OUTLIER DETECTION USING LAD METHOD IN CADASTRAL COORDINATE TRANSFORMATION

Yi-Chun Lin[a*] and Lao-Sheng Lin[b]

[a] Graduate student, Department of Land Economics, Chengchi University, No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 11605, Taiwan;
Tel:+886-9-12191655; E-mail:100257029@ nccu.edu.tw

[b] Associate Professor, Department of Land Economics, Chengchi University, No. 64, Sec. 2, ZhiNan Rd., Wenshan District, Taipei City 11605, Taiwan;
Tel:+886-9-26150390; E-mail: lslin@nccu.edu.tw

KEY WORDS: LAD, parameter estimation, outlier detection, 4-parameter, 6-parameter, Polynomial

Abstract: There are two coordinate systems with different geodetic datum in Taiwan region, i.e., TWD67 (Taiwan Datum, 1967) and TWD97 (Taiwan Datum, 1997). In order to maintain the consistency of cadastral coordinates, it is necessary to transform one coordinate system to another. However, no matter what transformation method was used, the most fundamental influence of accuracy is the quality of data itself. The LAD (Least Absolute Deviations) method was affected by nearly very little or none from blunders. Thus, LAD method, used for parameters estimation, has been successfully used for outlier measurements detection. Therefore, in order to ensure not only the quality of cadastral coordinate data but also the accuracy of cadastral coordinate transforming, this study will take the Least Absolute Deviations method for parameter estimation and outlier detection. The proposed algorithms and the detailed test results will be presented in this paper.

INTRODUCTION

Cadaster is the method of registering land, designed to ensure the rights of individuals and the state of their property. (Kiril Fradkin, 2002) With the changing time and the advance of survey technology, there may have two or more coordinate systems in a region. The cadaster of Taiwan can trace back to Japan manages period, and it has gone through several changes of the period until now. The digitization of graphic cadastral maps makes it convenient in reducing the use rate of paper maps, and offering reliable information on land revisions. Due to the cadastral maps were compiled long time ago, there are some problems, such as paper maps' distortions.

In order to maintain the consistency of cadastral coordinates, it is necessary to transform one coordinate system to another. There are two major coordinate systems with different geodetic datum in Taiwan region, i.e., TWD67 (Taiwan Datum, 1967) and TWD97 (Taiwan Datum, 1997). The detail of these two coordinate systems are shown in Table 1:

Table 1: The detail of TWD67 and TWD97 coordinate systems.

	TWD67	TWD97
reference ellipsoid	GRS67 (Geodetic Reference System 1967)	GRS80 (Geodetic Reference System 1980)
a	6378160 m	6378137 m
b	6356774.7192 m	6356725.3141 m
f	1/298.25	1/298.257222101

Where a is semi-major axis; where b is semi-minor axis; where f is the flattening of the ellipsoid.

There are three primary two-dimensional Cartesian coordinate transformation methods: the conformal transformation (4-parameter), the affine transformation (6-parameter), and the polynomial transformation. However, no matter what transformation method was used, the most fundamental influence of accuracy is the quality of data. Because we are uncertain whether there existing gross errors or not in a number of coordinate data, the outlier detection is an important work before transforming coordinates.

By using LAD (Least Absolute Deviations) theory, the result of adjustment is robust and hardly affected by blunders.

Moreover, the difficulty that condition expression which included absolute that cannot be differential was solved by the improvement of software and program, so LAD was benefit in parameter estimation and outlier detection. Therefore, the purpose of this study is using LAD method to estimate the transforming parameters of cadastral coordinate. And providing a test method to ensure the quality of cadastral coordinate and increase the precision of coordinate transformation before converting one coordinate system to another. Then, we will compare the result of LAD method with LS (Least Squares) method in parameter estimation and outlier detection.

LAD METHOD INTRODUCTION

LAD theory is proposed for straight line fitting by Laplace and Boscovitch during 1755-1757. The LAD is earlier than LSM (Least Squares Method) for 40 years. The LAD is difficult to calculate because un-differential. Thus the development has been at a standstill. Charnes, Cooper and Ferguson proposed a linear programming approach to deal with by the deviation into two nonnegative variable deviations. Thus LAD has become the hot spot of statistical researches.

