Three different cameras (Zeiss (Jena) UMK , Wild P32 and Galileo Santoni metric cameras) were used in the comparison between the MPPT and APPT methods . A non - metric camera was also used (Nikon FM 35 mm) , as well as a Wild T2 one second theodolite .

3.1 Field Work

Four photographs were taken with each of the three metric cameras and the non - metric camera . For each camera two of the photographs were taken from the left camera station (S1) and two from the right camera station (S2).The base distance (B_x) was 28.508m and the elevation difference between the two stations (B_y) was 0.232 m .

The spatial positions of (9) control points (which were not lying in one plane) were surveyed on the same co-ordinate system of the camera stations, using a Wild T2 theodolite .

3.2 Laboratory Work

The image co-ordinates of the non - metric photography and the nine control points on each metric photograph were measured on a Hilger and Watts stereocomparator . The ground co-ordinates of (24) control points were computed(using a bundle solution).

By applying the perspective transformation and using the points (4,5,6 and 7) , the image co-ordinates on the non - metric photograph were transformed to metric image co-ordinates

The artificial image co-ordinates of the control points 4,5,6 and 7 were calculated from the space co-ordinates .

By applying the perspective transformation the image co-ordinates on the non - metric photograph were transformed to image co-ordinates on the artificial photograph .
The mean standard deviation values (σXm , σYm , σDm and σRm) of the space co-ordinates of a total of 18 targets (control points) computed from the APPT , MPPT (Zeiss (Jena) UMK , Wild P32 and Galileo Santoni) and the Direct linear Transformation (DLT) method , are listed in Table 1 . The standard deviation values (σX , σY , σD) were calculated by using the emprical accuracy indicator (Gruen,1978).

4. ANALYSIS OF RESULTS, CONCLUDING REMARKS AND RECOMMENDATIONS

(1)In the APPT method there is no need for development and processing of the artificial image . Also there is no need for a comparator to measure the imaginary camera image co-ordinates which are obtained from the observed control points .
(2)In the APPT method there is no limitations on the depth of field and the format size .

(3)In the MPPT method the metric photographs are considered as permanent record and documentation which can be used in any time .

(4)The MPPT method is advantageous if only one non-metric photograph is available , and in this case object information is necessary for data processing .

(5)The MPPT method is recommended when the time plays an important role in the restoration (i.e when the damage has recently happened and the remaining part is unstable) .

(6)In both the MPPT and the APPT methods , the object width (W),the object height (H) , the base distance (B) and the object distance (D) are fixed as well as the elements of the exterior orientation (w, ø , k) of the metric camera which are dependant upon W , H and the ratio of the overlap . So ,the main significant difference in the accuracy between the APPT and MPPT methods is the difference between the accuracy of the theodolite used in the first method and the metric camera and comparator used in the second method .

(7)Improving the accuracy when using the MPPT method depends on the type of camera used and the accuracy of measuring the plate co-ordinates (σ) . In this study the accuracy achieved from measuring the plate co-ordinates on a Hilger and Watts stereocomparator was 6µm , and the Zeiss (Jena) UMK camera was the camera which gave us the best accuracy (but it is the most expensive camera) .

(8)Improving the accuracy when using the APPT method depends on the type of theodolite used , the accuracy of measuring the horizontal and vertical distances between the two stations (B_x and B_y) and the theodolite height with respect to the object used in the observation of the control points . So, in this case to obtain the best accuracy , we should , if possible , use the theodolite height which maximizes the accuracy of these control points . The values of the theodolite height (E_{th}) which maximize the accuracy of the control points at different values of base distance (B) and object distance (D) can be obtained (using equation derived by the author in 1989)from Table 2. Table 2 gives the ratio E_{th}/H for different ratios of B/W and D/W , where W and H are the dimensions of the object .

(9)On the basis of the results shown in Table 1 we can say that :

(a)theoretically and experimentally, the accuracy obtained from the APPT method is better than that obtained from the MPPT method and it is more economic .

(b)in appropriate circumstances (i.e avoid having all object space control points in one plane)the DLT method is the preferable method to be used for data reduction from non-metric photography because it gives better accuracy than the APPT and MPPT methods .It can also lead to a reduction in the cost of the data acquisition system by using non - metric cameras only.

(10)A further investigation should be done in a comparison of the APPT and MPPT methods which involves the variation in field relationships between camera and object and the analysis or measurement equipment effects .

References

Abdel-Aziz,Y.I.and Karara,H.M., 1971.Direct linear transformation from comparator co-ordinates into object space co-ordinates. Close range photogrammetry. American Socity of Photogrammetry. Falls Church, Virginia. Pages 1-18.

Fraser,C.S.,1978.Computer programme for resection/intersection routine for application when an object space control field is established .

Gruen , A.W., 1978 . Experiences with self-calibrating bundle adjustment.Paper presented to the ACSM - ASP Convention , Washington, D.C, February / March , 1978.

Gruen,A.W.,1985. Processing of amature photographs . Photogrammetric Record , 10(65):567-579.

Mahmoud , A . A . E .,1989 . The application of close rangephotogrammetry to the restoration of architectural features . Ph.D. dissertations , Department of Civil Engineering , Zagazig University Banha Branch, Egypt ,129 pages.

Thompson,E.H. , 1962. Photogrammetry in the restoration of Castle Howard.Photogrammetric Record, 4 (20):94-119.

Thompson,E.H., 1965. A perspective theorem and rectification. Photogrammetria,20(1965):143-161.

TABLE 1 Instruments,focal length,film format,mean standard deviation values of the space co-ordinates and the approximate price for each method used for data reduction from non-metric photography .

Method	Instruments Used	Focal Length (mm)	Image Format (mm)	σX_m (m)	σY_m (m)	σD_m (m)	σR_m (m)	Approx. Price (unit) *
APPT	Nikon FM/Wild T2 Theodolite	100	_____	0.0237	0.0059	0.0307	0.0393	1.0+18.20
MPPT	Nikon FM/Zeiss(Jena) UMK	100	180x130	0.0278	0.0164	0.0367	0.0489	1.0+92.0
MPPT	Nikon FM/Wild P32	64	90x65	0.0301	0.0169	0.0387	0.0519	1.0+28.0
MPPT	Nikon FM/Galileo Santoni	150	180x130	0.0358	0.0202	0.0446	0.0607	1.0+ ?⊠
DLT	Nikon FM	28	24x36	0.0081	0.0092	0.0288	0.0313	1.0+0.0

* out of production

⊠ unit= £ 250.00 (1986)

TABLE 2

The ratio of Eth/H for different ratios of B/W and D/W which maximizes the accuracy of the control points .

D/W \ B/W	0.2	0.4	0.6	0.8	1.0	1.2	1.4
0.1	0.50	0.50	0.40	0.50	0.45	0.47	0.50
0.2	0.50	0.50	0.48	0.50	0.49	0.48	0.51
0.3	0.50	0.50	0.45	0.50	0.51	0.32	0.51
0.4	0.50	0.50	0.46	0.50	0.51	0.52	0.41
0.5	0.50	0.50	0.47	0.40	0.51	0.34	0.50
0.6	0.50	0.50	0.47	0.45	0.35	0.53	0.53
0.7	0.50	0.44	0.47	0.52	0.43	0.41	0.41
0.8	0.50	0.48	0.51	0.52	0.53	0.52	0.37
0.9	0.50	0.48	0.51	0.45	0.53	0.54	0.47
1.0	0.50	0.49	0.51	0.45	0.52	0.39	0.54