Analytical deformation on aerial photographs by using digital photogrammetric applications +

تحليل التشوهات في الصور الجوية باستخدام تطبيقات المسح التصويري الرقمي

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Abstract:-

Deformation is a change in the position of a point on aerial photographs, map, manuscript or print from its originally plotted position. This change is the result of differential shrinkage and /or expansion of the film or paper or lens sensitivity of the cameras and/or the positions of projectors during operation.

There are many methods used before to solve this problem such as resection intersection method, and rotation coordinates method.

The research aim to analysis the deformation on aerial photographs and show the ablates how to use application of digital photogrammetric to the measurement of deformation , also two different approaches method of stereomodels with control, multi station photogrammetry. Are identified and compared, references to and summaries of recent work are made. And show the result which be attached .it will be strongly recommended that to use the first method because it is easy, quick and cost lower money than the second one by practical, but still the second one more accurate in the result .

المستخلص:

التشوه في الصورة الجوية عبارة عن تغيير في مواقع النقاط على الصور الجوية ،الخريطة ا والمخطوطات عن موقعها الأصلية نتيجة للتغيرات في انكماش أو تمدد الفلم (اللوح السالب) أو الورقة المطبوع عليها أو ناتج عن حساسية العدسات في آلة التصوير أو من موقع جهاز الإسقاط في أجهزة التحشية أثناء العمل. هنالك طرق عديدة استخدمت من قبل للتخلص من التشوهات:منها طريقة التقاطعات الخلفية والأمامية وكذلك طريقة دوران الإحداثيات . في هذا البحث تم بيان استخدام تطبيقات المسح التصويري الرقمي في تحليل التشوهات التي تحصل في الصور الجوية من خلال طريقتين مختلفة هي طريقة استخدام نقاط الضبط على النموذج المجسم وطريقة محطات الضبط المصححة المتعددة ومقارنتها مع بعضها وبيان المستجدات في هذا المجال. وتم عرض النتائج التي توصل إليها الباحث وأوصى الباحث بان الطريقة الأولى هي أسهل من الناحية التطبيقية وأسرع في تطبيقاتها وتكاليفها اقل ولكن الطريقة الثانية تبقى أكثر دقة في النتائج.

Introduction:-

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The use of digital aerial photographs for topographic mapping is standard practice in land surveying. Stereoscopic viewing of pairs of aerial photographs in a stereoplotter and the use of triangulation control points from first order for scaling and leveling stereomodels is a well known. applied method for producing contoured maps. However, because this method is so well understood and applied by land surveyors. There is a possibility that all other applications of digital photogrammetry will be conceived as a deriving from methods developed for topographic mapping using controlled stereopairs. This approach is not being encouraged. It leads to severe limitations on the variety of measurements problems which can be solved by digital photogrammetry and on the accuracies of the possible solution. Topographic mapping from accurately controlled stereopairs of nearly vertical aerial photographs is only one special application of photogrammetry.

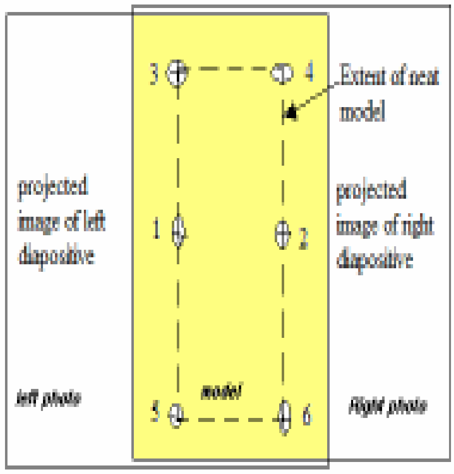
It should no longer be necessary to stress this point. The activities of photgrammetrists, surveyor. Engineers and other in applying photogrammetry to the measurements of object other than the surface of the earth are comprehensively described in close range photogrammetry a description which many prefer to the negative "non- topographic" . The word deformation means change of shape and has nothing to do with size [1]. However, in deformation of structures, which the subject of this paper. Change in size, or relief- displacement is usually important and therefore the word "deformation "will be used to include change in size.

This paper examines two different photogrammetric methods using respectively.
A) Controlled stereomodels.
B) Multi station photogrammetry.
Procedures a brief discussion of design and statistical testing is also included.

