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Research Article

Investigation and Comparison of Localization and Accurate Industrial Measurement through Classic and Modern Mapping Methods

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Abstract: The purpose of this study is investigation and comparison of localization and accurate industrial measurement through classic and modern mapping methods. in this research and it is proved that if the objective is to determine the coordinates of an event or the geometry of an object, there is no need to align and the coordinates of points on a target, which is generally an ultimate objective of a local mapping project, can be reached and can save the necessary time for aligning and deploying device only through measuring the lengths and angles in Theodolite orthogonal framework. Existence of error in measurement and the need for a unit and close-to-truth response for measured quantities are among the most important issues of measurement science, so that it is possible to determine the accuracy and reliability of mapping projects only through these issues and proper application of mathematical language. Observations of total station (Horizontal angle, vertical angle and oblique length) are performed in the Local Astronomy Coordinate System which can be time consuming and cause disruption in core activity of industrial sector according to the time required to locate and align device. Alignment in Goniometer and Distance Measurement or Total Station tools are investigated. Numerical results of this research indicate the complete success of presented method. Thus, this paves the ways for application of total station as a quick tool in open industrial environments and provided theory can create the industrial capabilities for classic mapping.

Keywords: Astronomy coordinate, geodetic coordinate, theodolite, total station

INTRODUCTION

Geodesy astronomy was previously considered as the necessities of localization due to the need for transferring the longitudinal and angular observations performed by Goniometers and Distance Measurement tools from Local Astronomy Coordinate System (LA) to Geodetic Coordinate System (G) {Geodetic Length, Geodetic Width and Elliptical Height}. When a Goniometer or Distance Measurement tool is aligned, the Local Astronomy Coordinate System is created through horizontal and vertical extension and this is due to the classic geodesy and observation in "Local Astronomy Coordinate" System and the need to transfer the observations from LA coordinate system to Geodesy by the help of astronomical observations. Figure 1 shows the Local Astronomy Coordinate System. A star as a point is shown in this Figure and this could be another point in the ground surface. Nowadays, total station equipment, which are in fact an integration of an Electronic Distance Measurement and Goniometer, are gradually replaced with observations of Theodolite and Electronic Distance Measurement; therefore, we refer to total station in this study instead of Theodolite and Distance Measurement tool.

Nowadays, the theory of localization has been changed and application of total stations has been primarily limited to industrial activities or local localization with spread of satellite methods especially GPS. This study aims to provide new mathematical models and equations by which the alignment and station-establishment stages can be eliminated from observation stages with total station. This change in the use of observations lead to a significant increase in the rate and ease of observation and can meet the maximum needs of industrial applications and determine the local localization needed for speed of above observation. Local Astronomy Coordinate System is shown in Fig. 1.

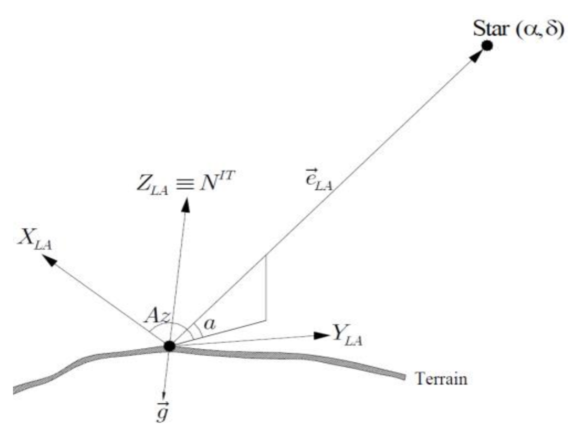

Fig. 1: Local Astronomy coordinate system (LA)

Observed point can be an earth point or in the shape of star as shown in this figure. In the case of observing as the star, the length is excluded from observations and unknowns are changed into the components of extension to the star instead of coordinates. Thus, distances and angles required to locate the points of an industrial object can be measured in a factory without alignment and station in a little time without any damages to production line due to the long stop. For instance, there is a new method, Plane Serve, in industry with a triaxial slider, interferometer laser and an engine which moves on an industrial broad and without-friction surface. The curvature, shape and position of surface are maintained while elevating this metal surface by elevator; this method also has a high resolution and accuracy. Through the geodetic techniques this study seeks to investigate various ways of location and finally measuring the components. The appropriate method can be applied among the methods according to parameters such as cost, accuracy, speed and time in different industrial applications. However, every selection should be the most possible economical way as well as providing the required accuracy and this can be achieved through a proper analysis (Kavanagh and Glenbird, 2000).