Least Absolute Deviations (LAD) is known as Least Absolute Errors (LAE), Least Absolute Value (LAV) or L_1 norm. The basic theory of LAD is that supposing there is a set of data that contains points (x_i, y_i) i = 1, 2, ..., n, and finding a formula makes $f(x_i) \approx y_i$. Therefore, supposing $f(x)$ is a linear formula $f(x) = bx + c$ (b, c unknown) or quadratic polynomial $f(x) = ax^2 + bx + c$ (a, b, c unknown) , and making the sum of absolute of observation residuals to be minimized. The function is shown as below:

$$S = \sum_{i=1}^{n} |y_{i-} f(x_i)| \Rightarrow min \tag{1}$$

So far, Least Squares method has been popular in geodetic studies due to its speed, efficiency and simplicity (Amin Nobakhti, 2009). The objective function of LS theory is making the sum of squares of observation residuals to be minimized. Though there are many advantages of this method, the LS method also has some disadvantages, such as more affected from blunders in the observation and spread of blunder in other observations (Yasemin Sisman, 2011). In view of the mathematical model established in accordance with the LS solution, the residuals, obtained as a result, are influenced from all errors of the observations based on the functional model. The most important thing in adjustment with LS method is to assume the observations have the normal distribution. If the observation group has error, observation distribution is not normal distribution. In the LS solution, since the all observations are used in the parameter estimation, even only one outlier in the observation group affected the accuracy and sensitivity of all unknown parameters. The effect of this outlier spreads on all other residuals as well. As a result, if there is an outlier in the observations, the outlier detection, made with the LS method result, may not be done correctly. The solution of LAD method and the results obtained with trial and error method for the parameter estimation are less affected by blunder (Yasemin Sisman, 2011). The observation error is not spread into the other observation residuals less than in LS method. For this reason, LAD method is generally used in outlier detection and it is more robust than LS method (Bektas and Sisman, 2010). Besides, it especially conduces to use in researches that ignore considering the issue of outliers. The table of functional model and the objective function of LS and LAD methods is shown as below:

The table of functional model and the objective function of LS and LAD methods is shown as below:

Table 2: The functional model and the objective function of adjustment methods.

Method	Functional Model	Objective function
The least square method	$L + V = AX$	$[PVV] = min.$
The least absolute deviations method	$L + V = AX$	$[P\|V\|] = min.$

Although LAD method overcomes the shortcoming of LS method, how to establish and implement algorithm is still a difficulty. However, with the developing of software and programs, the difficulty of un-differential absolute is conquered. Thus, LAD method leads to good effectiveness in not only parameter estimation but also outlier detection.

CADASTRAL COORDINATE TRANSFORMATION METHODS

The flow chart of this study is shown as Figure 1.