These two methods have been applied extensively too many different measurements problems (including deformation) there are application when the deformations to be measured are large in comparison with the accuracy of photogrammetry and when fixed.
Although several papers have appeared recently which deal with the theory of bundle methods in close- range photogrammertry. Sometime with survey measurements incorporated and sometimes using the method of inner constraints, reports of applications to determination measurements are few, although several are in progress .mainly theoretical treatments are given by [2]; test results given; [3]; mainly variance analysis, [4]; an experimental illustration a good basic introduction with useful references, a combination of aerial and terrestrial, photogrammetry.
The location of orientation points. The neat model extends from one principal point to the next in (h) direction of the flight line and is approximately twice as wide normal to the direction flight. As shown in figure (1 a & b).

The individual effects of the orientation element are shown graphically in figure (2).
A small(Δ_bx)error causes a slight scale error and dose not affects elevations by any appreciable amount unless the terrain relief is considerable. This error raises or lowers the model a small amount which is allowed for by proper indexing of the elevation counter.

A small(Δby) error has no effect on elevations, but simply introduces y- parallax throughout the model as shown in figure (3). A (Δbz) error of either or both projectors has the effect of tipping the model in the x-direction. This error is overcome in the leveling process as shown in figure (4). The(Δd_{k}) error tilts the model in the y-direction. This error is also overcome in the leveling process as shown in figure (5).A small($\Delta\Phi$) error causes the level datum to become slightly cylindrical as shown in figure (6). A small($\Delta\omega$) error introduces a diagonal warpage of the model. It is to be noted that if vertical control points are located in each of y the four corners of the model, the effect of a $d\omega$ error can be detected as shown in figure(7). .However; this control configuration will not detect the effect of a($\Delta\Phi$) error as can be seen by a study of figure.(2) this latter error can only be detected by placing a fifth vertical control point somewhere in the middle of the model.



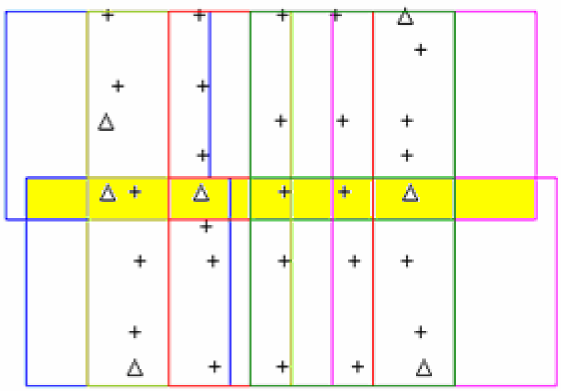


Figure- 1-a- shows Location of orientation for the 6 points [2]

Figure -1-b – location of tie point on model .[2]

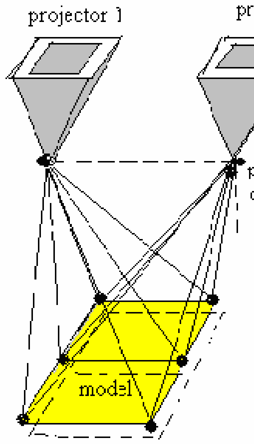


Figure:- 2-The effect
of(Δdx) error[٤]

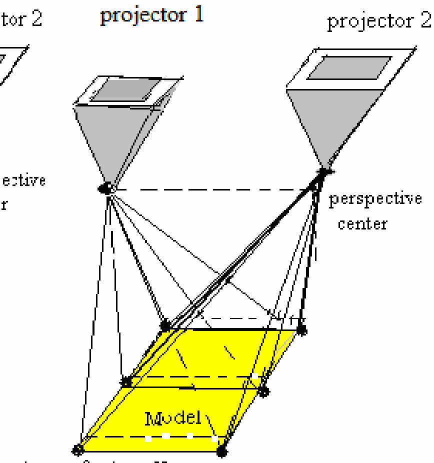


Figure: 3 -the effect
of(ΔY)error[٤]

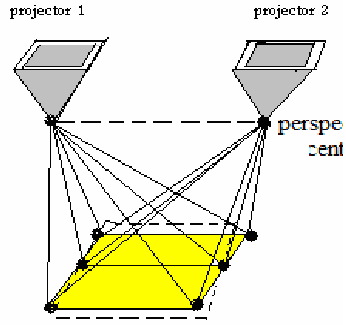


Figure- 4-The effect
of (Δbz) error[٤]

