National Association Of Surveying And Geoinformatics Lecturers First Annual General Meeting/Conference

MINNA 2019

EXPLORING THE FRONTIERS OF SURVEYING AND GEOINFORMATICS FOR NATIONAL DEVELOPMENT

4TH -7TH FEBRUARY, 2019

School of Environmental Technology, Federal University of Technology, Minna, Niger State

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Book *of* Proceedings

BOOK OF PROCEEDINGS

VOLUME 1 No. 1 2019 ISBN: 978- 978 – 55067 – 3 – 0

A PUBLICATION OF

Printed and bound in Nigeria by:
The Rock Press Venture
08039717276

BOOK OF PROCEEDING

for

National Association of Surveying and Geoinformatics Lecturers
1^{ST} AGM/Conference Maiden Edition
Minna 2019

Federal UNIVERSITY OF TECHNOLOGY MINNA,
NIGER STATE, NIGERIA

Theme:

"Exploring the Frontiers of Surveying and Geoinformatics for National Development"

Date: 4 – 7 February, 2019

Venue: School of Environmental Technology Complex
Time: 9am – 6pm

Book of Proceeding

for

National Association of Surveying and Geoinformatics Lecturers 1st Annual General Meeting/Conference Minna 2019

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Published by:

National Association of Surveying and Geoinformatics Lecturers (NASGL)

C/O 30 S.O Williams Crescent, Off Anthony Enahoro Street, Off Okonjo Iweala Way, Utako Berger, P.M.B 763, Garki, Abuja.

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4th – 7th FEBRUARY, 2019

School of Environmental Technology

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FOREWORD

The organizing committee of the 1st National Association of Surveying and Geoinformatics Lecturers (NASGL) 1st AGM/Conference Minna 2019 is pleased to welcome you to Federal University of Technology Minna, Niger State, Nigeria.

The conference provides forum for researchers and professionals in the geospatial industry and allied professions to address fundamental problems and challenges of National Development-Exploring the Frontiers of Surveying and Geoinformatics. The conference is a platform where recognized best practices, theories and concepts are shared and discussed amongst academics, practitioners and researchers. The scope and papers are quite broad but have been organised around the sub-themes listed below:

- Education, Training and capacity Building in Surveying and Geoinformatics
- Advancement in Earth Observation and Geospatial Technologies
- Best Practice Models in Land Administration
- Spatial Data Infrastructure for National Security
- Surveillance and Security Monitoring
- Geo-Hazards Prediction and Mitigation
- Energy and Water Resources Inventory and Governance
- Food security and National Development

We hope you enjoy your time at our conference, and that you have the opportunities to exchange ideas and share knowledge, as well as participate in productive discussions with the like-minded researchers and practitioners in the geospatial environment and academia**.**

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It is the policy of the National Association of Surveying and Geoinformatics Lecturers (NASGL) AGM/Conference that for papers to be accepted for inclusion in the conference proceedings it must have undergone the blind review process and passed the academic integrity test. All papers are only published based on the recommendation of the reviewers and the scientific Committee of NASGL Conference.

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Dr. (Surv.) Y.D. Opaluwa
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TABLE OF CONTENTS

3-D Position Determination Using Close Range Photogrammetry for 3rd Order Accuracy Positioning

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Abstract

In close range photogrammetry, the 3D object space coordinates of points can be obtained from its 2D pixel coordinates using any of the available transformation condition equations. This paper presents the use of collinearity condition equation to obtain both the space resection (Exterior Orientation parameters) and the space intersection (determination of points coordinates from a known point), for a vertical plane close range photogrammetry operation. This was carried out by using a total station instrument to coordinate five structural control points (P1 to P5) and nine other check/analysis points (SA1-SA9), marked on one side of a building. Thereafter, two different calibrated android phones camera (Tecno W3 and Infinix X509) where used for the photogrammetry data capture to the same building side at different positions (right and left).The data obtained were processed in a multi stage process, which includes: the pixel extraction using Matlab application, pixel coordinate to camera coordinate in millimeter conversion, Space resection and intersection using collinearity condition equation with least square adjustment iterative method at 0.001 convergence condition. The 3D object space coordinate output statistically reveals that there is no significant difference between the mean and variance of the transformation coordinates output and that of the total station coordinate output, for a third order job at 99% confidence level of accuracy. And also, that there is no statistical difference between the coordinate outputs of two different phones camera (Tecno W3 and Infinix X509 with focal lengths of 543.342mm and 839.092mm respectively) output obtained, also at 99% confidence level.