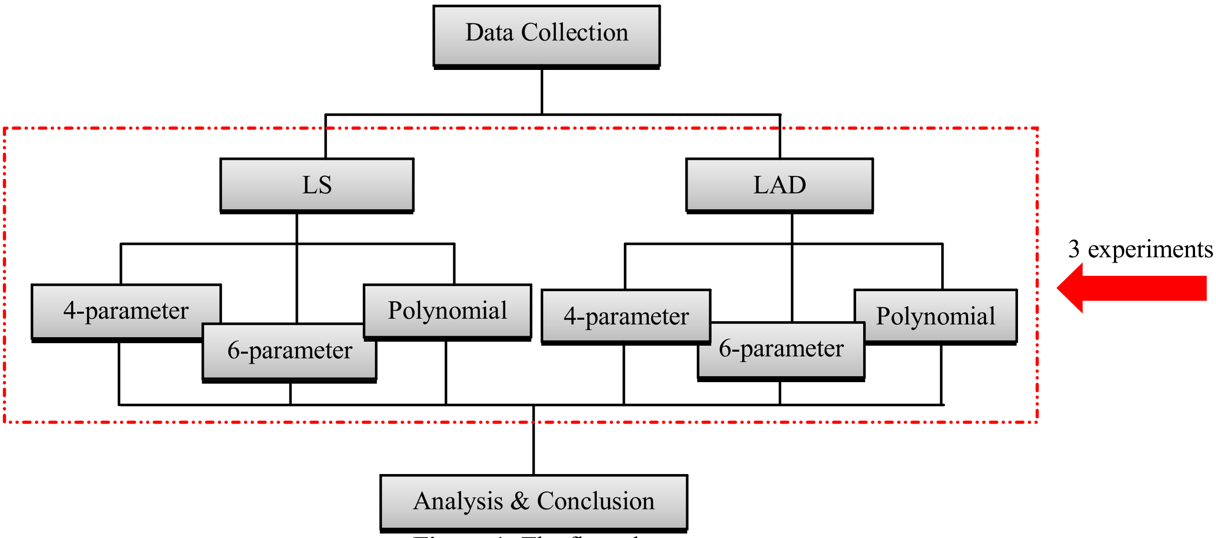

Figure 1: The flow chart

The first step is data collection. The data of this study takes Hualien's graphic cadastral coordinates. There are 37 center stakes (contain TWD67 and TWD97 coordinates) in this area, choosing 16 center stakes as reference points and regarding others as check points, shown as figure 2. Otherwise, in order to investigate the different methods in a variety of circumstances, this study will test in three different experiments which are introduced afterwards.

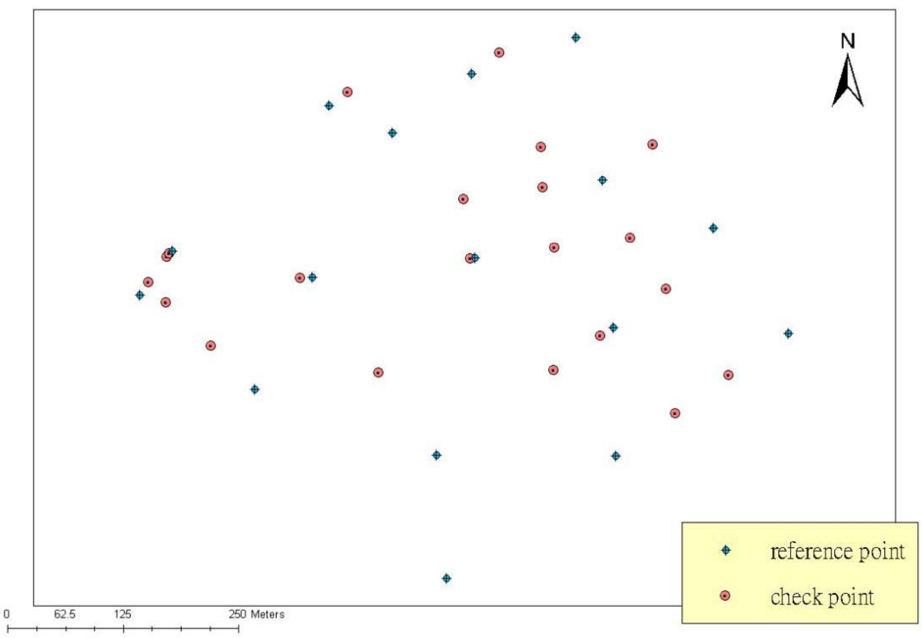

Figure 2: The distribution of reference points and check points

The three primary two-dimensional Cartesian coordinate transformation methods are the 4-parameter (conformal) transformation, the 6-parameter (affine) transformation, and the polynomial transformation. The details about these methods are introduced below:

1. The 4-parameter transformation (or conformal transformation) is a linear transformation. This method contains two rotation parameters and two origin shift parameters (T_x, T_y). The rotation is defined by one rotation angle and the scale change by one scale factor. The simplified equation expresses as formula(2):

$$\begin{cases} ax - by + T_x = X + V_X \\ bx + ay + T_y = Y + V_Y \end{cases} \tag{2}$$

The transformation parameters are a, b, T_x, T_y.

Then, formula (2) is converted into $AX=L+V$ matrix model in order to solve conveniently, shown as formula (3):

$$\begin{bmatrix} x & -y & 1 & 0 \\ y & x & 0 & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ T\ x \\ T\ y \end{bmatrix} = \begin{bmatrix} X \\ Y \end{bmatrix} + \begin{bmatrix} V_X \\ V_Y \end{bmatrix} \tag{3}$$

2. The 6-parameter is known as affine transformation is a linear transformation. The transformation function is expressed with 6 parameters: one rotation angle, two scale factors, a scale factor in the x-direction and a scale factor in the y-direction, and two origin shifts. The simplified equation is:

$$\begin{cases} ax + by + c = X + V_X \\ dx + ey + f = Y + V_Y \end{cases} \tag{4}$$

where the transformation parameters are a, b, c, d, e and f.