The purpose of this study is investigation and comparison of localization and accurate industrial measurement through classic and modern mapping methods.

MATERIALS AND METHODS

Literature: calculation of distance in an orthogonal framework of a total station: Suppose that you want to calculate the spatial distance between two points of B and C (Fig. 2), thus we put a Theodolite in a desired location such as A. According to the internal structure of theodolite, the orthogonal framework XYZ is formed in the point A. Measureable quantities in this orthogonal framework include:

- Spatial length AC
- Spatial length AB
- Extension of H_B (Angle read from plane XAY of orthogonal framework XYZ from horizontal circle equal to zero to extension of point B
- Extension of H_C (Angle read from plane XAY of orthogonal framework XYZ from zero circle to extension of point C)
- Angle V_C (Angle read from the axis Z of orthogonal framework XYZ in plane AZC)
- Angle V_B (Angle read from the axis Z of orthogonal framework XYZ in plane AZB)

Since the spatial distance can be calculated between every two points on the object, the geodetic adjustment and use of lengths more than the minimum requirement will be introduced to improve the accuracy (Vanícek and Krakiwsky, 1982). Condition or parametric equation methods can be applied for performing the adjustment. Since the parametric adjustment method is extremely easy in terms of creating the equations, we do the adjustment on this basis in this study. Orthogonal Framework XYZ of a total station and measurable lengths and angles is shown in Fig. 2.

Implementation and research procedures: In summary, the research area and implementation field include the following stages:

- Selecting a desired object as the subject in order to do measurement on it (Subject in this study is a concrete cube with length of sides equal to 30 cm) (Joint Target with short-range photogrammetry)

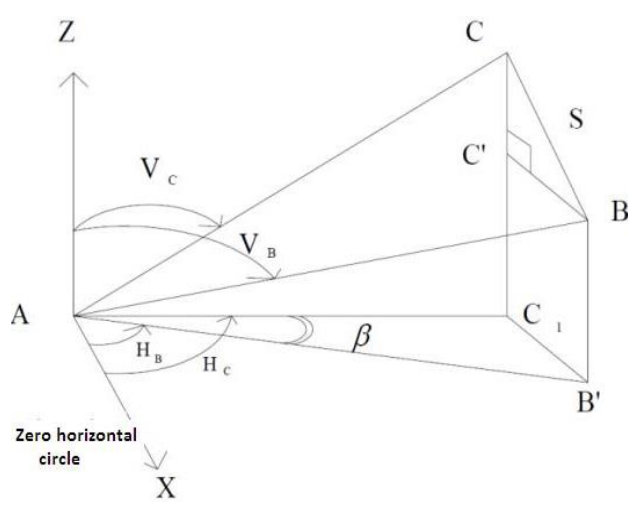

Fig. 2: Orthogonal framework XYZ of a total station and measurable lengths and angles

- Installing a number of sticky reflectors on this object or subject
- Creating the control points
- Installing a number of reflectors on the control points surrounding the subject
- Locating the installed reflectors on control points and subject outlines and obtaining the approximate coordinates of control points
- Designing the optimal geodetic grid
- Linear and angular observation in two ways:
  - Classic method (Here, the classical method refers to a way in which there is the ground station and the camera can be deployed on all stations and do observations and the camera is also aligned and cantraged.) with setting the station and alignment
  - Non-classic (modern) method without setting the station and alignment
- Determining the exact and ultimate coordinates of subject outlines (desired cubic) and its volume
- Investigating the final accuracy and determining the accuracy of coordinates
- Controlling and comparing obtained accuracy with direct measurement accuracy on target