Keywords: *Collinearity Equation, Space resection, Space intersection, 3D object space coordinate, 2D Pixel coordinate*.

1.0 Introduction

To rigorously determine the geometric relationship that exist between image and object as at the time of image capture is the major task of photogrammetry [2]. This is so because of the transformation process from one coordinate system to the other (Image coordinates system, to Comparator coordinates system, to Camera coordinate system, then finally to object coordinate system) that photogrammetry operation is involved with. Exterior orientation thus involves the process of determination of the 3D spatial position and the three orientation parameters of the camera, as at the time of exposure [6]. There are three major fundamental condition equations used in photogrammetry to obtain these (Exterior orientation parameters), which includes: the collinearity, co-planarity, and co-angularity condition equations, which all uses point coordinate as their input data [3].

Several approaches have been developed over years in the field of photogrammetry for solving the problem of exterior orientation as discussed in previous researches, these includes: the Direct Linear Transformation (DLT) which is often used in photogrammetry [3]. This method gives the exterior orientation parameters without initial approximation been supplied [3]. Also [4], used matrix factorization and homogenous coordinate representation which is a cooperative strategy between the 2-D projective transformation and collinearity model linear version for linearly recovering of the exterior orientation parameters in a planar object space. In a study on the comparison of Close-Range Photogrammetry to terrestrial laser scanning for heritage documentation, [5] noted that there is no significant difference between the result outputs from two entirely independent survey processes of the photogrammetric data captured, and the laser scanner output.

The comparison between Close range Photogrammetry (CPR) using Non- Professional cameras with traditional field survey technique for volume estimation was also carried out at using the Deralok Hydropower plant site, comparing the Digital Elevation Model (DEM) for both methods [1]. The result obtained showed that the CRP method was less time consuming and more accurate for volume calculation. Mokros et al, [7] used close-range photogrammetry for estimating tree diameters, a method which was said to give as accurate result as the terrestrial laser scanning (TLS) and more hardware cost effective for forest stand survey.

This paper thus presents the use of collinearity condition equation for close range photogrammetry in vertical plane to determine both the Exterior orientation (space resection), and Pixel to Object Space Coordinates transformation (Space intersection), and the comparing of the obtained result with the total station coordinates output.

2.0 Methodology

Camera Calibration

Camera Calibration is the process of acquiring the intrinsic parameters of the camera so as to use it as a measuring device [8]. Camera calibration for the two non-metric camera used for the image acquisition was thus carried out by taking ten(10) captures to a mounted checker board which has five rows and seven columns with 11.3cm dimension of each squares, as displayed in Plate 1.

Plate 1: Checker Board on a plane surface

The acquired images were then processed using Matlab 2014a programme with a camera calibration Add-In tool programme. Information from this process are displayed in Tables 1 and 2.

Table 1: Results obtained from the camera calibration process using Tecno W3 phone

Parameter	Values in pixel
Focal Length	2053.66252
Perspective point	1334.81371, 1002.13721

Table 2: Result obtained from the camera calibration process using Infinix X509 phone

Parameter	Values in pixel
Focal Length	3171.38219
Perspective point	2111.01873, 1654.50768

A Ground control point (AST 002) was established some few meters away from the structure and coordinated using Deferential Global Positioning System (DGPS). The coordinate output is displayed in Table 3.