In order to solve conveniently, converting formula (4) into $AX=L+V$ matrix model, shown as formula (5):

$$\begin{bmatrix} x & y & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x & y & 1 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \\ d \\ e \\ f \end{bmatrix} = \begin{bmatrix} X \\ Y \end{bmatrix} + \begin{bmatrix} V_X \\ V_Y \end{bmatrix} \tag{5}$$

3. The polynomial transformation is a non-linear transformation method. It relates two coordinate systems through a translation, a rotation and a variable scale change. The transformation function can have an infinite number of terms. The equation is:

$$\begin{cases} X = a_0 + a_1 x + a_2 y + a_3 xy + a_4 x^2 + a_5 y^2 \\ Y = b_0 + b_1 x + b_2 y + b_3 xy + b_4 x^2 + b_5 y^2 \end{cases} \tag{6}$$

The transformation parameters are a_0, a_1, a_2, a_3, a_4, a_5, b_0, b_1, b_2, b_3, b_4 and b_5.

In order to solve conveniently converting formula (6) into $AX=L+V$ matrix model, shown as formula (7) and formula (8):

$$\begin{bmatrix} 1 & x & y & xy & x^2 & y^2 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix} = [X] + [V_X] \tag{7}$$

$$\begin{bmatrix} 1 & x & y & xy & x^2 & y^2 \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix} = [Y] + [V_Y] \tag{8}$$

TEST DATA

In this study, it is going to transform coordinates from TWD67 system to TWD97 system. Here are three experiments tested in this study with three different data sets-set 1, set 2, and set 3.

1. The first experimental data (set 1) is original, shown as Table 3.

Table 3: The coordinates of reference point -set 1.

ID	TWD67		TWD97	
	X(m)	*Y(m)*	*X(m)*	*Y(m)*
C476	310165.450	2652240.630	310994.503	2652050.615
C454	310348.990	2652373.510	311178.023	2652183.555
C473	309958.560	2652446.100	310787.563	2652256.040
C463	310154.950	2652374.680	310983.993	2652184.592
C429	310535.740	2652506.970	311364.760	2652317.042
C444	310346.322	2652513.160	311175.303	2652323.207
C421	309833.880	2652549.340	310662.855	2652359.271
C423	310019.990	2652568.090	310848.957	2652378.054
C425	310196.510	2652588.550	311025.485	2652398.566
C386	309868.810	2652596.070	310697.770	2652406.018
C428	310454.560	2652621.410	311283.531	2652431.484
C361	310334.950	2652673.020	311163.878	2652483.085
C363	310107.130	2652723.980	310936.058	2652533.995
C376	310038.330	2652753.660	310867.260	2652563.677
C359	310192.790	2652788.050	311021.716	2652598.074
C348	310305.658	2652828.485	311134.573	2652638.515

2. In the second experimental data, the blunder (100m) is added to x coordinate of C463 in TWD67 system, shown as Table 4.

Table 4: The coordinates of reference point -set 2.

ID	TWD67		TWD97	
	X(m)	*Y(m)*	*X(m)*	*Y(m)*
C463	310254.950	2652374.680	310983.993	2652184.592

3. In the third experimental data, besides the blunder has added in C463, the blunder (-10m) is separately added to x and y coordinate of C376 in TWD67 system, shown as Table 5.

Table 5: The coordinates of reference point -set 3.

ID	TWD67		TWD97	
	X(m)	*Y(m)*	*X(m)*	*Y(m)*
C463	310254.950	2652374.680	310983.993	2652184.592
C376	310028.330	2652743.660	310867.260	2652563.677

TEST RESULTS AND DISCUSSION

1. Experiment 1 (use set 1 data):
When there is not existing blunder, the result of transforming parameters is shown as Table 6:
Table 6: Estimation values of unknown parameters.