RESULTS AND DISCUSSION

Designing the three-dimensional control grid: In general, definition of a coordinate system is indispensable and necessary in grid of control points in order to determine the mathematical position of points. In other words, achieving the mathematical position of points (coordinates) and the relationship between the observations and unknown parameters are subject to the introduction of coordinate system. Constraints are the information about definition of coordinate system in a grid of control points. In fact, the mathematical location of control points can be on a line (one-dimensional), on a plane (two-dimensional), or on the space (three-dimensional) (Maes *et al*., 1997).

According to what was mentioned, our control points in this study have been considered three-dimensional before and after replacement. It should be noted that definition of system origin is never possible through observations and the height of a point in one-dimensional system, X and Y of a point in two-dimensional systems and X, Y and Z of a point in three-dimensional systems should be specified in order to introduce the parameter of origin (Maes *et al*., 1997).

This grid, which has temporary station points, contains three station points, called α-β and y which make three vertices of triangle. Stages of grid design are described as follows (Bouarda, 1976).

Grid designing stages: The aim of grid designing is to provide a stable source framework by which other points can be determined with special accuracy. Grid designing involves several stages as follows:

Table 1: Parametric coordinates of points on the site surface

Coordinates of points on the wall (1)	(X, 0, z)
Coordinates of points on the wall (2)	(0, y, z)
Coordinates of points on the wall (3)	(X, b, z)
Coordinates of points on the wall (4)	(A, y, z)
Coordinates of points on the wall (5) (top)	(X, y, c)
Coordinates of points on the wall (6) (bottom)	(X, y, 0)

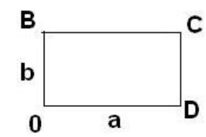

Fig. 3: A rectangle with dimensions a and b

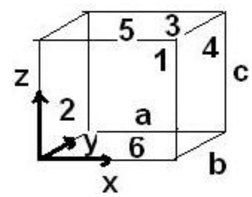

Fig. 4: Schematic view of room space

- Determining or justifying the coordinate system
- Determining the optimal form of grid
- Determining the optimal weight matrix
- Grid expansion

Proposed algorithm of grid designing: The main part of this method is manifested in definition of coordinate system in which we have applied the geometry of site, itself, for defining the coordinate system and coordinates of points. In presented Algorithm, the coordinate system can be defined as follows:

Origin can be assumed in one of the vertices of rectangle, for example 0 and the two-dimensional coordinate axes are extended along the rectangular sides. For instance, the extension of axis X can be assumed on the side 0D and extension of axis Y on the side 0B. In this regard, the coordinates of each point on the side 0D is equal to (X, 0) and coordinates of each point on 0B is equal to (0, Y). Thus, it is observed that the not-fixed point on the wall in local coordinate system is in a way that it is not out of or into the wall. Coordinates are defined in Table 1 for three-dimensional mode (Fig. 3 and 4).

The important point in this method is that dimensions of working place should be carefully defined in order to specify the coordinates accurately. According to definition above, the coordinate system is defined at this stage by geometry of environment in a way that possible movements for point of grid are normally along some of the coordinate axes and have no component on other axes, so that the point goes no more outside or inside (Grafarend and Schaffrin, 1974). According to the definition of coordinate system and possible movements for points of grid, we have movement only along the certain axes and there is no movement along other axes. Another advantage of this method is that the exact dimensions of working place can be easily extracted after adjustment according to the coordinates of points.