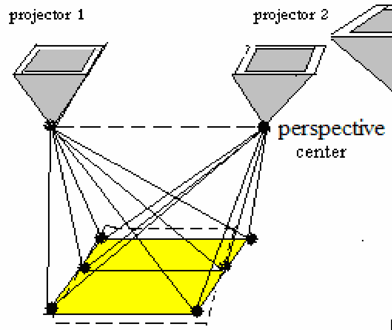


Figure: - 5 -the effect
of(Δk)error[٤]

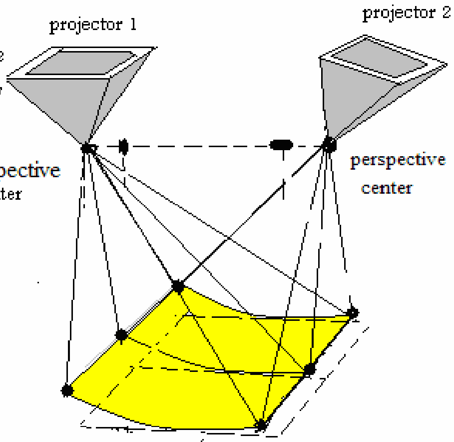


Figure:-6 -The effect
of (ΔΦ) error[٤]

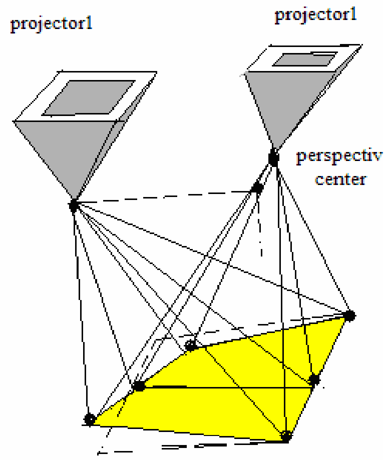


Figure: 7-The effect
of (Δω) error[٤]

Where: - Δbx=small motion on X-axis   Δby= small motion on Y-axis

Δbz= small motion on Z-axis   Δbω= small rotation about X-axis

ΔbΦ= small rotation about Y-axis   Δbk= small rotation about Z -axis

<u>Method of stereo models with ground control</u>:-

Aerial Photography to give single stereomodels, a strip or even a block of stereomodels with independently surveyed control perhaps extended by aerial photogrmmetric triangulation can be obtained before and after deformation of the object, inner and exterior orientation of each stereopair can be carried out analytically or in mechanical analogous stereoplotter and two sets of spatial coordinates (or graphical results) obtained to represent the object. Differences between the two sets of digital or graphical data represent deformation. Usually it is necessary to survey the control before and after deformation because the control itself, if it is not or close to the object, is likely to undergo

deformation [5].

This application of digital photogrammetry is similar to aerial survey, but there are differences which become important when mechanical analogy stereoplotters are to be used for inner difference may be summarized as follows ;

1) Cameras with variable focal might be used, sometimes uncalibrated.

2) Elements of relative orientation (base components and rotations) might be outside the mechanical range of the plotter.

3) The depth of object (”z range” for the aerial survey) might be outside the mechanical range of the plotter.

4) Empirical methods of relative orientation which involve observation and removal of y parallaxes often do not work in close range photogrammetry. Either because of the large depth range of the object or because only part of the format contains photogrammetric detail [1].

For these reasons, analogy stereo plotters usually give lower accuracies than analytical method and sometimes they cannot be used at all. The often quoted advantage of their giving a direct graphical representation is not so important because point measurements in a comparator can now be easily transformed to produce profiles. Sections and contours which can be plotted automatically, particularly when a minicomputer and drawing table is used on line a stereo comparator [5].

In any case, in deformation measurement it is often the relief displacements which are required to be presented graphically and not the object itself in either the initial or deformed state, analogue stereo plotters cannot readily provide data for automatic plotting of deformation, analytical inner, relative and absolute orientation can be carried out to differences by different choices of the mathematical model of each stage. If enough control, suitably distributed, is available, certain parameters of the inner orientation can be recovered (principal distance and a few terms of geometrical lens distortion and film deformation for example).But the size and distribution of residual errors of exterior orientation might make extensive calibration superfluous[1].

The accuracy of point measurement in a comparator (about$\pm$ 2µm to $\pm$ 0.3µm)casts some doubt on the validity of regarding coordinates of surveyed control points as error free [6] ; describes a method for taking the coordinates of the control as correlated measurements into the least square solution for the inner and exterior orientation. Using the covariance matrix of the control coordinates and the variances of stereocomparator measurements as the basis of the Weight matrix.

Sequential adjustment procedures are used so that the observer can see what improvements (if any) continued comparator reading is having on the precision of the orientation parameters [7].