Method	LS		LAD	
4-parameter	a = 1.000059	T_x = 829.099622	a = 0.99997585	T_x = 829.10505768
	b = 0.000236	T_y = -190.070636	b = 0.00017394	T_y = -190.03276822
6-parameter	a = 1.000027	d = 0.000217	a = 1.00002573	d = 0.00015388
	b = -0.000264	e = 1.000108	b = -0.00033495	e = 1.00009674
	c = 829.121566	f = -190.095593	c = 829.13023996	f =-190.06866809
polynomial	a_0 = 829.13195479	b_0 =-190.14783684	a_0 = 829.11606068	b_0 =-190.06724505
	a_1 = 1.00006220	b_1 =0.00050552	a_1 = 0.99995498	b_1 =0.00037147
	a_2 = -0.00033891	b_2 =1.00017927	a_2 = -0.00022456	b_2 =0.99994621
	a_3 = -0.00000012	b_3 =-0.00000055	a_3 = 0.00000009	b_3 =-0.00000028
	a_4 = 0.00000009	b_4 =0.00000006	a_4 = 0.00000002	b_4 =0.00000008

	a_5 = 0.00000009	b_5 =0.00000004	a_5 = -0.00000008	b_5 =0.00000020

The following table is the residuals of this experiment.

Table 7: The residuals of point coordinate with real case application.

ID	LS					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	-0.0003	-0.0024	0.0096	-0.0185	0.0107	-0.0244
C454	-0.0008	-0.0113	-0.0005	-0.0242	0.0022	-0.0093
C473	-0.0109	0.0060	-0.0004	0.0038	-0.0043	-0.0114
C463	-0.0225	0.0760	-0.0161	0.0667	-0.0204	0.0601
C429	-0.0082	0.0136	-0.0176	0.0039	-0.0096	0.0178
C444	0.0182	-0.0057	0.0145	-0.0116	0.0121	-0.0094
C421	-0.0146	-0.0083	-0.0031	-0.0031	0.0015	-0.0017
C423	-0.0001	0.0037	0.0051	0.0064	0.0017	0.0054
C425	-0.0025	-0.0055	-0.0035	-0.005	-0.0092	-0.0081
C386	-0.0086	-0.0143	0.0005	-0.0075	0.0052	0.0015
C428	0.0091	-0.0008	-0.0011	-0.0034	-0.0013	-0.0107
C361	0.0328	-0.0169	0.0250	-0.0148	0.0210	-0.0245
C363	0.0074	-0.0176	0.0053	-0.0088	0.0047	-0.0023
C376	-0.0057	-0.0341	-0.0065	-0.0225	-0.0027	-0.0059
C359	-0.0007	-0.0026	-0.0073	0.0078	-0.0075	0.0075
C348	0.0075	0.0204	-0.0039	0.0307	-0.0043	0.0155

Table 8: The residuals of point coordinate with real case application.

ID	LAD					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	-0.006207	-0.005200	-0.000896	0.004929	-0.001065	0.000993
C454	0.001338	0.026083	0.018891	0.023831	0.013529	0.001200
C473	-0.025463	-0.009252	0.023249	-0.028112	0.002892	0.001076
C463	0.006856	-0.073137	0.034275	-0.079423	0.023616	-0.072139
C429	0.016062	0.023822	0.045790	0.009182	0.032286	-0.031558
C444	-0.026435	0.031919	0.013736	0.012731	-0.001517	0.000193
C421	-0.038516	0.005928	0.033037	-0.027913	0.006788	0.000530
C423	-0.038760	0.007008	0.026530	-0.025366	0.004331	-0.007656
C425	-0.022939	0.028798	0.036842	-0.002509	0.016583	0.001339
C386	-0.044544	0.017980	0.032791	-0.020809	0.007186	0.000793
C428	-0.014993	0.042706	0.037211	0.012603	0.016340	-0.009633
C361	-0.051904	0.055757	0.014575	0.017016	-0.008039	0.006796
C363	-0.048540	0.046615	0.037505	-0.002857	0.014253	-0.003585
C376	-0.043039	0.061299	0.051216	0.006859	0.027948	0.003814
C359	-0.037328	0.042262	0.054761	-0.013237	0.031052	-0.023687
C348	-0.038569	0.029606	0.054402	-0.028517	0.029189	-0.046733

Table 9: The standard deviation of reference points.

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.0209	0.0322	0.0156	0.0259	0.0127	0.0219	0.0132	0.0240	0.0106	0.0223	0.0099	0.0200

Table 10: The standard deviation of check points.