Table 3: AST 002 Control point Coordinate

Station point	Easting(m)	Nothings(m)	Height(m)
AS 002	220145.632	1054958.580	235.067

After a proper test of instrument has been carried out on ZTR 320 Hi-Target Total Station instrument and found reliable for use, it was then set up on control point “AST 002” in a reflectorless mode, to coordinate the marked points on the building, i.e. five structural control points (P1-P 5) used in obtaining the exterior orientation parameters, and nine other points (SA1-SA9) used for the analysis. The obtained 3D coordinate are contained in Table 4

Table 4: Structural control points and Analysis points, coordinated using Total Station

POINT ID	EASTINGS (m)	NORTHINGS (m)	HEIGHT(m)
P1	220180.890	1054935.374	234.042
P2	220180.766	1054935.267	242.362
P3	220163..662	1054929.622	238.111
P4	220148.927	1054918.689	242.317
P5	220149.043	1054918.689	233.924
SA1	220177.970	1054934.366	240.216
SA2	220170.271	1054930.274	240.255

SA3	220168.665	1054928.825	235.495
SA4	220166.562	1054927.807	236.306
SA5	220163.087	1054925.937	234.236
SA6	220152.406	1054920.313	234.9
SA7	220151.289	1054920.381	240.25
SA8	220175.894	1054932.695	237.86
SA9	220169.454	1054929.400	237.865

Plate 2 describes the structural control points (P1 toP5) and the analysis marked points (SA1 to SA 9) on the building.

Plate 2: Structural control points (P1 to P5) and analysis control points (SA1 to SA9) on the building

The two calibrated non-metric android phones camera (Tecno W3 and Infinix X509) were used to capture the building part under survey from two different positions each (Left and right sides) at 100% overlap, as displayed in Plate 3. The small white stars inscribed in the black stars identifies the exact point coordinated using the total station instrument.

Plate 3: Images from Tecno W3 camera Left and right position capture, with structural control points identified

3.0 Data Processing

Extraction of image pixel coordinates.

MatLab application was used as the comparator, for the extraction of the pixel coordinates of the points of interest (P1-P5 and SA1-SA9) from the acquired images. Plate 4 shows the picture of the MatLab environment during the pixel point extraction.

Plate 4: Matlab pixel extraction window

The pixel coordinate (x,y) of the left and right images of each of the cameras is displayed in the Tables 5 and 6

Table 5: Pixel coordinate (x,y) of points from Tecno W3 capture for both stations

Side	Left		Right	
Point ID	x pixel coordinate	y pixel coordinate	x pixel coordinate	y pixel coordinate
P1	175	984	159	967
P2	170	518	176	551
P3	1149	740	919	736
P4	2159	515	2064	455
P5	2154	983	2054	998
SA1	322	633	263	652
SA2	813	630	665	635
SA3	969	896	812	893
SA4	1067	853	901	849
SA5	1282	965	1105	964
SA6	1944	924	1805	928
SA7	2010	626	1873	592
SA8	482	767	397	773
SA9	883	767	733	767

Table 6: Pixel coordinate(x,y) of points captured from Infinix X509 at both stations.

Side	Left		Right	
Point ID	x pixel coordinate	y pixel coordinate	x pixel coordinate	y pixel coordinate
P1	365	1499	496	1581
P2	342	751	493	896
P3	1910	1094	1842	1191
P4	3566	1469	3663	1583
P5	3580	689	3670	729
SA1	581	934	678	1056
SA2	1368	923	1374	1031
SA3	1626	1350	1618	1445
SA4	1780	1276	1766	1371
SA5	2128	1453	2094	1550
SA6	3211	1376	3250	1474
SA7	3326	882	3372	946
SA8	841	1149	908	1254
SA9	1483	1140	1485	1241

Pixel coordinates to image coordinate in millimeter conversion

Since the Matlab environment has its origin at the top right corner, transformation to the camera coordinate which has his origin at the perspective point was carried out by subtracting the x pixel coordinate from the x principal point coordinate (obtained from camera calibration) and subtracting the y principal point coordinate (obtained also from camera calibration process) from y pixel coordinate. The result of each camera coordinates were then multiplied by the pixel to millimetre conversion constant “0.2645833333”

Tables 7 and 8 displays the camera coordinates in millimetres for Tecno W3 and infinix X509 cameras.