Assuming that the ground control is not in error and that the vertical control point has been correctly identified in the model, the main source of the discrepancy is due to model deformation. The model deformation in turn is caused by inexact relative orientation between the two photographs or projectors.

After an initial orientation the base components are:-

b_{x1}=225.00mm; b_{y1}=-8.16mm; bz1=+6.76mm.The data for two horizontal /vertical control points are as follows;

Table 1- computes the amount of deformation for two selective points

point	Ground X (M)	Ground Y(M)	ELEV(M)	Model X(mm)	Model Y(mm)	Model Z(mm)
1228	747,746.58	249,305.93	817.64	-22.057	-63.046	-156.466
3414	750,093.51	250,998.89	973.83	64.157	-74.845	-155.109

If the map scale is 1/1200. Compute the base components necessary to bring the model to
the map scale.
The ground spatial length = 471.67m
The corrected model spatial length then is 471.67/1200 = 0.39306m = 393.06 mm
The model spatial length following initial relative orientation is
d_0 =399.85 mm,b_{X2}=221.8mm,b_{y2}=-8.02mm,b_{z2}=+6.65mm.
if the elevation of the ground control points were not known, the computation would then be as follows:
d=470.61m
The corrected model length = 392.18mm
d_0=398.90m
The new base component are then {b_{x2}=221.21mm,b_{y2}=-8.02mm,bz2=+6.65mm}.
The difference in the (b_x)components between the two solutions is caused by the model not being level at this stage.

Leveling the model:-

A stereoscopic model can be always be made to fit three vertical control points since three points are sufficient to define the datum plane .however, it is not always possible to level a model using four or more vertical control points .as shown in figure 8.

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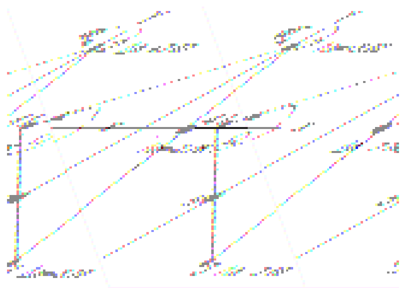

Figure -8- leveling based on analysis of three vertical controls Points [2]

Table – 2-Given the following data pertaining to the points shown in figure (8) .

Point number	Δh (mm)	line	Length(mm)
1	-2.76	1-3	260
2	+3.02	2-3	234
3	-3.10	2-4	76
		1-5	174
		1-4	163
		2-5	176

Compute the amount of Ω and Φ -rotation required to level the model.

L2 - 4

Δh4= +1.03mm----------=Δh2+------------------ *(Δh3-Δh2)……………… [2].

L2 - 3

L1 - 5

Δh5=-2.99mm-----------=Δh1+--------------------* (Δh3-Δh1)……………. [2].

L1 - 3

Tan Ω = -0.03415

Ω =- 1 ˚57' 20"

Tan Φ= 0.02325

Φ= 1 ˚20' 00"

The front of model must be raised by the Ω-rotation, and the left side of the model must be raised by the Φ --rotation. So the model has been leveled now

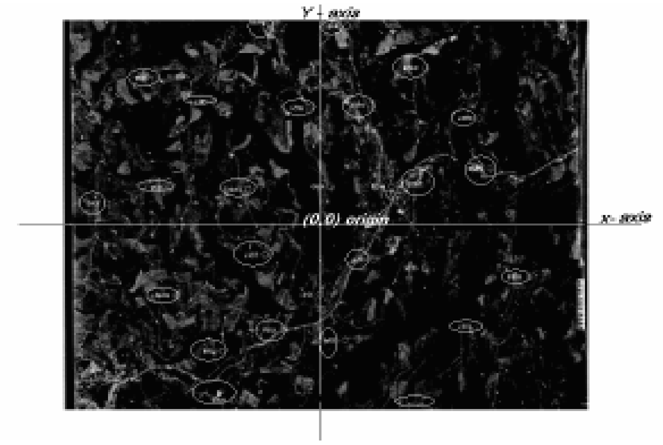

Figure-9a-the photo use in this project

Analytical interior orientation results
Gives the results of the analytical interior orientation