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.0177	0.0179	0.0173	0.0186	0.0163	0.0103	0.0176	0.0089	0.0148	0.0099	0.0144	0.0109

Discussion: On the whole, the best accuracy is calculated by LS method with polynomial. Moreover, the precision of LAD method with polynomial is improved between LS method with 4-parameter and 6-parameter, this result is better than the result of LAD method with 4-parameter and 6-parameter. If the accuracy of LAD method with polynomial has satisfied the need of standardization, this method will be more useful. However, the accuracy of LS method is better than LAD method in general. Therefore, the LS method is the better and more convenient when there is no blunder in the data.

2. Experiment 2 (use set 2 data):
The following is the result of transforming parameters, when blunder (100m) is added.

Table 11: Estimation values of unknown parameters with tainted point coordinates.

Method	LS		LAD	
4-parameter	a = 0.993188	T_x = 813.022472	a = 0.99999136	T_x = 829.12463090
	b = -0.019182	T_y = -182.549214	b = 0.00014589	T_y = -190.00915109
6-parameter	a = 0.990366	d = 0.000205	a = 0.99998986	d = 0.00021118
	b = 0.049198	e = 1.000119	b = -0.00031220	e = 1.00000437
	c = 796.387602	f = -190.100405	c = 829.15737540	f = -190.05617310
polynomial	a_0 = 831.63076781	b_0 =-190.12701619	a_0 = 829.09167259	b_0 = -190.20612595
	a_1 = 0.84910435	b_1 = 0.00032080	a_1 = 1.00003899	b_1 = 0.00060686
	a_2 = -0.06246376	b_2 = 1.00015167	a_2 = -0.00014560	b_2 = 1.00048621
	a_3 = 0.00014916	b_3 = -0.00000026	a_3 = -0.00000013	b_3 = -0.00000066
	a_4 = 0.00016708	b_4 = 0.00000008	a_4 = 0.00000015	b_4 = -0.00000013
	a_5 = 0.00007664	b_5 =0.00000002	a_5 = -0.00000014	b_5 = -0.00000028

The following is the residuals of this experiment.
Table 12: The residuals of point coordinate with tainted values.

ID	LS					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	-12.5419	2.6530	-22.4209	-0.0230	-22.4688	-0.0293
C454	-11.2233	-1.8327	-17.6317	-0.0297	-22.9095	-0.0241
C473	-7.1413	5.2669	-10.2690	0.0041	-6.2024	-0.0036
C463	89.4298	0.0961	83.3218	0.0842	76.5810	0.0832
C429	-9.9224	-6.3510	-12.8520	-0.0026	-1.7322	0.0087
C444	-8.4744	-2.7348	-10.6836	-0.0157	-14.9324	-0.0157
C421	-4.2837	6.9642	-3.9606	-0.0002	7.5364	0.0043
C423	-5.1838	3.2336	-4.8232	0.0071	-9.3423	0.0053
C425	-6.0018	-0.3437	-5.5252	-0.0064	-13.5081	-0.0104
C386	-3.6103	5.9589	-1.9831	-0.0045	3.6766	0.0024
C428	-7.1253	-5.5754	-6.3907	-0.0077	1.5040	-0.0089
C361	-5.2776	-3.6237	-2.6562	-0.0170	-2.7936	-0.0223
C363	-2.7482	0.4492	2.0457	-0.0076	-5.0266	-0.0062
C376	-1.7122	1.5647	4.1668	-0.0201	-2.0716	-0.0131

C359	-2.1007	-1.6394	4.3746	0.0086	0.8577	0.0068
C348	-2.0829	-4.0858	5.2875	0.0304	10.8317	0.0229

Table 13: The residuals of point coordinate with tainted values.

ID	LAD					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	-0.035095	-0.027907	-0.027573	0.005181	-0.000722	0.019513
C454	-0.034122	0.006465	-0.004226	0.025839	0.001017	-0.002018
C473	-0.056907	-0.040947	-0.015521	0.002974	0.003375	-0.002195
C463	-100.024764	-0.112806	-99.994814	-0.087306	-99.981284	-0.108588
C429	-0.026037	0.007373	0.026333	0.012817	0.011075	-0.006228
C444	-0.065772	0.010061	-0.012654	0.027792	-0.006639	-0.001099
C421	-0.070922	-0.030865	-0.012553	0.019853	-0.003400	-0.001415
C423	-0.074578	-0.024855	-0.012812	0.013468	0.004284	-0.021026
C425	-0.062068	0.001569	0.003364	0.028100	0.019689	-0.006149
C386	-0.078803	-0.018557	-0.012609	0.029272	-0.002193	-0.006275
C428	-0.059043	0.022205	0.012239	0.031460	0.013240	0.021785
C361	-0.095548	0.031102	-0.015860	0.047495	-0.001813	0.029010
C363	-0.090082	0.014779	-0.002260	0.045384	0.020019	0.002111
C376	-0.084347	0.027073	0.008309	0.061784	0.030367	0.010416
C359	-0.081994	0.011836	0.016612	0.036014	0.043604	0.007010
C348	-0.086120	0.001719	0.019380	0.018001	0.048282	0.016813

Table 14: The standard deviation of reference points.