Angular observations of grid: Angular observations are obtained from comparing the measurement standard of angle or measurement unit of these observations (Degree, Grad, or Radian) in both horizontal and vertical plane through the tools with measureable quantitative. The accuracy of angular observations depends on the following three factors:

- Accuracy of tools
- Accuracy of modifications (Modification of conversion into horizon or out of the station for camera and modification of sphericity and refraction)
- Accuracy of measurement ways

Furthermore, since it is assumed that the observation errors are just random errors with zero mean and normal distribution, it is necessary to have no systematic errors in determining the accuracy of angular observations if possible in order not to have systematic errors in adjustment and calculations at next stages. Establishment of required geometry conditions in measurement tools is the most reliable way to ensure the absence of system a tic error in observation measurement tools. Every tool has a geometric condition. The geometry conditions of totals are met through their calibration (In accurate cameras for high resolutions).

Longitudinal observations of grid: Target lengths are read with calibrated totals which are easily applied. The lengths have the resolution equal to 1 mm and the longitudinal observations have high resolution. Since the target wave (laser) is done as the sweep from the camera to sticky reflector (target point) in longitudinal observations, its resolution is much higher than the one-way state. In this study, the target lengths of in our grid are mapped for several times by total and their average values are considered. After defining the initial coordinates of points as mentioned, we implement the grid design algorithm for step 1 design. The aim in step 1 design is to optimize the shape of grid in order to increase the ability to detect the error observations and thus the obtained coordinates have target accuracy. Applied algorithm is as follows:

- We discretely move the points of grid; it should be noted that each points of grid can be placed in various in finite situations because partial computational and displacement of grid points will have a little impact on grid optimality (For each station, we select several relatively states with differences).

Table 2: Coordinates of control points on the walls and stations

Points	X	Y	Z
α	107.0000	102.5000	100.0000
β	105.0000	105.0000	100.0000
γ	102.0000	104.5000	100.0000
X_1	111.9600	100.0000	100.0000
X_2	105.5000	100.0000	100.0000
X_3	100.0000	100.0000	100.0000
X_4	100.0000	110.2500	100.0000

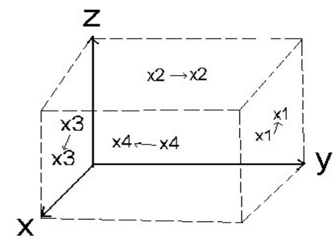

Fig. 5: A view of displacement of points in working place

- We obtain designing for each matrix states and then calculate the Matrix of Freedom (A grid has optimal shape that the minimum number of freedom in that grid is maximum compared to other states and the variance of the numbers of freedom is not high and all are in average.) as follows:

$$R = I - A(A^T PA + D^T D)^{-1} A^T P \tag{1}$$

where,
A : Design matrix
P : Weight matrix
D : Ditm matrix

- The optimal form of grid is obtained after creating the mathematical model in different states and calculating the matrix of freedom for each one according to the above constraint. It is worth noting that more than ten million different states of grid were evaluated in this study in order to design the applied grid in this research and finally the following grid, in which the variance of number of freedom was not high and also its minimum number of freedom was maximum compared to other cases, is selected with results as follows. In this table, the coordinates of each grid point are presented in completely local coordinate system on one of the vertices of working place (Branner, 1979). Coordinates of control points on the walls and stations is shown in Table 2.

The local coordinate system and points are calculated through primary information of working place and exact dimensions measured by observation and then the grid is designed as follows:

- Displacement of grid points and creating the second mode (Fig. 5)
- Creating Design matrix

- Creating the Matrix of freedom
- Determining the minimum number of freedom in matrix
- Repeating the steps 1 to 4
- Determining the state of grid which its minimum number of freedom is maximal compared to others (As mentioned, 10 million different states are tested in this section in order to analyze all possible states of grid.)

A Grid, which is obtained after doing the stage 6, is an optimal grid that should be implemented with respect to the local coordinate system. After implementing the above coordinates on the walls, the final observations are done in order to determine the exact coordinates of grid points to achieve the maximum accuracy and strength. Figure 5 show a view of displacement of points in working place.