This file is called: Inner orientation
Project Name = abdull-kadir
Model Identification = by the number of photographs (2650 - 2651)-- (2651 - 2652)
Left photograph number = 2650 (figure 9a)
Right photograph number =2651
Camera Information = Camera Name Wild RC10 universal
Left camera = focal length 153.03
Right camera = focal length 153.03
Left Interior Orientation
Transformation type = Affine
Number of left points = 8
Table -3- Left Interior Orientation

point	number	Ground coordinates XN	YN	Stage Coordinates XS	YS	Residuals XR	YR
1	1226	747,237.37	249,573.26	18.564	229.194	-0.001	0.002
2	1228	747,746.58	249,305.93	124.586	232.066	-0.002	-0.008
3	1314	749,295.85	250,516.03	230.527	226.911	0.004	0.007
4	1315	748,458.34	250,110.92	233.394	120.865	0.003	0.010
5	1316	749,541.44	249,935.06	228.253	14.938	-0.005	0.000
6	1418	750,856.86	250,302.48	122.215	12.075	-0.002	-0.007
7	3312	748,945.82	250,987.05	16.263	17.199	0.004	0.009
8	3414	750,093.51	250,998.89	13.40	123.244	0.003	-0.005
					Average Residuals	0.003	0.006

Rotation and scale shift

Left Lens Distortion: -0.99999 0.0108 152.876

Table- 4 - shows Left lens distortion values

Left distortion values								
-1.8	-3.0	-4.1	-3.9	- 3.7	-3.0	-2.0	-0.3	1.5
3.2	3.8	3.2	2.5	1.3	0.9	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Right Interior Orientation

Transformation type = Affine

Number of right points = 8

Table- 5 - shows Right Interior Orientation

point	number	Fiducials coordinates XN	YN	Stage Coordinates XS	YS	Residuals XR	YR
1	1226	747,237.37	249,573.26	14.804	227.159	0.006	--0.006
2	1228	747,746.58	249,305.93	120.770	231.467	0.000	-0.006
3	1314	749,295.85	250,516.03	226.770	227.751	0.005	0.004
4	1315	748,458.34	250,110.92	231.041	121.758	0.005	0.002
5	1316	749,541.44	249,935.06	227.314	15.756	-0.012	-0.001
6	1418	750,856.86	250,302.48	121.323	11.443	0.005	-0.005
7	3312	748,945.82	250,987.05	15.335	15.144	0.003	0.002
8	3414	750,093.51	250,998.89	11.055	121.130	0.004	0.006
Average Residuals						0.005	0.004

Rotation and scale shift

Rights Distortion: -1.0001 -0.0025 151.889

Right Lens Distortion

Table-6 - shows Right lens distortion values

Right distortion values								
-1.8	-3.0	-4.1	-3.9	- 3.7	-3.0	-2.0	-0.3	1.5
3.2	3.8	3.2	2.5	1.3	0.9	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

End of file

Mullti station photogrammetry:-

The main difference between this method and the first method is that all photogrammetric observations are used in the estimation of exterior orientation elements (and inner orientations if they are sought as part of the photogrammetry) and not just the observations of control point images. the number of parameters which are estimated is usually a few hundred and is made up of control coordinates (three per point), exterior orientation elements (six per camera station), coordinates of all other object points (three per point) and inner orientation parameters (three plus up to about 25 additional parameters, often assumed to be constants for all photographs(block- invariant). Measurements consist of comparator coordinates of image points (two per point) and any survey measurements between object points that may be necessary or desirable, such as horizontal and vertical angles. slope distances and height differences .when the object is difficult or dangerous to survey, bundle adjustments can be carried out with minimum control (perhaps only one distance) or with no measured control at all and can yield very high and uniform internal precision and correspondingly precise deformation data [1]

The observation equations

Now become

$$\begin{vmatrix} A & 0 & 0 \\ B1 & B2 & B3 \end{vmatrix} \begin{vmatrix} x \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} b \\ c \end{vmatrix} \text{------------- (2)}$$

$$\begin{vmatrix} A & 0 \\ B1 & B2 \end{vmatrix} \begin{vmatrix} X \\ Y \end{vmatrix} = \begin{vmatrix} b \\ C \end{vmatrix} \text{............ (1)}$$