Table 7: Tecno W3 camera coordinates

Side	Left		Right	
Point ID	x pixel coordinate	y pixel coordinate	x pixel coordinate	y pixel coordinate
P1	-306.867	4.799	-311.101	9.297
P2	-308.190	128.090	-306.603	119.360
P3	-49.163	69.357	-110.017	70.415
P4	218.066	128.890	192.931	144.760
P5	216.743	5.063	190.285	1.0946
SA1	-267.974	97.668	-283.584	92.640
SA2	-138.063	98.461	-177.222	97.138
SA3	-96.788	28.082	-138.328	28.876
SA4	-70.859	39.459	-114.78	40.518
SA5	-13.974	9.826	-60.805	10.090
SA6	161.181	20.674	124.404	19.615
SA7	178.643	99.520	142.395	108.520
SA8	-225.640	62.213	-248.130	60.626
SA9	-119.542	62.213	-159.230	62.213

Focal length =543.341905mm

Table 8: Infinix X509 camera coordinates

Side	Left		Right	
Point ID	x pixel coordinate	y pixel coordinate	x pixel coordinate	y pixel coordinate
P1	-461.967	41.145	-427.307	19.449
P2	-468.053	239.053	-428.101	200.689
P3	-53.1862	148.301	-71.178	122.636
P4	384.964	49.082	410.628	18.920
P5	388.668	255.457	412.481	244.874
SA1	-404.817	190.630	-379.153	158.355
SA2	-196.590	193.540	-195.003	164.970
SA3	-128.328	80.568	-130.445	55.432
SA4	-87.582	100.150	-91.286	75.011
SA5	4.4930	53.316	-4.503	27.651
SA6	291.037	73.688	301.356	47.759
SA7	321.464	204.390	333.635	187.459
SA8	-336.026	133.750	-318.299	105.968
SA9	-166.163	136.130	-165.634	109.407

Focal length =839.093814mm

Transformation from camera coordinates to object space coordinate system

The collinearity condition equation was being used for the transformation from camera coordinate system to object space coordinate system for this work

For this transformation, the two stages undergone are:

a. Space resection stage (Determination of the Exterior Orientation Parameters)
b. Space intersection stage (Determination of the 3D object space coordinate from the camera coordinate).

Space Resection

The exterior orientation parameters of the camera positions were determined by writing a Matlab code for the collinearity condition equation for space resection, with least square adjustment equation iteration convergence at 0.001. Equations 3.1 and 3.2 below are the close range photogrammetry collinearity condition equations for space resection.

$$x_a = b_{11}d\omega + b_{12}d\phi + b_{13}d\kappa - b_{14}X_L - b_{15}Z_L - b_{16}Y_L + J \qquad (1)$$
$$y_a = b_{21}d\omega + b_{22}d\phi + b_{23}d\kappa - b_{24}X_L - b_{25}Z_L - b_{26}Y_L + K \qquad (2)$$

Were:

$d\omega$, $d\phi$ and $d\kappa$ are the corrections to be applied to omega, Phi and Kappa respectively

X_L, Y_L and Z_L are the 3D exposure station coordinates

x_a and y_a are the camera coordinate of the control points

$$b_{11} = \frac{x}{q}(-m_{33}\Delta Y + m_{32}\Delta Z) + \frac{f}{q}(-m_{13}\Delta Y + m_{32}\Delta Z)$$
$$b_{12} = \frac{x}{q}\left[\Delta X \cos\phi + \Delta Y(\sin\omega \sin\phi) + \Delta Z(-\sin\phi\cos\omega)\right]$$
$$+\frac{f}{q}\left[\Delta X\left(-\sin\phi\cos k\right) + \Delta Y\left(\sin\omega\cos\phi\cos k\right) + \Delta Z\left(-\cos\omega\cos\phi\cos k\right)\right]$$
$$b_{13} = \frac{f}{q}\left(m_{21}\Delta X + m_{22}\Delta Y + m_{23}\Delta Z\right)$$
$$b_{14} = \frac{x}{q}\left(m_{31}\right) + \frac{f}{q}\left(m_{11}\right)$$
$$b_{15} = \frac{x}{q}\left(m_{32}\right) + \frac{f}{q}\left(m_{12}\right)$$
$$b_{16} = \frac{x}{q}\left(m_{33}\right) + \frac{f}{q}\left(m_{13}\right)$$
$$J = \frac{\left(qx + rf\right)}{q}$$