Conversion of coordinate systems: Since that each of stations creates a local coordinate system and thus its performed observations are independent on other stations, it is necessary to transfer all observations to a same system in order to be interpretable; in other words, all coordinate s are converted into a coordinate system through the coordinates of each control points and consistent transformation. According to the summary process, the conversion coefficients are calculated for each system to one of the systems like the system depending on second station setting and the observation coordinates can be transferred from all stations to a system with these specified coefficients after determining the appropriate type of conversion (Affine: 3D Affine Coordinate Transformations, Conformal, DLT (Direct Linear Transformation), Procrustes, etc.) and by the control points with specified coordinates in all systems. In practice these two steps are done together and in a system of equations through the least squares method for calculating the coefficients and coordinates in new system. Thus, each of reading step at that station is done in that coordinate and independent on other systems, but for creating a one-dimensional model, consisting of all selected points, it is necessary to transfer all coordinates to a same single but desired system. Therefore, it is necessary to compare the conditions of systems according to two states:

- State of aligned camera
- State without aligned camera

In this study, 12-parametric conversion (3D translation, 3D rotation, different scale factor along each axis and 3D skew) is used for converting the system into each other; their practical results are presented as follows (Cooper, 1982).

Parametric conversion: It is assumed in this performed conversion in target project that the scales along three axes are not equal and three unknowns of scale are S_x, S_y, S_z. Furthermore, there are three non-orthogonal unknowns of axes x, y, z, as $\delta_x, \delta_y, \delta_z$ with three rotations and three transfers. Thus, this conversion includes twelve unknown parameters which should be measured and we need at least four points with known coordinates in both systems in order to estimate the unknown parameters. Matrix of this conversion is as follows:

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = S_x S_y S_z M_{\omega\phi k} M_{\delta_x \delta_y \delta_z} \begin{pmatrix} x \\ y \\ z \end{pmatrix} + k \rightarrow \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{pmatrix} d_1 \\ d_2 \\ d_3 \end{pmatrix} \tag{2}$$

where,

k = Three transfers of $\delta_x, \delta_y, \delta_z$
M = The parameters of non-orthogonality
$M_{\omega\varphi k}$ = The rotations of both systems
S_z, S_y, S_x = Scales of both systems

According to this conversion, all possible states are considered for transformation and two systems can be properly converted into together. This conversion can be linear as follows:

$$x' = a_1x + b_1y + c_1z + d_1 \Rightarrow F_1 = -x' + a_1x + b_1y + c_1z + d_1 = 0 \tag{3}$$

$$y' = a_2x + b_2y + c_2z + d_2 \Rightarrow F_2 = -y' + a_2x + b_2y + c_2z + d_2 = 0 \tag{4}$$

$$z' = a_3x + b_3y + c_3z + d_3 \Rightarrow F_3 = -z' + a_3x + b_3y + c_3z + d_3 = 0 \tag{5}$$

$$\text{BV+A}+\omega = 0 \Rightarrow \begin{cases} A = \begin{bmatrix} x & y & z & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & x & y & z & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & x & y & z & 1 \end{bmatrix} \\ B = \begin{bmatrix} -1 \\ -1 \\ -1 \end{bmatrix} \\ V = \begin{bmatrix} V_{x'} \\ V_{y'} \\ V_{z'} \end{bmatrix} \\ \delta = \left[a_1 b_1 \ldots d_3\right]^T \end{cases} \tag{6}$$

Values of transfer are attainable from each system to the reference system after the least squares solution. After doing the conversion calculations and according to the observations of object by station, which their coordinates are obtained through the control points; all of them are defined in a coordinate system. We do the adjustment with respect to the classic and non-classic observations:

Adjusted observations:
Grid constraints: The number of constraints in a grid is the first point which should be considered in the

classic state. The grid cannot rotate around the axes x and y in classic mode (because we have aligned the camera in all points and the only rotation is around the axis z). Unlike the three-dimensional mode, in which we need at least 7 constraints, here we introduce 5 constraints to the grid as follows:

- Three-dimensional coordinates of a point
- Coordinate x or y or z from another point
- Coordinate system scale

This constraint is introduced for scale of system due to the longitudinal observations, but x, y and z of a point like x of another point should be optionally introduced for introducing other constraints. According to the main point of introducing the constraints, these constraints should be introduced equally in both states in order to compare both classic and non-classic cases.