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
24.0754	4.0562	23.5667	0.0267	22.5928	0.0261	24.9895	0.0355	24.9982	0.0326	24.9983	0.0309

Table 15: The standard deviation of check points.

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.0181	0.0215	0.0163	0.0121	0.0199	0.0153	2.5026	4.0891	5.5782	0.0114	8.3595	0.0111

Discussion: According to experiment 1, using LS method to transform coordinate can get better accuracy. However, when there are blunders in observation, the effect of these errors will spread on all other residuals. In the second experiment, when 100m error is added, the error spread on all others. But, the residual of tainted point is obviously greater than other points, so we still can figure out the tainted point. On the other hand, when using LAD method, only the residual of tainted point is affected, and almost doesn't influence on others.

3. Experiment 3 (use set 3 data):
The following is the result of transforming parameters, when new blunders (-10m,-10m) are added.

Table 16: Estimation values of unknown parameters with tainted point coordinates.

Method	LS		LAD	
4-parameter	a = 0.993286	T_x = 811.814880	a = 1.00004972	T_x = 829.08542339
	b = -0.022373	T_y = -181.407242	b = 0.00018348	T_y = -190.04300568
6-parameter	a = 0.987976	d = -0.002163	a = 1.00001423	d = 0.00021154
	b = 0.053776	e = 1.004417	b = -0.00022115	e = 1.00004509
	c = 794.864482	f = -191.492581	c = 829.10202678	f = -190.07139001
polynomial	a_0 = 826.91172214	b_0 = -194.58491136	a_0 = 829.10663798	b_0 = -190.09077302
	a_1 = 0.88803836	b_1 = 0.03824167	a_1 = 1.00011640	b_1 = 0.00040614
	a_2 = -0.06405382	b_2 = 0.99797359	a_2 = -0.00030367	b_2 = 1.00005998
	a_3 = 0.00007458	b_3 = -0.00007288	a_3 = -0.00000022	b_3 = -0.00000032
	a_4 = 0.00016728	b_4 = 0.00000034	a_4 = 0.00000012	b_4 = -0.00000003
	a_5 = 0.00009615	b_5 = 0.00001963	a_5 = 0.00000010	b_5 = 0.00000009

The following table is the residuals of this experiment.

Table 17: The residuals of point coordinate with tainted values.

ID	LS					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	-12.9653	3.2905	-23.2379	-0.7726	-22.9632	-0.4863
C454	-11.2047	-1.7681	-18.2791	-0.6427	-21.6112	1.2382
C473	-6.9292	6.5847	-9.6509	0.6275	-7.9833	-1.7596
C463	89.4429	0.4610	82.9046	-0.3011	76.8192	0.3088
C429	-9.4597	-6.8694	-13.3347	-0.4842	-1.5849	0.1497
C444	-8.0104	-2.6481	-10.6852	-0.0221	-15.0780	-0.1714
C421	-3.7543	8.6900	-2.5719	1.3623	8.1744	0.6018
C423	-4.5764	4.3672	-3.7934	1.0095	-8.7382	0.5713
C425	-5.3118	0.2285	-4.8237	0.6660	-13.3738	0.1039
C386	-2.9283	7.5777	-0.4640	1.4761	5.6683	1.9213
C428	-6.3053	-5.8235	-6.1554	0.1949	0.0009	-1.4731
C361	-4.3045	-3.4850	-1.8989	0.6907	-3.4973	-0.7061
C363	-1.6347	1.3199	3.5809	1.4586	-2.2843	2.6689
C376	-10.6673	-7.0512	-4.4153	-8.2860	-7.9458	-5.7058
C359	-0.7744	-1.0358	5.9983	1.5473	3.1813	2.2958
C348	-0.6166	-3.8385	6.8266	1.4757	11.2159	0.4426

Table 18: The residuals of point coordinate with tainted values.