$$b_{21} = \frac{y}{q}(-m_{33}\Delta Y + m_{32}\Delta Z) + \frac{f}{q}(-m_{23}\Delta Y + m_{22}\Delta Z)$$
$$b_{22} = \frac{y}{q}\left[\Delta X \cos\phi + \Delta Y(\sin\omega \sin\phi) + \Delta Z(-\cos\phi\sin\omega)\right]$$
$$+\frac{f}{q}\left[\Delta X\left(\sin\phi\sin k\right) + \Delta Y\left(-\sin\omega\cos\phi\cos k\right) + \Delta Z\left(\cos\omega\cos\phi\sin k\right)\right]$$
$$b_{23} = \frac{f}{q}\left(-m_{11}\Delta X - m_{12}\Delta Y - m_{13}\Delta Z\right)$$
$$b_{24} = \frac{y}{q}\left(m_{31}\right) + \frac{f}{q}\left(m_{21}\right)$$
$$b_{25} = \frac{y}{q}\left(m_{32}\right) + \frac{f}{q}\left(m_{22}\right)$$
$$b_{26} = \frac{y}{q}\left(m_{33}\right) + \frac{f}{q}\left(m_{23}\right)$$
$$K = \frac{\left(qy + sf\right)}{q}$$

Graph of the iterative convergence (0.001) for both orientation and camera position, for Infinix X509 left camera position is shown in Figure 1.

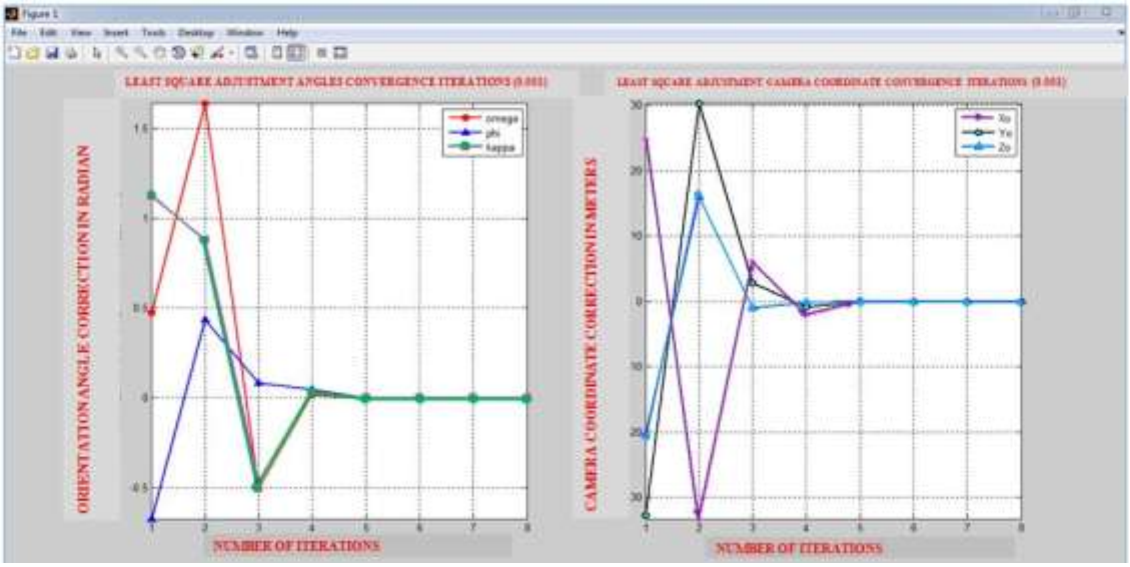

Figure 1: Iteration graphs of Infinix X509 right image

Adjusted exterior orientation parameters for each camera position acquired using a developed MatLab Program codes are displayed in Table 9.