Adjustment equations: The three-dimensional adjustment and least squares parametric method have been applied for adjustment of this grid. Observations (L), vector of unknowns (X) and matrix of coefficients (A) are the vectors as follows:

$$L=[H_{\alpha},...,V_{\alpha\beta},V_{\alpha\gamma},V_{\beta\gamma},S_{\alpha\beta},...,h_{i\alpha},...,H_{\alpha1},H_{\alpha2},...,V_{\alpha1},...,S_{\alpha1},...,$$
$$H_{\beta2},H_{\beta3},H_{\beta9},H_{\beta12},V_{\beta2},...,S_{\beta2},...,H_{\gamma9},H_{\gamma10},H_{\gamma11},H_{\gamma12},V_{\gamma9},...,S_{\gamma9},...]^T$$

$$X=\left[x_{\beta},y_{\beta},z_{\beta},x_{\gamma},y_{\gamma},z_{\gamma},\ldots,x_{q4},y_{q4},z_{q4}\right]^T \quad (7)$$

$$A=\left[\frac{\partial L_i}{\partial X_j}\right]_{\begin{Bmatrix} i=1:n \\ j=1:n \end{Bmatrix}}$$

Equations of observations in this project are written three-dimensionally. In this case, the equation of horizontal angle observations is exactly like the two-dimensional state, but the equations of vertical angle observations are written as follows:

$$V_{ij}=Arc\cos\left[\frac{Z_j-(Z_i+h_{ti})}{\sqrt{(x_j-x_i)^2+(y_j-y_i)^2+(Z_j-(Z_i+h_{ti}))^2}}\right] \quad (8)$$

where,

Z_i = The height of deployment station
h_{ti} = The height of camera in deployment station

Equation of observation for oblique lengths is written as follows:

$$S_{ij}=\sqrt{(x_j-x_i)^2+(y_j-y_i)^2+(Z_j-(Z_i+h_i))^2} \quad (9)$$

Now, an approximate coordinates is given to all points in adjustment model through the initial observations. In this study, the approximate coordinates of all points was given from the point α to other points and then for introducing the constraints, x, y, z of point α were assumed to be constant and x of point β was selected as constraint. Then the replication circle is made after this step and the unknowns are obtained from the following formula:

Table 3: Final coordinates of target vertices in coordinate system associated with α

Point	X	Y	Z
Z_1	999.8958	1002.7e+003	101.1648
Z_2	1000.1e+003	1002.9e+003	101.1237
Z_3	1000.1e+003	1002.8e+003	100.7958
Z_4	999.8985	1002.6e+003	100.8802
Z_5	1000.100	1002.9	101.1237
Z_6	1000.000	1003.1e+003	101.1184
Z_7	1000.0e+003	1003.1e+003	100.8150
Z_8	1000.100	1002.8	100.7958
Z_9	1000.000	1003.1	101.1184
Z_{10}	999.9419	1002.9	101.1031
Z_{11}	999.9469	1002.8	100.7888
Z_{12}	1000.0e+003	1003.1	100.8150

Table 4: Final coordinates of Z_1 to Z_4 points on the target from α to β system

Points	X	Y	Z
Z_1	1000.1329	995.3208	100.0642
Z_2	1000.3073	995.5635	100.0600
Z_3	1000.3192	995.5516	99.7627
Z_4	1000.1445	995.3099	99.7635

Table 5: Final coordinates of Z_9 to Z_{12} points on the target from γ to β system

Points	X	Y	Z
Z_9	1000.0652	995.7399	100.0454
Z_{10}	999.8702	995.4963	100.0496
Z_{11}	999.9049	995.4892	99.7502
Z_{12}	1000.0784	995.7276	99.7464

Table 6: Final coordinates of Z_1 to Z_4 points on the target from α to β system

Points	X	Y	Z
Z_1	1000.1665	995.3828	100.0480
Z_2	1000.3557	995.6228	100.0332
Z_3	1000.2809	995.5048	99.7834
Z_4	1000.0974	995.2577	99.8009