ID	LAD					
	4-parameter		6-parameter		polynomial	
	Vx	*Vy*	*Vx*	*Vy*	*Vx*	*Vy*
C476	0.003501	-0.014315	0.001834	0.010540	0.000000	0.002483
C454	-0.001245	0.005402	0.008609	0.025722	0.000000	0.004212
C473	0.001487	-0.031572	0.000216	0.000042	0.011940	-0.002802
C463	-99.986354	-0.110402	-99.979795	-0.087437	-99.980027	-0.103383
C429	0.000957	-0.008498	0.022466	0.007199	0.006305	-0.013492
C444	-0.027489	0.000948	-0.012470	0.021990	-0.011141	0.003076
C421	-0.001372	-0.022829	-0.003179	0.012762	0.000000	0.000716
C423	-0.015185	-0.024908	-0.009680	0.005546	0.000000	-0.012529
C425	-0.012208	-0.006313	0.000333	0.019282	0.010182	-0.001029
C386	-0.009534	-0.014561	-0.008342	0.020266	-0.006233	-0.000105
C428	-0.023009	0.002706	-0.000071	0.021212	0.000000	0.004570
C361	-0.050593	0.013086	-0.029956	0.035188	-0.022111	0.014359
C363	-0.029915	0.002352	-0.015445	0.031084	-0.008884	-0.002643
C376	9.979614	10.017832	9.992028	10.048866	9.993892	10.009156

C359	-0.024419	-0.007550	-0.004495	0.019074	0.002366	-0.016333
C348	-0.033612	-0.024269	-0.008159	-0.000626	0.000000	-0.030406

Table 19: The standard deviation of reference points.

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
24.1425	5.0141	23.5702	2.3537	22.7447	1.9531	25.2825	2.5086	25.2838	2.5100	25.2845	2.5050

Table 20: The standard deviation of check points..

standard deviation											
LAD with 4-parameter		LAD with 6-parameter		LAD with polynomial		LS with 4-parameter		LS with 6-parameter		LS with polynomial	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.0177	0.0135	0.0145	0.0101	0.0146	0.0103	2.7721	4.7435	6.2207	0.6819	8.8188	1.3056

Discussion: According to the checking results is as shown in Table 20, the method of LAD method can remove most of errors. In addition, it is difficult to figure out data with blunder by LS method when there are containing both 100m and -10m errors. Due to the effect of LS theory which is spreading errors into the other observation residuals, these residuals even over -10m. For this reason, theses blunders will be hard to recognize by LS method. Thus, the adjustment results will not be tainted even data with 100m or -10m errors in this dataset by using LAD method.

CONCLUSIONS

1. The accuracy of transformation by LS method is better, but it would be easily affected by blunders. Although the accuracy of transformation by LAD method is not that good as LS method, LAD method is independent of blunders. Therefore, processing the coordinate transformation without detecting blunders, there is no certainty that LS method would be better than LAD method. In the other hand, the combination of LAD and polynomial could achieve the same level of accuracy with 4-parameter or 6-parameter transformation.

2. According this study, LAD method transformation wouldn't be affected by blunders. It could find out blunders by residuals to verify the ability of error detecting.

3. For better result, the study recommended that one should use LAD method to detect blunders first. After deleting these data, there should be a better result produced by LS method.

REFERENCES:

Kiril Fradkin, Yerach Doytsher, 2002. Establishing an urban digital cadastre: analytical reconstruction of parcel boundaries. Computers, Environment and Urban Systems, 26 (2002), pp.447–463.
Bijan Bidabad, 2005. L1 Norm Based Data Analysis and Related Methods. Tehran, Iran.
Amin Nobakhti, 2009. Algorithm for very fast computation of Least Absolute Value regression. 2009 American Control Conference.
Yasemin Sisman, 2010. Outlier measurement analysis with the robust estimation. Scientific Research and Essays Vol. 5(7), pp. 668-678.
Yasemin Sisman, 2010. The comparison of L1 and L2-norm minimization methods. International Journal of the Physical Sciences Vol. 5(11), pp. 1721-1727.
Yasemin Sisman, 2011. Parameter estimation and outlier detection with different estimation methods. Scientific Research and Essays Vol. 6(7), pp. 1620-1626.