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ACCURACY INVESTIGATION OF THREE-POINT RESECTION METHOD USING KNOWN POINTS DISTRIBUTION IN FOUR-QUADRANTS

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ABSTRACT

This paper presents a simple way of finding the accuracy of three-point resection problem. The main idea is to distribute known points in four-quadrants and compute the coordinates of the resected point (P), then investigate the affection of known points positions in one quadrant or combination quadrant for the accuracy of resected point (which is a new idea in the literature). This article aims to find out the affections of distribution control points in different quadrants on the accuracy of the resected point, and also choosing the best positions of the three-points in terms of their positions in one quadrant or their positions in combination quadrants. The relative positions of the known points and the resected point are playing the main role to decide the accuracy of the resected point. The study of the relationship between relative positions of unknown point will be explained in detail, other known-points and the accuracy of the unknown point will be introduced, and the positions of known points (Distributed in quadrants) of having the best accuracy of the resected point will be defined.

Keywords: Three-Point Resection Problem, Surveying, Accuracy, Three-point solution, Resected point, Four-quadrants.

1. INTRODUCTION

The three-point resection method (also known as the “three-point problem”) is used to compute the coordinates of an unknown point by occupying the resected point and measuring angles and distance toward three known points, since the angles between three known points are determined at the unknown point (ElHassan, 1986). The idea of computing the coordinates of an unknown point using relative angular measurements to three known stations is a basic concept in surveying engineering (El Hassan, 1989) and it is a very useful technique for fixing positions quickly where it is best needed for setting-out purposes which has been discussed and solved analytically or graphically in the last centuries in most previous articles and books, such as (ElHassan, 1986; Font-Llagunes & Batlle, 2009; Haralic et al., 1991; Ligas, 2013; Problem, n.d.; Wang et al., 2018). Moreover, (El Hassan, 1989) tried to detect the accuracy of the three-point resection method by changing the position of resected and control points, and this paper has reached to the relative location of the resected point, indicating that the three control points have a big affection on deciding the accuracy of the resected point.

There are various methods to solve three-point resection, yet so far all of them failed in the control point case, and the resected point lie on the circumference of a circle. A lot of methods produce questionable results if the known points lie on a straight line, the method of computation should be chosen with consideration, and independent checks should be used wherever possible. (Point & Problem, 1981)

This paper precedes the study to find out an accurate coordinates which will be obtained using three-point resection calculations in terms of the positions of three known points in one quadrant or combination between two or three quadrants and comparing them with the real coordinate of the resected points, and also to find out the appearance of any relationship between the unknown point and the three-point position. Furthermore, it should be noted that all previous articles and books concerning to this method did not address the question “Does the position of the three points in one quadrant affect the accuracy of the coordinates of the unknown point or not?” and the answer will be presented in this paper.

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2. METHODOLOGY

2.1 The resection method cases

There are three types of resection method:

1- Space resection on photogrammetry.
2- Two-points resection method on surveying Engineering (free station).
3- Three-point resection method and this is the article topic.

2.2. Space resection on photogrammetry

The space resection is described as an optimization model. The function of objective model is to reduce the number of squared residuals (Easa, 2010). The model is given by:

$$x=(-f)\left(\frac{r_{11}(X_A-X_L)+r_{12}(Y_A-Y_L)+r_{13}(Z_A-Z_L)}{r_{31}(X_A-X_L)+r_{32}(Y_A-Y_L)+r_{33}(Z_A-Z_L)}\right)$$
$$y=(-f)\left(\frac{r_{21}(X_A-X_L)+r_{22}(Y_A-Y_L)+r_{23}(Z_A-Z_L)}{r_{31}(X_A-X_L)+r_{32}(Y_A-Y_L)+r_{33}(Z_A-Z_L)}\right)$$

where: (X_A, Y_A, Z_A) are the terrestrial coordinates, (x, y) are the image coordinates, (X_L, Y_L, Z_L) are the coordinates of the exposure station or the camera, (f) is the focal length of the camera, and (r_{ij}) is the rotation matrix elements, if the value of camera's focal length and the coordinates of known ground point, then the equation (x, y) becomes a function of the three exposure station elements (X_L, Y_L, Z_L) and the rotation angle elements (ω, ϕ, k), will obtain linear equations by distributing the equations in a Taylor series. It can be solved by numerical methods or least square method as well.

2.3. Two-points resection method (free station)

Two-point resection is a method of positioning new control point (resected point) by taking observations and measurements towards the other known control points on a network. There are two types of resection that can be performed, including angular resection by measuring horizontal angles and distance resection by measuring horizontal distances. Both measurements are very useful for obtaining on-site temporary control points which known as free station points. (*Topic 6 : Angle Measurement : Intersection and Resection*, n.d.)

2.4. Angular resections

Angular resections are used to compute the coordinate point observing the existing control points – the advantage of this method is that the resection can be performed without occupying any control points during measurements. The resected point can be determined in angular resection by measuring its angles from at least three existing control points in a three-point resection, which presented below:(*Topic 6 : Angle Measurement : Intersection and Resection*, n.d.)