With weight matrix

$$\begin{vmatrix} Wb & 0 \\ 0 & WC \end{vmatrix} \text{------------ (3)}$$

Here, the notation follows that X now represents all object point coordinates and Z represents inner orientation and additional parameter. The normal equations are:-

$$\begin{vmatrix} B1^T\, Wc\, B2 + A1^T Wb A & B1^T\, Wc\, B2 & B1^T\, Wc\, B3 \\ B2^T\, Wc\, B2 & B2^T\, Wc\, B2 & B2^T\, Wc\, B3 \\ B3^T\, Wc\, B2 & B3^T\, Wc\, B2 & B3^T\, Wc\, B3 \end{vmatrix} \begin{vmatrix} \hat{X} \\ \hat{Y} \\ \hat{Z} \end{vmatrix} = \begin{vmatrix} B1^T\, Wc\, C + A^T\, Wcb \\ B2^T\, Wc\, C \\ B3^T Wc\, C \end{vmatrix} \text{........(4)}$$

Or

$$\begin{vmatrix} N11+P & N12 & N13 \\ N12 & N22 & N23 \\ N13 & N32 & N33 \end{vmatrix} \begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} l1 \\ l2 \\ l3 \end{vmatrix} \text{.......................(5)}$$

The structure of the normal equations (assuming 20)object points , the first five of which were the subject of independent survey measurements , three camera stations and five additional parameters) is as shown in figure 9b. if all points are imaged on all photographs the shaded matrices will be full, but even when this is the case and when far more points are included than in this small example, data storage may be significantly reduced by suppressing zeros in the sub matrices (N_{11}+P), and N_{22} . Computation using algorithms for sparse and m, particularly, and matrices in the adjustment of large blocks of aerial triangulation, can be implemented to obtain the least squares solution for(X, Y and Z) if computer storage problems make conventional algorithms difficult to use.

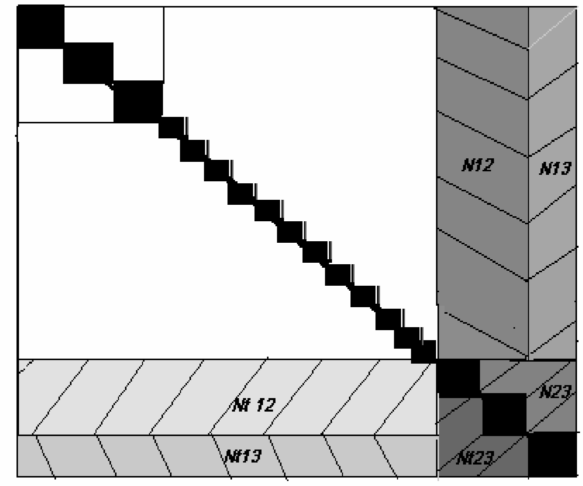

Figure -9b- the structure of the coefficient matrix of the normal equation for 22 object and three camera station

The solution for all unknowns should be accompanied by the covariance matrix of y least the object point coordinates and the variance factor at each stage (in other words before and after deformation). These data are the basis of statistical inference about deformation. Should be exercised in the selection of additional parameters. Any which are highly correlated with elements of exterior orientation or are insignificantly small should be dropped from the solution which might otherwise become unstable, so far it has been assumed that any matrix of coefficients of normal equation (N) is non singular and that a least squares solution can be found from matrix inverse of N. generally, however, N will be singular with a rank deficiency of between (1 and 7). Conventionally, this problem is overcome by arbitrarily assigning fixed values to coordinates of object points and by deleting from N those rows and columns which correspond to the fixed coordinates (and of course also deleting those fixed coordinates form (X). This defines a datum for the adjustment, which may not be a suitable datum for deformation. If no coordinates are held fixed the rank deficiency of N will be. fixing the easting, northing and height of point removes the translational difference of three; fixing the three coordinates of another point removes the scale deficiency of one and two rotational deficiencies, fixing the height of a third (non -collinear) point removes is not altogether suitable in deformation monitoring when two independent surveys are made at different times, or epochs. The covariance matrix of the coordinates depends upon the datum selected for computation, so this should be the same for each epoch. Also, some functions of the coordinates from two epochs depend upon the datum chosen. If the points chosen for the computational datum are not suitable as a datum for studying and analyzing deformation, difficulties will a rise network adjustment. One way of doing this is to solve the rank deficient set of normal equations[8].