Table 9: Adjusted Exterior Orientation Parameters

Phone Type	Tecno W3		Infinix X509	
Capture Position	Left Images	Right images	Left Images	Right images
Adjusted Omega(degrees)	182.9322	183.4229	183.0718	185.2538
Adjusted phi (degrees)	-26.7967	-41.2212	-38.8186	-28.4174
Adjusted kappa (degrees)	181.1068	182.3364	181.4428	181.6795
adjusted xo(m)	220145.4223	220136.0937	220141.1457	220146.3859
Adjusted yo(m)	1054958.9838	1054950.7310	1054953.2322	1054957.4581
Adjusted zo(m)	235.3817	235.3238	234.6407	234.9954

Space Intersection

Transformation from the 3D camera coordinate to 3D object coordinate system was carried out by writing a MatLab code using the space intersection collinearity condition equation given in equation 3.3 and 3.4.The formula requires the exterior orientation parameters of the left and right camera stations, and the homogenous points camera coordinates (in millimetres) from two images of the same camera at different positions (left and right), in other to give the 3D object space coordinate of those points.

$$vx_a = b_{14}X_a + b_{15}Z_a - b_{16}Y_a + J \quad (3)$$
$$vy_a = b_{24}X_a + b_{25}Z_a - b_{26}Y_a + K \quad (4)$$

The coordinate output from the space intersection process for both Tecno W3 and Infinix X509 data capture are presented in Table 11

4.0 Result and Discussion

This involves the presentation of results from the processed data, analysis, and discussion of results.

3D Object Space Coordinates

The 3D object coordinates obtained from the analysis points (SA1 to SA9) by total station instrument and the two cameras (Tecno W3 and Infinix X509) transformation are presented in Tables 10 and 11 respectively.

Table 10: Coordinates of points obtained using Total station.

POINT ID	EASTINGS (m)	NORTHINGS (m)	HEIGHT(m)
P1	220180.890	1054935.374	234.042
P2	220180.766	1054935.267	242.362
P3	220163.662	1054929.622	238.111
P4	220148.927	1054918.689	242.317
P5	220149.043	1054918.689	233.924
SA1	220177.570	1054934.667	240.216
SA2	220170.271	1054930.394	240.255
SA3	220168.165	1054928.665	235.550
SA4	220166.562	1054927.807	236.340
SA5	220163.087	1054925.937	234.236

SA6	220152.406	1054920.413	235.020
SA7	220151.289	1054920.381	240.330
SA8	220175.894	1054932.699	237.890
SA9	220169.424	1054929.490	237.865

Table 11: 3D Object space coordinates of points obtained from Tecno W3 and Infinix X509 capture.

POINT ID	EASTINGS (m)	NORTHINGS (m)	HEIGHT(m)	EASTINGS (m)	NORTHINGS (m)	HEIGHT(m)
		Tecno W3			Infinix X509	
SA1	220177.452	1054934.759	240.157	220177.716	1054934.506	240.288
SA2	220170.256	1054930.551	240.240	220170.249	1054930.323	240.302
SA3	220168.150	1054928.653	235.556	220168.137	1054928.693	235.619
SA4	220166.552	1054927.847	236.339	220166.630	1054927.827	236.424
SA5	220163.185	1054925.898	234.290	220163.140	1054926.061	234.416
SA6	220152.412	1054920.426	234.981	220152.488	1054920.554	235.091
SA7	220151.301	1054920.411	240.283	220151.398	1054920.317	240.402
SA8	220175.820	1054933.009	237.867	220175.816	1054932.790	237.974
SA9	220169.325	1054929.583	237.866	220169.468	1054929.439	237.96

Coordinates Residuals

The residual coordinates of total station with Tecno W3, Total Station with infinix X509, and Tecno W3 with Infinix X509 are given in Tables 12, 13 and 14 respectively.