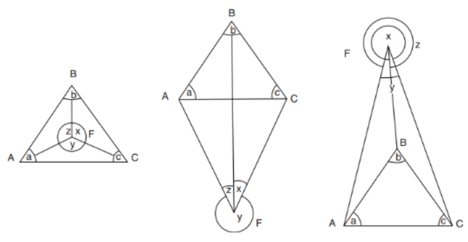

Figure (1) the three cases of the angular resection

Three-point resection method:

There are three cases in this method as shown in **Figure (1)**, the three cases are considered to the position of the known and unknown points. The position of the unknown point can be located in the middle of a polygon or in one corner of the polygon. In this paper, the position of the unknown point located in the corner of the polygon as presented in the following figure:

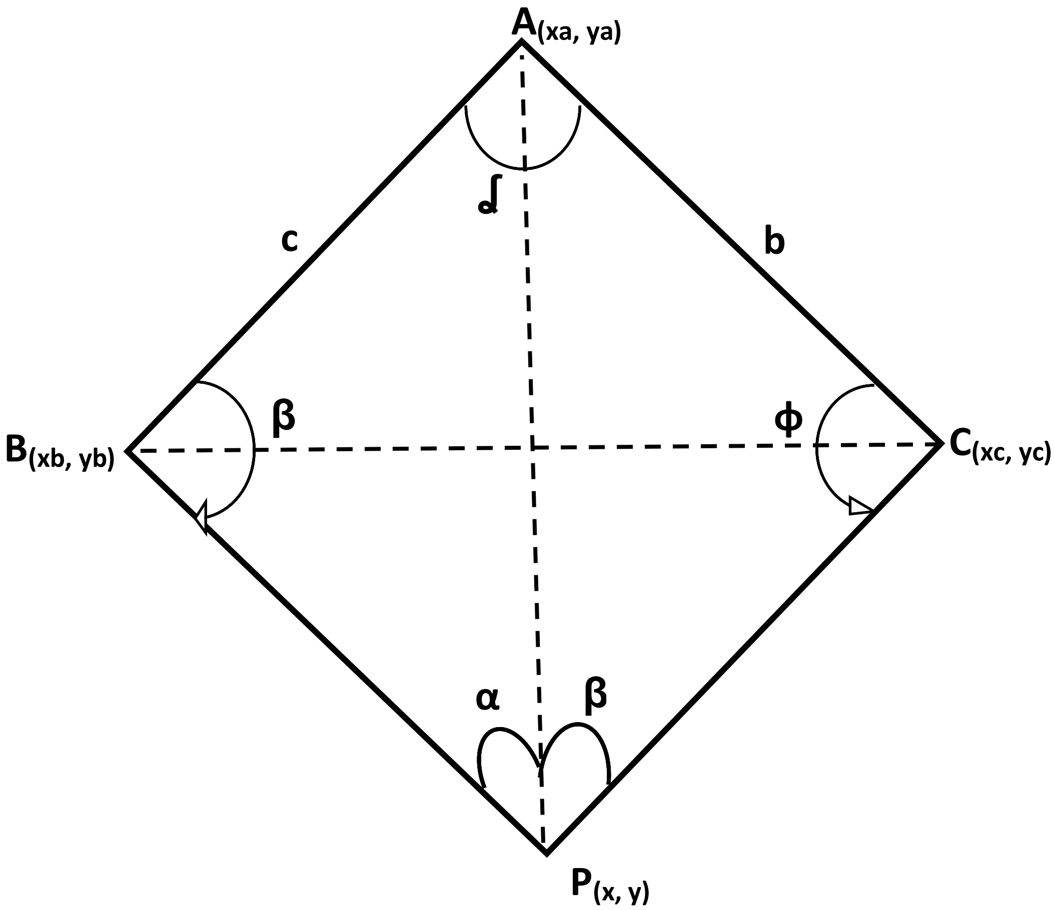

Figure (2) the positions of unknown point P and known points (Point & Problem, 1981)

where P is the resected point (unknown point), A, B, C are the control points (known points coordinates), α, β are the angles between the known points measured from the resected point, ϕ, β, ʆ are the angles that will be calculated mathematically using the following formulas, and b, c are the distances between three known points which will be calculated mathematically as well.

Resection solution

There are a lot of previous studies that produced resection three-point problem solution which have been conducted with different ways and methods. This paper is using the solution from (Point & Problem, 1981) and it has been found that this solution gives high accuracy compared to the other solutions. The first step is to calculate the angles since (A, B, C) are known points, the angle (ʆ) can be calculated by the deflection differences of the two lines.

Calculating the assisting angles ɣ and Ø. Firstly, it needs to be noted that the sum of the interior angles is equal to 360^{o} [the summation of interior angles of any polygon should equal $(n - 2)*180^{o}$].(Point & Problem, 1981)

$$\alpha + ɣ + \beta + ʆ + \emptyset = 360 \qquad (1)$$

Rearrange:

$$ɣ = 360 - (\alpha + \beta + ʆ) - \emptyset \qquad (2)$$

The interior angles α, ʆ, and β are known, therefore the calculation of assisting angles ɣ and Ø is needed:

$$ɣ = R - \emptyset \qquad (3)$$

Assuming that:

$$K_1 = \frac{b}{c} * \frac{\sin(\alpha)}{\sin(\beta)} = \frac{\sin(ɣ)}{\sin(\emptyset)} \qquad (4)$$

Or it can be said that:

$$K_2 = \frac{c}{b} * \frac{\sin(\beta)}{\sin(\alpha)} = \frac{\sin(\emptyset)}{\sin(ɣ)} \qquad (5)$$

Therefore, it can be concluded that:

$$K2 = \frac{1}{K1} \qquad (6)$$

Calculating the distance of c and b between the control points by:

$$\text{Distance b} = \sqrt{[(A_x - C_x)^2 + (A_y - C_y)^2]} \qquad (7)$$

$$\text{Distance c} = \sqrt{[(A_x - B_x)^2 + (A_y - B_y)^2]} \qquad (8)$$

From these equations, angles (Ø, ɣ) can be computed using the following equations:

Compute Ø

$$\cot(\emptyset) = \frac{K_1 + \cos(R)}{\sin(R)} \qquad (9)$$

Compute ɣ

$$\cot(ɣ) = \frac{K_2 + \cos(R)}{\sin(R)} \qquad (10)$$

Figure (1), was done by solving or taking the triangle (APC) and the angle ϕ on point C that will be calculated using equation No (9). Then, by finding the line deflection (CP) from the line deflection (CA) (known deflection), and finally the coordinates calculation of the resected point (P) was done using the following equations: (Point & Problem, 1981)

$$\Delta E = L * \sin(\alpha) \qquad (11)$$

$$\Delta N = L * \cos(\alpha) \qquad (12)$$

Where ΔE is the difference of Easting between resected point (P) and the control point (C), and ΔN is the difference of Northing between resected point (P) and the control point (C).