By computing $N X = I$ ……….. (6)

$X = N + I$ …….. (7)

Where N_t is the pseudo-inverse (or more pseudo-inverse) of N ..This gives a least squares solution for X for which the covariance matrix N_t has a minimum trace. Computation of Nt is often difficult in practice unless the measurements are all of the same kind (for example all comparator readings and no survey measurements) and another method for arriving at the minimum trace, least squares solution is generally used. This method is

known as the method of "inner constraints" and was first developed in a survey context by [9];
 the singular normal the augmented normal equations.
Which have the solution

$$\begin{vmatrix} N & G \\ G_t & 0 \end{vmatrix} \begin{vmatrix} X \\ K \end{vmatrix} = \begin{vmatrix} I \\ 0 \end{vmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\begin{vmatrix} X \\ K \end{vmatrix} = \begin{vmatrix} N & G \\ G_t & 0 \end{vmatrix}^{-1} \begin{vmatrix} I \\ 0 \end{vmatrix} = \begin{vmatrix} N_t & G(G_t\ G)^{-1} \\ (G_t\ G)-1\ G_{t1} & 0 \end{vmatrix} \begin{vmatrix} I \\ 0 \end{vmatrix} \quad \ldots\ldots\ldots\ldots(9)$$

Here G is a matrix satisfying the condition

$AG = 0$ ……… (12)

And K is a vector of lag ranging multipliers. Forms of G suitable for a particular problem depend upon the datum deficiencies in N arising from the column rank deficiencies in A. the matrix of coefficients of the observation equations and gives suitable form for G when defects of scale. Translation and rotation are all present, gives extensive theoretical consideration of free networks in a geodetic context, but it is equally applicable to photogrammetry .if the normal equation (7) has a rank deficiency, then augmentation by a suitable form of G gives the minimum form. Least squares solution:

$$\begin{vmatrix} X \\ Y \\ Z \\ K \end{vmatrix} \begin{vmatrix} N_{11}+P & N_{12} & N_{13} & 6 \\ N_{t12} & N_{22} & N_{23} & 0 \\ N_{t13} & N_{t23} & N_{33} & 0 \\ G_t & 0 & 0 & 0 \end{vmatrix}^{-1} = \begin{vmatrix} I_1 \\ I_2 \\ I_3 \\ 0 \end{vmatrix} \quad \ldots\ldots\ldots\ldots\ldots(10)$$

Here the inner constraints have been applied over all the object points with coordinates X ,when this is done in an iterative least squares solution ,it is important to realize that the starting values for the coordinates of all points which have the inner constraint condition imposed on them in the first pre-deformation survey. The implied positional datum is the controlled of these starting values and the average distance between all points defines scale in the a absence of any measured distances thus, no control and no measurements in the object space are necessary and for some studies of deformation, their absence is an advantage for example, if the stability of no point can be guaranteed before deformation begins, the starting values of objects point coordinates can be taken as the datum, if the object cannot be measured directly because such measurement would itself cause deformation ,or would be dangerous, then again the method of inner constraints offers a solution. In practice, distances are sometimes measured and height differences defining the vertical direction are measured reducing the deficiency by a further two. In these cases appropriate forms of the bordering matrix G must be used [10].

Design and statistical testing:-

The design of networks and the incorporation of statistical tests on the results have recently received much attention from geodesists and potogrammetrists .most of the theory is directly applicable to deformation measurement in general and not to photogrammetric method a lone.

Design is mentioned here only because it is necessary to stress that proper design is an essential part of protestation practice. The zero, first and second order design problems of geodesy in general must be considered in deformation measurement. In addition, the sensitivity and reliability of the design must be considered. Very briefly, the survey should be designed so that a given deformation can be detected at a high confidence level (about 95%) with an adequate safeguard by; against undetected systematic and gross errors [1]. Useful references for these matters are given an extremely useful introduction with many references. General design considerations for deformation monitoring and; statistical test on repeatedly measured networks [11].

Comparison: and Suggestion:-

The procedure of regarding the control coordinates as not free from error led to improved overall accuracy particularly at close range when spatial residuals at the control were reduced from about 1mm to 0.3mm and the variance factor from about 11 to 1.8. The mean object distance was about 1.5m. Significantly higher precision could have been obtained from the same photogrammetric observations if more precise control had been used. Accuracies obtained vary considerably
but the method is most accurate when the object has little depth and fully calibrated cameras are used (the conventional air survey case) and the base distance ratio is not smaller than about 1:5. Accuracies of the order of 1mm to 2mm at 10m can be achieved.