Table 7: Final coordinates of Z_9 to Z_{12} points on the target from γ to β system

Points	X	Y	Z
Z_9	1000.0652	995.7399	100.0454
Z_{10}	999.8702	995.4963	100.0496
Z_{11}	999.9049	995.4892	99.7502
Z_{12}	1000.0784	995.7276	99.7464

$$dx=(A^TPA)^{-1}A^TPdl \quad (10)$$

$$dl=L_{OBS}-L_{COMP} \text{ and } (P=\sum L^{-1}) \quad (11)$$

$$X_{new}=X_{old}+dx \quad (12)$$

The coordinates of all grid points is achieved after adjustment. However, some of the observations were eliminated from the observation equation during the

Table 8: Comparison of lengths in both classic and non-classic methods

Measured lengths	Calculated lengths (classic)	Calculated lengths (non-classic-first type)	Calculated lengths (non-classic-second type)
L_{z1z4} = 30.2	L_{z1z4} = 30.34	L_{z1z4} = 30.11	L_{z1z4} = 29.51
L_{z2z9} = 30.5	L_{z2z9} = 31.13	L_{z2z9} = 29.98	L_{z2z9} = 31.34
L_{z9z10} = 30.1	L_{z9z10} = 30.21	L_{z9z10} = 29.99	L_{z9z10} = 29.99
L_{z3z12} = 30.2	L_{z3z12} = 30.55	L_{z3z12} = 29.86	L_{z3z12} = 30.33

Table 9: Results of ANOVA test with repeated measurement[1] in 3 study groups in SPSS

Source		Type III S.S.	df	M.S.	F	Sig.
F	Sphericity Assumed	2.135	3.000	0.712	12.854	0.000
	Greenhouse-Geisser	2.135	1.729	1.234	12.854	0.003
	Huynh-Feldt	2.135	2.561	0.834	12.854	0.001
	Lower-bound	2.135	1.000	2.135	12.854	0.016
Error (F)	Sphericity Assumed	0.830	15.000	0.055		
	Greenhouse-Geisser	0.830	8.647	0.096		
	Huynh-Feldt	0.830	12.805	0.065		
	Lower-bound	0.830	5.000	0.166		

[1]: When the same measurements are carried out on a subject or case for several times, ANOVA test with repeated measurements should be used in order to analyze data and compare mean data among these several times. However, if there is an intergroup factor, it can be analyzed through defining the group in this test. The null hypothesis about the effects of intergroup and intra-group factors can be tested by this statistical method; S.S.: Sum of square; M.S.: Mean of square