Or it can be:

$$E_P = E_B + L * \sin(\alpha) \qquad (13)$$

$$N_P = N_B + L * \cos(\alpha) \qquad (14)$$

The triangle (APB) in Figure 1 was used to ensure that the previous computations are correct and the angle Ø should be computed using the equation (9), to find the coordinates point (P) using similar equations as before, and the final equations of computing resected point will be as follows:

$$\Delta E = L * \sin(\emptyset) \qquad (15)$$

$$\Delta N = L * \cos(\emptyset) \qquad (16)$$

Where L is the distance between resected point P control point (B), ΔE is the difference of Easting between resected point (P) and the control point (B), ΔN is the difference of Northing between resected point (P) and the control point (B).

Or it can also be presented as:

$$E_P = E_B + L * \sin(\emptyset) \qquad (17)$$

$$N_P = N_B + L * \cos(\emptyset) \qquad (18)$$

Data collection and the way of calculation

The site of study has an area of 1000 m^2 and the data contains 21 points including the resected point (P). The angles and distances between the control points are measured by occupying the resected point using Total station instrument. There is a total of 21 control points which were measured in this study and the measurements were performed using GPS-RTK instrument, all those data have been observed during this project, and the control points have been distributed into 4 quadrants in this study as shown in **Figure (3)** and **Figure (4)** below:

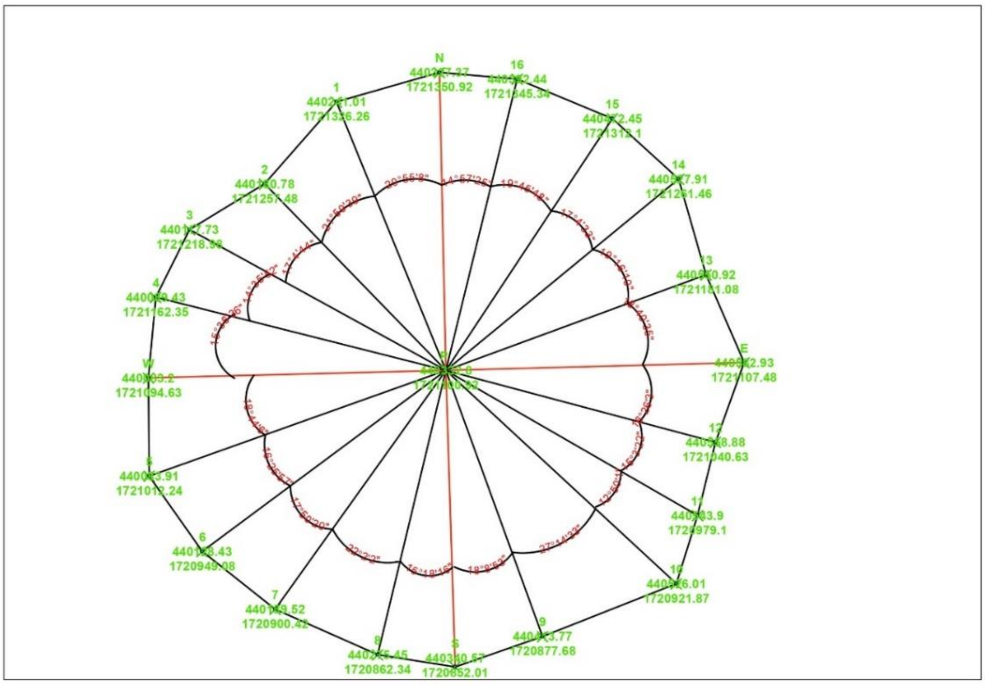

Figure (3) distributions of control points around the resected point in four-quadrants

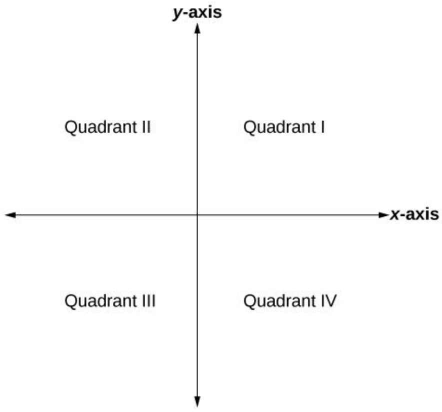

Figure (4) the general shape of the site

The **figure (3)** above shows that four known points have been distributed in each quadrant except the control points located in the vertical and horizontal axis. The known points have been divided into eight sectors and two groups, every group contains of 4 sectors. The first group represented by the normal quadrants and the second group represented by the combinations between two quadrants. Their classifications are presented as follows:

- **Group A:** Represented by the First quadrant, second quadrant, third quadrant, and fourth quadrant.
- **Group Two:** First, it consists of the combination between the first and second quadrants which contained the known points named as (E, 13, 14, 15, 16, N, 1, 2, 3, 4, W). Second, the combination between the second and third quadrants which contains of known points named as (N, 1, 2, 3, 4, W, 5, 6, 7, 8, S). Third, the combination between the first and second quadrants which contains of known points named as (W, 5, 6, 7, 8, S, 9, 10, 11, 12, E). Fourth, the combination between the first and second quadrants which contains the known points named as (S, 9, 10, 11, 12, E, 13, 14, 15, 16, N).