Result :-

Analytical Relative Orientation results
This file is called: Relative orientations

Project name abdull-kadir
Model Identification = by the number of photographs (2650 - 2651) -- (2651 - 2652)
left photograph number = 2650
Right photograph number =2651
Camera Information = Camera Name Wild RC10 universal
Relative Orientation Measurements
Number of parallax points = 10

Table-7 - Relative Orientation Measurements

Point	Name	Photo Coordinates			
			XL	YL	XR YR
1	1226	23.079	-59.870	-69.767	-57.300
2	1228	-2.010	2.497	-92.305	6.730
3	1314	11.080	107.182	-78.151	110.998
4	1315	9.891	101.334	-79.220	105.181
5	1316	92.522	0.092	2.331	-2.175
6	1418	94.521	-0.477	4.155	-2.854
7	3312	96.641	105.662	8.985	103.641
8	3414	107.693	-71.946	13.077	-75.127
9		11.457	-98.986	-83.588	-95.456
10		-0.672	-1.396	-91.014	2.723

Table-8- Relative Orientation Measurements

Point	Name	Model coordinates XM	parallax YM	ZM	YP
1	1226	-22.057	-63.046	-156.466	-0.004
2	1228	-47.869	1.167	-153.663	-0.013
3	1314	-35.302	100.522	-144.353	0.003
4	1315	-36.383	95.474	-145.118	0.002
5	1316	48.121	-1.281	-154.219	0.018
6	1418	50.005	-1.847	-153.985	-0.004
7	3312	47.448	100.627	-146.577	-0.005
8	3414	64.157	-74.845	-155.109	-0.007
9		-33.985	-103.756	-157.087	0.006
10		-46.517	-2.784	-154.023	0.005
				Average Parallax	0.008

Table-9a - Relative Orientation Values

Rotations (degrees)		
Kappa (γ)	Phi(φ)	Omega(ω)
Left 0.000	0.0000	0.0000
Right 3.910	0.0818	-0.2301
Projection Center Coordinates		
X	Y	Z
Left -45.835	-1.366	0.198
Right 45.835	1.366	-0.198

Table- 9b- projection center coordinates

Projection Center Coordinates		
Rotation Matrix	Left Fiducial	System to Model System
1.0000000	0.0000000	0.0000000
0.0000000	1.0000000	0.0000000
0.0000000	0.0000000	1.0000000

Table- 9c- projection center coordinates

Projection Center Coordinates		
Rotation Matrix	Right Fiducial	System to Model System
0.9976710	-0.0681942	0.0014282
0.0681880	.9976644	0.0000000
-0.0016986	-0.0039085	0.9999909

END OF FILE

Analytical orientation results

CAMERA data

Calibrated focal length 153.03 mm

Left photo number 2651

Right photo number 2652

Table-10 - INCLINATIONS

INCLINATIONS	LEFT PHOTO	RIGHT PHOTO
OMEGA [deg]	-0.30815	-0.85802
PHI [deg]	-0.04716	0.06782
KAPPA [deg]	5.24203	5.92211
		ROTATION SEQUENCE OME, PHI, KAP (Rotated Axes)

Table 11- PROJECTION

PROJECTION CENTERS	LEFT PHOTO	RIGHT PHOTO	BASE
XGO,BX [m]	828397.444	831140.715	2743.271
YGO,BY [m]	181319.337	181576.246	256.908
ZGO,BZ [m]	4706.243	4715.516	9.273

Table -12 - INTERIOR ORIENTATION.

INTERIOR ORIENTATION	LEFT PHOTO	RIGHT PHOTO
USED FIDUCIALS	8	8
X - SHRINKAGE	1.0000405	0.9999816
Y - SHRINKAGE	0.9998676	0.9999504

Table -13 - RELATIVE ORIENTATION.

PARALLAX POINTS	9
MEAN PARALLAX [mm]	0.0033
MAX PARALLAX [mm]	0.0055

Table -ABSOLUTE ORIENTATION

ABSOLUTE ORIENTATION	PLANIMETRY	ELEVATION
USED CONTROL POINT	9	9
MEAN RESIDUAL [m]	0.5362	0.6841
MAX RESIDUAL [m]	0.8077	1.1320

Table -14 - General data used in this research.

FLIGHT HEIGHT	2690 m/GND
PHOTO SCALE	1: 17,500
LEVELING	ON
EARTH Curvature. correction	ON
EARTH RADIUS [m]	6371300

End of file.

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Conclusions and Recommendation :-

It is important that a method of applying photogrammetry to the measurement of deformation is selected that will give an adequate result in the quickest and cheapest way. The remarks made in this paper are intended to indicate to the reader some of the possibilities offered by photogrammetry in the Measurements of deformation. It should be clear that in exceptional circumstances photogrammetry can be used without any survey measurements.
it will be strongly recommended that to use the first method because it is easy, quick and cost lower money than the second one by practical, but still the second one more accurate in the result

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