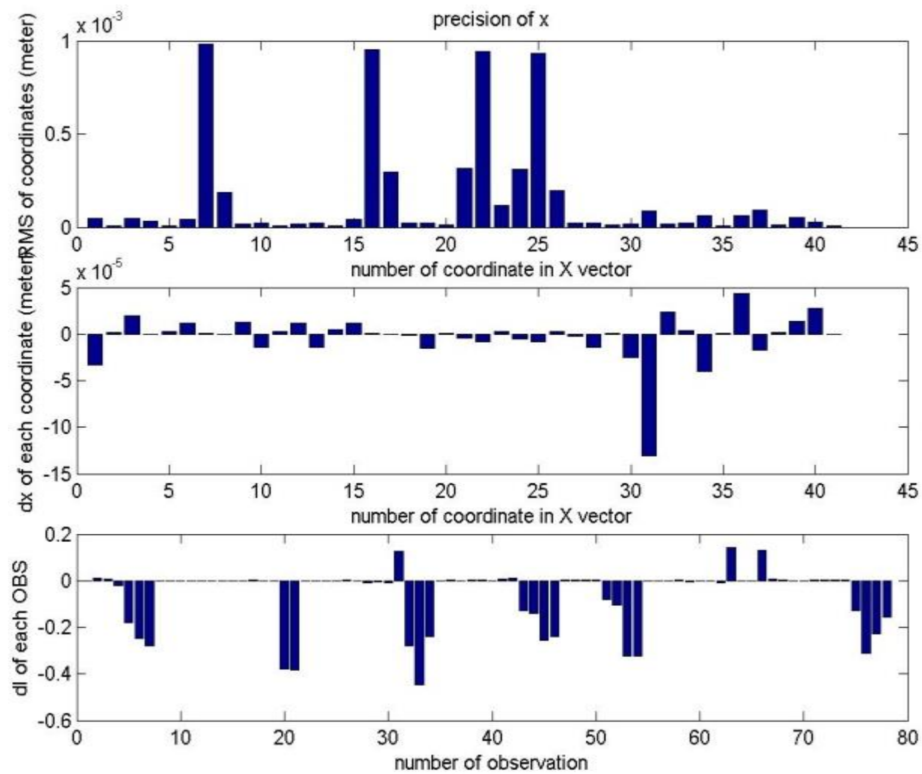

Fig. 6: Accuracy of coordinates points on the subject, final dx and dl

adjustment due to the vast differences with results and since there were control points on surrounding walls, the grid was encountered with no rank deficiency (Another benefit of control points). Obtained results after adjustment are as follows (Table 3).

The accuracy of results is also calculated through the formula $\sum X = (A^t PA)^{-1}$ and is shown in Fig. 6. This figure also shows the final dx and dl:

Non-classic method: In this case, there is no need to cantrage and align the cameras while replacement. Moreover, another advantage of this method is that the camera height is not important here because the origin of our coordinate system is the center of camera. Lack of alignment and cantrage means that we initially deploy the arbitrary points and read the points on the structure (target) and then replace the camera for reading the rest of points on the structure and start reading after deployment (in an arbitrary place) without adjustment. The important point is that several points in common with previous stations should be read in order to link the observations among multiple stations (at least 4 points). These points can be put on the structure or surrounding objects (e.g., walls). In this project, the camera is placed at three favorite stations and observation is done without alignment and cantraging of camera. Finally, we transferred the calculated coordinates at each point to other stations through the common points in each station. In this case, the final results are different according to the accuracy:

- First station of alignment and cantrage and remaining without alignment and cantrage
- No alignment and cantrage are done in them

Results of first case are presented in Table 4 and 5 and results of second case in Table 6 and 7.

CONCLUSION

As inferred from the numerical results, the second state has relatively low accuracy in non-classic method compared to the first state, the overall outcome of lengths. Moreover, both states have high accuracy close to classic methods. Table 8 compares some of the lengths.

As observed, difference from direct measurement is negligible in both methods. In other words, the length difference is 2-3 mm on average (in all dimensions) in classic method compared to direct measurement and this difference is also existed in non-classic method-first type compared to direct measurement. Length difference in non-classic method-Second type is 3 mm on average (in all dimensions) compared to the direct measurement. Both non-classic methods can be applied depending on environmental conditions, time, cost and accuracy considered by employer. It is worth noting that the slight difference of lengths compared to the classic method and direct measurement will lead to the application of these methods in large-scale projects with high expenditures.

However, the following output (Table 9) shows all changes in two sources of factor (two classic and non-classic models) and error. As shown, the Sig. of this figure is lower than the significance level of 5% in each four tests. Therefore, it can be concluded that there is significant difference between the mean localization and accurate measurement based on the classic and non-classic models (both states) and the type of model has a significant impact on mean of localization and accurate measurement.

Results of ANOVA test with repeated measurement in 3 study groups in SPSS is shown in Table 9.

This study indicates the way for determining the coordinates through utilization of defined orthogonal frame work in the structure of a Total Station. Furthermore, all mathematical equations are provided and proved for determining the coordinates without alignment and setting the station. Numerical results of case indicate the great success of presented method. This has paved the way for application of Total Station as a quick tool in industrial environments and provided theory can create new industrial features for classic mapping.

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