4. Result and Discussion

The result shows that the coordinate accuracy of the resection point in four quadrants and four combination quadrants contains of comparison between the real coordinate of the resection point and the computed coordinates from three-point resection solution in all quadrants by representing them in schedule. The coordinates of the resected point (P) has been determined two times. First, the real coordinates using GPS-RTK and second, it has been computed several times using three-point resection method as explained previously. Thus, the real and computed coordinates of the resected point (P) from different positions of control points has already compared or calculated. Almost all the results represent in a difference of three decimal digits, with the exception of some cases, which are:

- There are two cases in the first quadrant that gives differences greater than 1 meter in the northern coordinate compared to the real coordinates of the known point (P), which are: The combination (the triangle) of the (S, 11, 12) known points with the unknown point (P), and by taking the combination of (S, 12, E) known points with the unknown point (P).
- There is one case in the second quadrant with differences greater than 1 meter in the northern coordinate and more than 2 decimeters in the eastern coordinates which is the combination (the triangle) between the (W, 5, 6) known points with the unknown point (P).
- There are three cases for the known points located in the third quadrants: based on the points combination (2, 3, 4) with the unknown point (P), it has differences greater than 2 decimeters in

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the northern coordinate, and the case of taking the combination of the points (3, 4, W) with the unknown point (P) has differences greater than 4 decimeters in the northern coordinate and finally the combination between points (N, 1, 3) with the unknown point (P) has differences greater than 5 decimeters in the eastern coordinate.

- Finally, the case in the fourth quadrant combined from the points (E, 15, 13) with the resected point (P), have differences greater than 1 meter in the northern and eastern coordinates.

Above exception cases have not calculated on the graph accuracy of the resection points.

Representation of Resection Method Accuracy

As explained in the discussion previously, the three-point resection accuracy in this study shows a difference of three decimal digits which has been represented in schedules. Every quadrant has taken 10 cases except the combination of the first and second quadrants. The combination between second and third quadrants represents by 9 cases of the three-point resection triangles. The schedules divided into two parts, the first part were the normal quadrants which are the first, second, third and fourth quadrants, and the second part were the combination quadrants which are the combination-quadrants between first and second, second and third, third and fourth, and finally fourth and first. The representations are presented in two divisions as follows:

A. <u>The four single-quadrants results:</u>

The four single-quadrants contains the first, second, third and fourth quadrants, most of the accuracy reached millimeters and centimeters. However, there are exception cases, such as two cases in the first quadrant, one case in the second quadrant, three cases in the third quadrants and finally the case in the fourth quadrant. All that will be explained in details in the schedules below:

1- Computing the accuracy of resected point (P) for the first quadrant:

No.	Triangle No( )	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<>P 10,9,S	1721100.920	440332.800	1721100.921	440332.801	0.001	0.001
2	<>P 11,10,S	1721100.920	440332.800	1721100.917	440332.798	-0.003	-0.002
3	<> P 12,11,S	1721100.920	440332.800	1721102.200	440332.770	1.280	-0.030
4	<> P E,12,S	1721100.920	440332.800	1721102.193	440332.765	1.273	-0.035
5	<> P 11,10,9	1721100.920	440332.800	1721100.917	440332.799	-0.003	-0.001
6	<> P 12,11,9	1721100.920	440332.800	1721100.850	440332.810	-0.070	0.010
7	<> P E,12,9	1721100.920	440332.800	1721100.973	440332.778	0.053	-0.022
8	<> P 12,11,10	1721100.920	440332.800	1721100.892	440332.770	-0.028	-0.030
9	<> P E ,12,10	1721100.920	440332.800	1721100.933	440332.860	0.013	0.060
10	<> P E,12,11	1721100.920	440332.800	1721100.973	440332.730	0.053	-0.070

Table (1): The real and computed coordinates and the Accuracy of the resected point (P) in the first quadrant

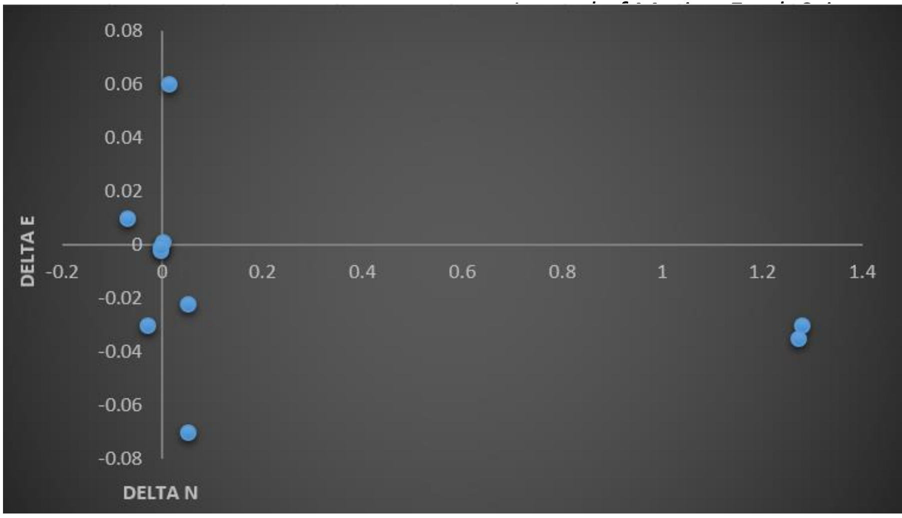

Figure (5) shows the accuracy of the resected point (P) in the first quadrant

- **Table (1)** shows that there are two cases in the first quadrant that gives differences greater than 1 meter in the northern coordinate compared with the real coordinates of the known point (P), which are: The combination (the triangle) of the (S, 11, 12) known points with the unknown point (P), and by taking the combination of (S, 12, E) known points with the unknown point (P). Those two cases have not been counted on **figure (5),** some of the differences in the first quadrant have millimeters and most of them reached centimeters as presented in **Table (1)** and **figure (5).**