Table 12: Total Station and Tecno W3 Coordinates with residuals

Total station				Infinix X509			Residuals		
Pt ID	**Eastings (m)**	**Northings (m)**	**Height (m)**	**Eastings (m)**	**Northings (m)**	**Height (m)**	**E (m)**	**N (m)**	**H (m)**
SD1	220177.570	1054934.667	240.216	220177.452	1054934.759	240.157	0.118	-0.092	0.059
SD2	220170.271	1054930.394	240.255	220170.256	1054930.551	240.240	0.015	-0.157	0.015
SD3	220168.165	1054928.665	235.550	220168.150	1054928.653	235.556	0.015	0.012	-0.006
SD4	220166.562	1054927.807	236.34	220166.552	1054927.847	236.339	0.010	-0.040	0.001
SD5	220163.087	1054925.937	234.236	220163.185	1054925.898	234.290	-0.098	0.039	-0.054
SD6	220152.406	1054920.413	235.020	220152.412	1054920.426	234.981	-0.006	-0.013	0.039
SD7	220151.289	1054920.381	240.330	220151.301	1054920.411	240.283	-0.012	-0.030	0.047
SD8	220175.894	1054932.699	237.890	220175.820	1054933.009	237.867	0.074	-0.310	0.023
SD9	220169.424	1054929.490	237.865	220169.325	1054929.583	237.866	0.099	-0.093	-0.001

Table 13: Total Station and Infinix X509 Coordinates With Residuals

Total station				Infinix X509			Residuals		
Pt ID	**Eastings (m)**	**Northings (m)**	**Height (m)**	**Eastings (m)**	**Northings (m)**	**Height (m)**	**E (m)**	**N (m)**	**H (m)**
SA1	220177.570	1054934.667	240.216	220177.716	1054934.506	240.288	-0.146	0.161	-0.072
SA2	220170.271	1054930.394	240.255	220170.249	1054930.323	240.302	0.022	0.071	-0.047
SA3	220168.165	1054928.665	235.550	220168.137	1054928.693	235.619	0.028	-0.028	-0.069
SA4	220166.562	1054927.807	236.340	220166.630	1054927.827	236.424	-0.068	-0.020	-0.084
SA5	220163.087	1054925.937	234.236	220163.140	1054926.061	234.416	-0.053	-0.124	-0.180
SA6	220152.406	1054920.413	235.020	220152.488	1054920.554	235.091	-0.082	-0.141	-0.071
SA7	220151.289	1054920.381	240.330	220151.398	1054920.317	240.402	-0.109	0.064	-0.072
SA8	220175.894	1054932.699	237.890	220175.816	1054932.790	237.974	0.078	-0.091	-0.084
SA9	220169.424	1054929.490	237.865	220169.468	1054929.439	237.96	-0.044	0.051	-0.095

From the Table 13, it can be observed that the highest residuals are 0.118m (northings), -0.310m, (eastings), and 0.059m (height). With point SA1 having two of its dimensions falling in.

It can also be observed here that SA1 has two of it coordinates dimensions falling within the highest residuals. i.e. 0.146m for the Northings, and 0.161m for the Eastings. Point SA5 has the highest residuals for the height dimension.

Table 14: Tecno W3 and Infinix X509 3D Coordinates with Residuals

Total station				Infinix X509			Residuals		
Pt ID	Eastings (m)	Northings (m)	Height (m)	Eastings (m)	Northings (m)	Height (m)	E (m)	N (m)	H (m)
SA1	220177.452	1054934.759	240.157	220177.716	1054934.506	240.288	-0.264	0.253	-0.131
SA2	220170.256	1054930.551	240.240	220170.249	1054930.323	240.302	0.007	0.228	-0.062
SA3	220168.150	1054928.653	235.556	220168.137	1054928.693	235.619	0.013	-0.04	-0.063
SA4	220166.552	1054927.847	236.339	220166.630	1054927.827	236.424	-0.078	0.02	-0.085
SA5	220163.185	1054925.898	234.290	220163.140	1054926.061	234.416	0.045	-0.163	-0.126
SA6	220152.412	1054920.426	234.981	220152.488	1054920.554	235.091	-0.076	-0.128	-0.11
SA7	220151.301	1054920.411	240.283	220151.398	1054920.317	240.402	-0.097	0.094	-0.119
SA8	220175.82	1054933.009	237.867	220175.816	1054932.790	237.974	0.004	0.219	-0.107
SA9	220169.325	1054929.583	237.866	220169.468	1054929.439	237.96	-0.143	0.144	-0.094

From Table 14, it can be seen that the highest residuals are -0.264m, 0.253m, and -0.13m for Northing, Easting, and Height coordinate respectively, which are all from SA1 point. It can thus be said that probably, this point (SA1) was not well defined during it pixel coordinate extraction from MatLab environment.