2- Computing the accuracy of resected point (P) for the second quadrant:

No.	Triangle No( )	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<>P 5,6,7	1721100.920	440332.800	1721100.949	440332.810	0.029	0.010
2	<>P 5,6,8	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
3	<>P 6,7,8	1721100.920	440332.800	1721100.930	440332.880	0.010	0.080
4	<>P 7,8,S	1721100.920	440332.800	1721100.921	440332.797	0.001	-0.003
5	<>P 6,8,S	1721100.920	440332.800	1721100.920	440332.799	0.000	-0.001
6	<>P 5,6,S	1721100.920	440332.800	1721100.931	440332.788	0.011	-0.012
7	<>P W,5,6	1721100.920	440332.800	1721099.890	440332.580	-1.030	-0.220
8	<>P W,6,7	1721100.920	440332.800	1721100.921	440332.802	0.001	0.002
9	<>P W,7,8	1721100.920	440332.800	1721100.921	440332.808	0.001	0.008
10	<>P W,8,S	1721100.920	440332.800	1721100.920	440332.804	0.000	0.004

Table (2): The real and computed coordinates and the Accuracy of the resected point (P) in the second quadrant

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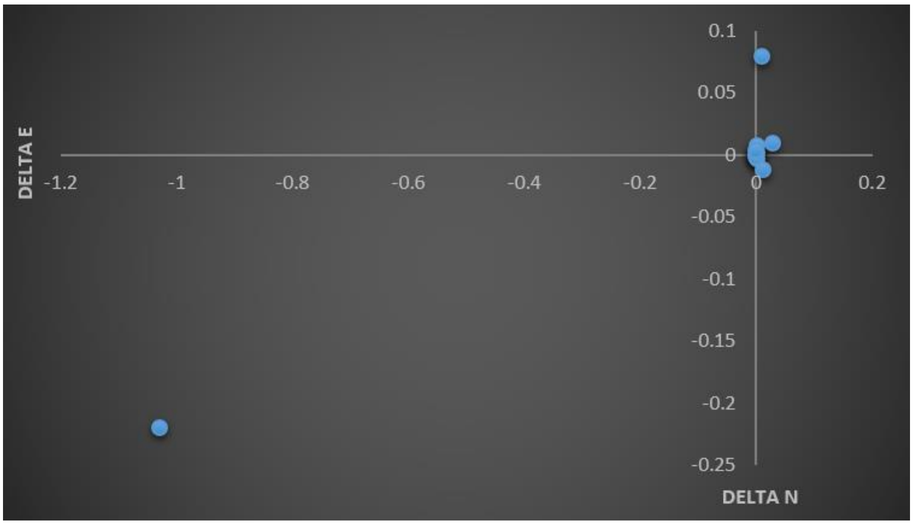

Figure (6) shows the accuracy of the resected point (P) in the second quadrant

- **Table (2)** shows that there is one case in the second quadrant with differences greater than 1 meter in northern coordinate and more than 2 decimeters in eastern coordinate, which is the combination (the triangle) between (W, 5, 6) known points with the unknown point (P). This case has not been counted on **figure (6).** Some of the differences in the first quadrant are in centimeters and most of them reached millimeters as presented in **Table (2)** and **figure (6).**

3- Computing the accuracy of resected point (P) for the third quadrant:

	Triangle No( )	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<>P N,1,2	1721100.920	440332.800	1721100.922	440332.804	0.002	0.004
2	<>P 1,2,3	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
3	<>P 2,3,4	1721100.920	440332.800	1721101.150	440332.856	0.230	0.056
4	<>P 3,4,W	1721100.920	440332.800	1721100.460	440332.811	-0.460	0.011
5	<>P N,3,4	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000
6	<>P N,1,3	1721100.920	440332.800	1721100.895	440332.220	-0.025	-0.580
7	<>P 1,2,W	1721100.920	440332.800	1721100.930	440332.799	0.010	-0.001
8	<>P 1,4,W	1721100.920	440332.800	1721100.922	440332.799	0.002	-0.001
9	<>P N,2,4	1721100.920	440332.800	1721100.918	440332.800	-0.002	0.000
10	<>P 2,4,W	1721100.920	440332.800	1721100.910	440332.800	-0.010	0.000

Table (3): The real and computed coordinates and the Accuracy of the resected point (P) in the third quadrant

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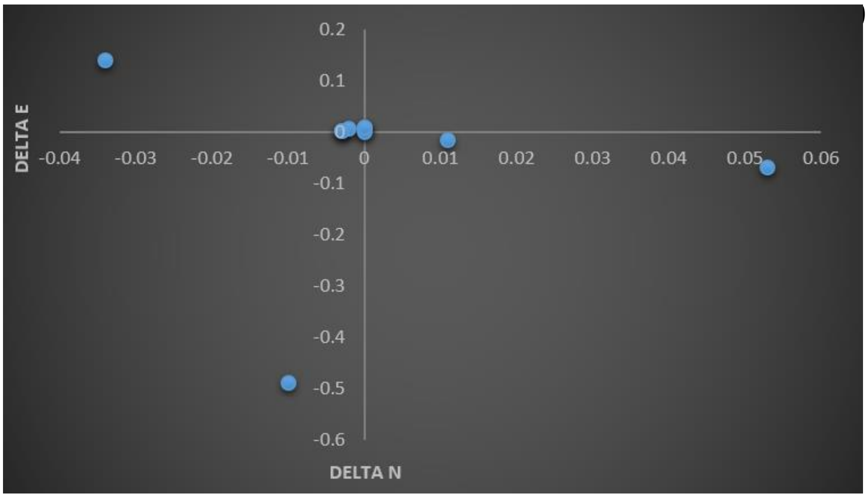

Figure (7) shows the accuracy of the resected point (P) in the third quadrant

- **Table (3)** shows that there are three cases for the known points located in the third quadrants: based on the combination points (2, 3, 4) with the unknown point (P) shows differences greater than 2 decimeters in the northern coordinate, and the case of taking the combination of the points (3, 4, W) with the unknown point (P) shows differences greater than 4 decimeters in the northern coordinate and finally the combination between points (N, 1, 3) with the unknown point (P) gives differences greater than 5 decimeters in the eastern coordinate, those three cases have not been counted on **figure (7).**

4- Computing the accuracy of resected point (P) for the fourth quadrant:

No.	Triangle No( )	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<> P N,16,15	1721100.920	440332.800	1721100.917	440332.803	-0.003	0.003
2	<> P 16,15,14	1721100.920	440332.800	1721100.918	440332.806	-0.002	0.006
3	<> P 15,14,13	1721100.920	440332.800	1721100.931	440332.784	0.011	-0.016
4	<> P 14,13,E	1721100.920	440332.800	1721100.917	440332.803	-0.003	0.003
5	<>P 16,15,13	1721100.920	440332.800	1721100.920	440332.801	0.000	0.001
6	<>P N,15,14	1721100.920	440332.800	1721100.910	440332.311	-0.010	-0.489
7	<>P 16,13,E	1721100.920	440332.800	1721100.886	440332.941	-0.034	0.141
8	<>P 15,13,E	1721100.920	440332.800	1721100.973	440332.732	0.053	-0.068
9	<>P N,13,E	1721100.920	440332.800	1721100.920	440332.810	0.000	0.010
10	<>p N,14,E	1721100.920	440332.800	1721100.920	440332.810	0.000	0.010

Table (4): The real and computed coordinates and the Accuracy of the resected point (P) in the fourth quadrant

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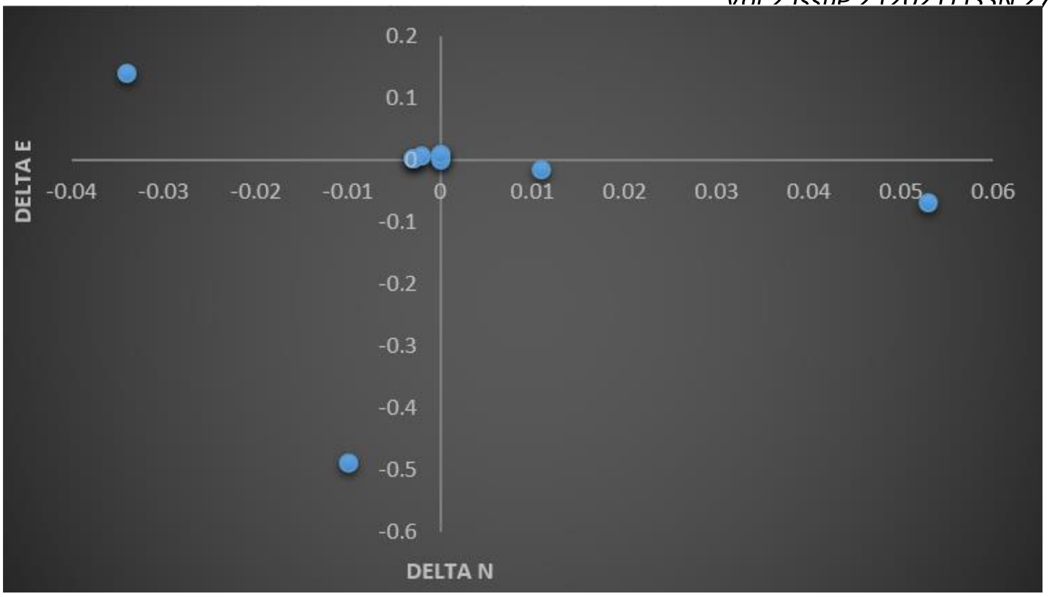

Figure (8) shows the accuracy of the resected point (P) in the fourth quadrant

From the **Table (2)** showed the case in the fourth quadrant combined from the points (E, 15, 13) with the resected point (P), gives differences greater than 1 meter in the northern and eastern coordinates, this case has not counted on **figure (6).**

B. Combination quadrants:

The Combination quadrants contains from the combination between first and second, second and third, third and fourth, and finally fourth and first. The accuracy of all those cases are in millimeters which means that the accuracy is higher compared to the points located in normal quadrants as presented in the tables, graphs and explanations below:

1- Computing the accuracy of resected point (P) for the combination of the first and second quadrants:

NO	Triangle No	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<>P 1,N,16	1721100.920	440332.800	1721100.918	440332.787	-0.002	-0.013
2	<>P 1,15,14	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000
3	<>P 1,14,13	1721100.920	440332.800	1721100.922	440332.801	0.002	0.001
4	<>P 1,13,E	1721100.920	440332.800	1721100.919	440332.800	-0.001	0.000
5	<>P 2,16,15	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
6	<>P 2,15,14	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
7	<>P 2,14,13	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
8	<>P 3,16,15	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
9	<>P 3,14,13	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000