Statistical Testing

Student t- Test

Student t-test statistical test, which checks the significant difference that may exist between the mean of any two independent variables was carried out for Total Station and Tecno W3 coordinates output, and also for Total Station with Infinix X509 coordinate output. These tests results are shown in Tables 15 and 16 respectively.

Table 15: t-test result of Total station and Tecno W3 Coordinates

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	sig.	t	df	Sig 2 tailed	99% Confidence Interval of the Difference	
						lower	upper
Northing Equal variances assumed	0.000	0.987	0.06	16	0.996	-12.61	12.65
Equal variances not assumed			0.06	16	0.996	-12.61	12.65
Easting Equal variances assumed	0.002	0.967	-0.032	16	0.974	-6.909	6.757
Equal variances not assumed			-0.032	15.99	0.974	-6.909	6.757
Height Equal variances assumed	0.001	0.975	0.012	16	0.990	-3.243	3.271
Equal variances not assumed			0.012	15.99	0.990	-3.244	3.271

From Table 15, the F and sig. columns are the Levene's test for equality of variance which tests the variance significant between the Tecno W3 and Total Station coordinate output. Since all the sig. Values are greater than the significant level chosen (0.01), it can then be said that there is no significant difference between the variance of the two approaches, which thus means that the null hypothesis (that there is no significance difference between the two methods) can be accepted.

Since the null hypothesis has been accepted, the upper values i.e. "equal variance assumed" will be read at the 'test for equality of means' part. t values and df (degree of freedom) was used to obtain the result of mean difference significance. The sig (2 tailed) column, with 0.996, 0.974

and 0.990 thus means that there is also no significant difference between the two means for each coordinate dimensions since the values are greater than the chosen significant level (0.01). Therefore, it can now be concluded that there is no significant difference between the variances and the means of the 3D coordinates of each methods i.e. the Tecno W3 output, and Total station transformation coordinate output.

Table 16: t-test result of Total station and Infinix X509 Coordinates

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	sig.	t	Df	Sig 2 tailed	99% Confidence Interval of the Difference	
						Lower	upper
Northing Equal variances assumed	0.000	0.992	-0.010	16	0.992	-12.68	12.60
Equal variances not assumed			-0.010	15.99	0.992	-12.68	12.60
Easting Equal variances assumed	0.001	0.975	-0.003	16	0.998	-6.767	6.755
Equal variances not assumed			-0.003	15.99	0.998	-6.767	6.755
Height Equal variances assumed	0.001	0.980	-0.077	16	0.940	-3.344	3.172
Equal variances not assumed			-0.077	15.99	0.940	-3.344	3.172

The determination of the variances differences between the Infinix X509 and total station coordinate outcome are shown in the F and sig. column, with sig. values of 0.992 (nothings), 0.975(eastings), and 0.980(height) coordinates. Since all these values are greater than 0.001which is the significant level, it can thus be concluded that there is no significant difference between the coordinates variance of these methods.

The t and df columns determines the 2 tail significant column which gives 0.992, 0.998 and 0.940 for northings, eastings, and height coordinate respectively. It can thus be said that there is no significant difference between the total station and infinix X509 coordinate results, since all the values are greater than the chosen significant level (0.01)

Therefore, it can be finally concluded that there is no significant difference between the mean and variances of the 3D coordinate of each of these methods at 99% confidence level.

5.0 Conclusions

This work which aims at ascertaining the statistical reliability of 3D space intersection for third order accuracy of position determination was achieved by using Collinearity condition equation using the least square adjustment for it iteration process. After all necessary survey measurement, data processing and result analysis has been properly done, it can thus be concluded that the transformation process using collinearity condition equation from 2D pixel coordinate to 3D object space coordinate for a close range Photogrammetry, obtained using android phone camera is as accurate as the use of Total station instrument for data acquisition, for any third order work accuracy, at 99% confidence level. Thus, survey works like: Volume Computation, Reconnaissance, less accurate demanding deformation studies and other survey work within third order job accuracy can be performed effectively using phone camera of at least 5 mega pixel.

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