Table (5): The real and computed coordinates and the Accuracy of the resected point (P) in the combination between first and second quadrants

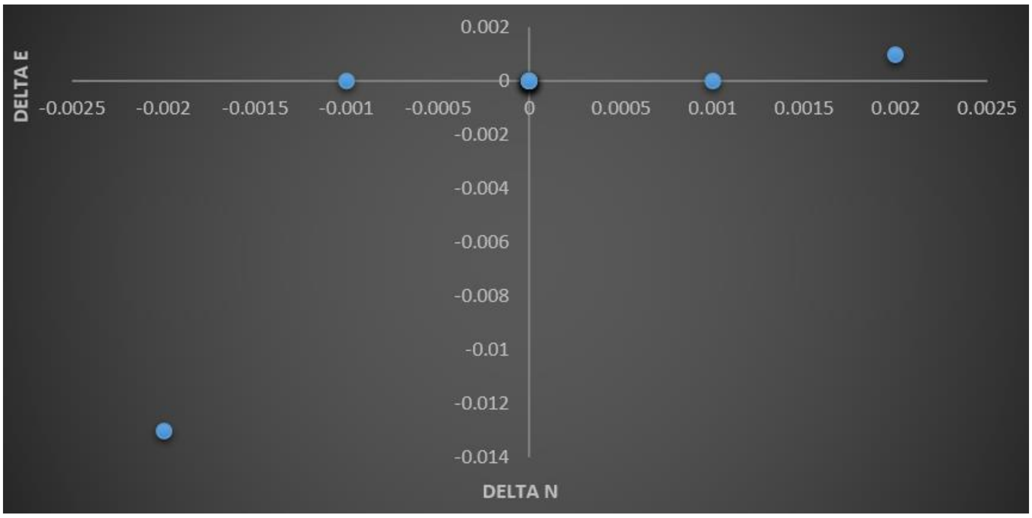

Figure (9) shows the accuracy of the resected point (P) in the combination between first and second quadrants

Table (5) and **figure (9)** show the case in the combination of the first and second quadrants, all of the cases has millimeters accuracy except the triangle of (1, N,16) which has one centimeter on the delta eastern coordinates (ΔE).

2- Computing the accuracy of resected point (P) for the combination between second and third quadrants:

No	Triangle No	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<>P 13,12,11	1721100.920	440332.800	1721100.921	440332.801	0.001	0.001
2	<>P 13,11,10	1721100.920	440332.800	1721100.921	440332.802	0.001	0.002
3	<>P 13,10,9	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000
4	<>P 13,9,S	1721100.920	440332.800	1721100.922	440332.806	0.002	0.006
5	<>P 14,12,11	1721100.920	440332.800	1721100.921	440332.801	0.001	0.001
6	<>P 14,11,15	1721100.920	440332.800	1721100.923	440332.800	0.003	0.000
7	<>P 15 ,12,11	1721100.920	440332.800	1721100.922	440332.803	0.002	0.003
8	<> p 15,10,9	1721100.920	440332.800	1721100.920	440332.799	0.000	-0.001
9	<>P 16,11,10	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000

Table (6): The real and computed coordinates and the Accuracy of the resected point (P) in the combination between second and third quadrants

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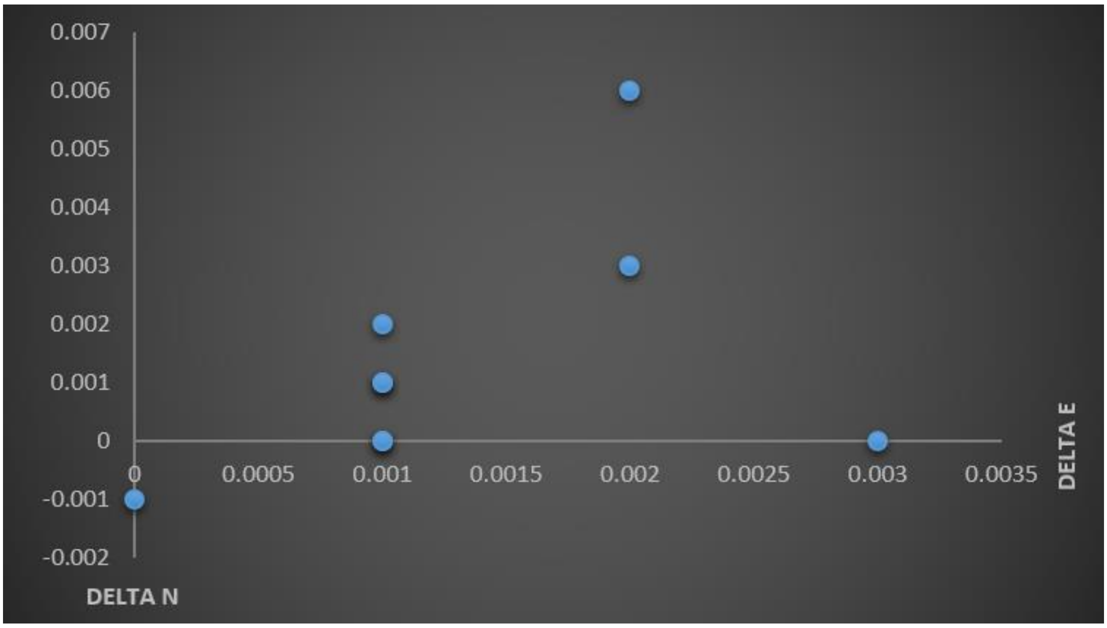

Figure (10) shows the accuracy of the resected point (P) in the combination between second and third quadrants

Table (6) and **figure (10)** showed that the case in the combination of the first and second quadrants which is all the cases has millimeters in their accuracy, indicating that its more accurate compared to the previous graphs.

3- Computing the accuracy of resected point (P) for the combination between third and fourth quadrants:

No	Triangle No	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<> P 9,8,7	1721100.920	440332.800	1721100.915	440332.809	-0.005	0.009
2	<> P 9,7,6	1721100.920	440332.800	1721100.918	440332.805	-0.002	0.005
3	<> P 9,6,5	1721100.920	440332.800	1721100.920	440332.801	0.000	0.001
4	<> P 9,5,W	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
5	<> P10,8,7	1721100.920	440332.800	1721100.920	440332.798	0.000	-0.002
6	<> P 10,7,6	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
7	<> P 11,8,7	1721100.920	440332.800	1721100.920	440332.801	0.000	0.001
8	<> P 11,6,5	1721100.920	440332.800	1721100.923	440332.801	0.003	0.001
9	<> P 12,8,7	1721100.920	440332.800	1721100.920	440332.801	0.000	0.001
10	<> P 12,6,5	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000

Table (7): The real and computed coordinates and the Accuracy of the resected point (P) in the combination between third and fourth quadrants

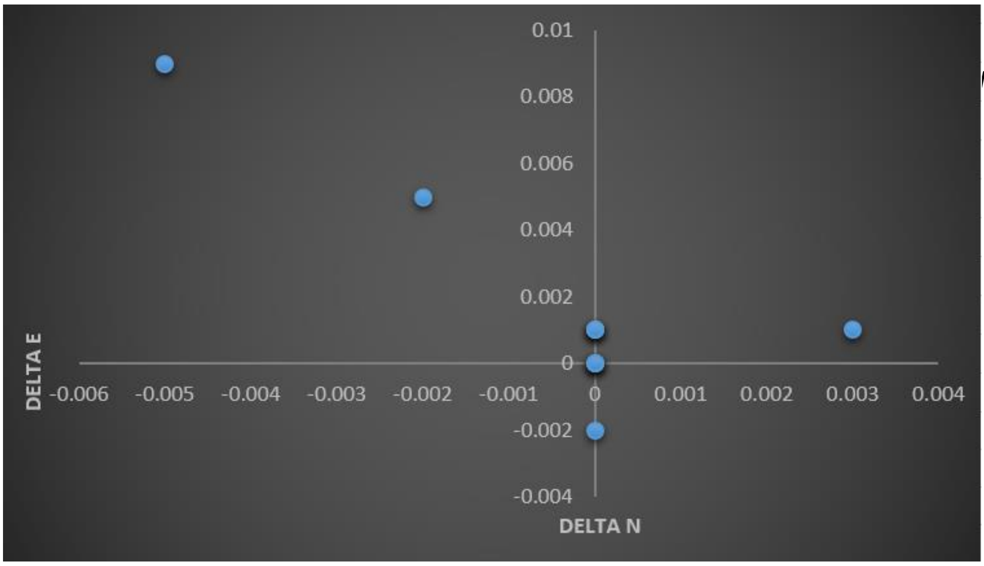

Figure (11) shows the accuracy of the resected point (P) in the combination between third and fourth quadrants

Table (7) and **figure (11)** showed the combination case of the first and second quadrants. All of the cases has millimeters in their accuracy, which means that its more accurate compared to the previous graphs.

4- Computing the accuracy of resected point (P) for the combination between fourth and first quadrants:

No	Triangle No	Observed Np	Observed Ep	Computed Np	computed Ep	Delta N	Delta E
1	<> P 5,4,3	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000
2	<> P5,3,2	1721100.920	440332.800	1721100.920	440332.790	0.000	-0.010
3	<> P 5,2,1	1721100.920	440332.800	1721100.921	440332.798	0.001	-0.002
4	<>p 5,1,N	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
5	<>P 6,3,2	1721100.920	440332.800	1721100.920	440332.803	0.000	0.003
6	<>P 6,2,N	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000
7	<> P 7,3,2	1721100.920	440332.800	1721100.930	440332.800	0.010	0.000
8	<> P7,2,N	1721100.920	440332.800	1721100.920	440332.801	0.000	0.001
9	<> P 8,3,2	1721100.920	440332.800	1721100.921	440332.800	0.001	0.000
10	<>P 8,2,N	1721100.920	440332.800	1721100.920	440332.800	0.000	0.000

Table (8): The real and computed coordinates and the Accuracy of the resected point (P) in the combination between fourth and first quadrants

Figure (12) shows the accuracy of the resected point (P) in the combination between fourth and first quadrants

Table (8) and **figure (12)** showed the case in the combination of the first and second quadrants which is all the cases has millimeters accuracy except the triangle of (5,3,2) which it has one centimeter on the delta eastern coordinates (ΔE) and the triangle of (7,3,2) which it has one centimeter on the delta northern coordinates (ΔN) as well.

5. Conclusion

The procedures of computing the coordinates of the resected point (P) from several known points (control points), and computing the differences between the real coordinates of the resected point and the coordinates of the three-point resection solution from several quadrants (the accuracy) have been conducted. Thus, this study concludes that there is a relationship between the positions of control points and the accuracy of resected point (P). Concerning to the accuracy tables which have been presented before, it shows that the positions of the known-points in combination quadrants have high accuracy compared to their positions in only one quadrant in the three-point resection solution which has been used in this study.

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