The Transformation Programming of 3-D Rectangular Coordinates Based on VBA

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Abstract

Since the emergence of GNSS space positioning technology, space rectangular coordinate system has been widely used. People often encounter problems of converting between different spatial rectangular coordinate systems. This paper first introduces the definition of WGS-84 geodetic coordinate system and the 2000 National Geodetic coordinate system, and when the mutual conversion between them, their common Bursa conversion model, and described the seven-parameter solving process, and then use VBA to achieve mutual conversion between the two coordinate systems, as well as four-parameters and seven-parameters calculation programs .Finally verify all programs with examples to ensure the reliability of its results.

Keywords

Spatial rectangular coordinate system, Bursa Model, Seven parameter, VBA.

1. Introduction

The social development requirement of modern surveying and mapping results must be accurate, intuitive, vivid and dynamic form presented to the user, both professionals and management personnel to meet the demand, can also satisfy the public understanding and cooperation of the world. That is the result of our traditional surveying and mapping such as paper map and later proposed 3D products (DLG, DEM, DOM) is increasingly showing its shortcomings.

In the popular of the geographic data sources today, how these from different equipment, different period, different reference systems and different precision data integration display is a very important research topic, and the integration of these data is the basic work of the independent sources of data to calculate the same coordinate system.

If the data from GPS system from the United States, Russia, the Grenadines or the Beidou system of China will have their own location, data from the base of laser scanning, mobile laser scanning, indoor laser data acquisition system also have their own assumptions or self positioning reference system, from the air base such as unmanned or someone aircraft equipped with different sensor data also have reference positioning system, and from all kinds of photographic equipment under different working environment have different coordinate system data, as well as large equipment installation construction coordinate system and so on, the common feature of these data is three-dimensional positioning system, namely the space Cartesian coordinate system, which is owned their coordinates O and perpendicular to the axis of a custom O_X-O_Y-O_Z system, the origin of no coincidence, axial coordinates vary, there are left-handed and the right hand.

The core of the conversion is the parameters of calculation in different coordinate system conversion , often using the seven parameter Bursa-Wlof model, Molodensky model and Wuhan measurement

model. When the two coordinate system have 3 common points, we can only calculate the 7 transformation parameters; more than 3 common point, must carry on the adjustment the calculation involves the transfer problem. The measurement error analysis is required on the accuracy of coordinate transformation, so as to effectively control the overall measurement accuracy.

This software makes the WGS-84 geodetic coordinate system and the 2000 national geodetic coordinate system can be converted to each other, and can also calculate the four parameters and seven parameters.

At the same time, the use of computer programs to process the measuring data, fast,accurate and repeatable.VBA has user-friendly operation interface, it's convenient,fast, powerful function, wide application and the database is easy to maintain, it not only can be extended two times and widely supported the development ability of height, but also has a powerful database access capability, in the measurement of program design, has the obvious superiority in the processing of batch data.

2. Bursa-Wolf transformation model

2.1 Coordinate conversion

The three-dimensional coordinate transformation model for Bursa-Wolf model, Wuhan measurement model and Molodensky model, the Molodensky model has low precision, low efficiency, and the bursa Wolf model has been widely used because there is no model error, projection distortion error and high precision.Bursa - Wolf model is also known as the seven parameter Hull mote transform (7-Parameter Helmert Transformation) or seven parameters (7-Parameter Transformation transform), as shown in Figure 1 in the model. The 7 parameters are used, 3 translation parameters T_X, T_Y, T_Z, 3 rotation parameter w X w Y w Z (also known as the 3 Euler angles) 1 and the scale parameter m [1].

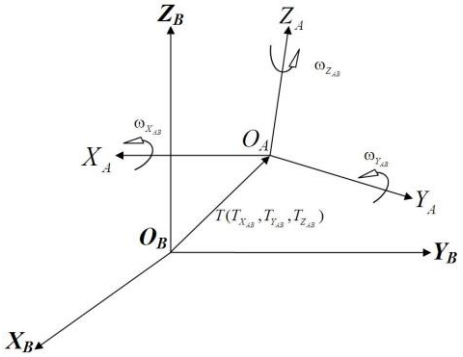

Fig.1 Bursa seven-parameter transformation

The geometric definition of WGS-84 geodetic coordinate system is: the origin is located at the centroid of the earth, Z axis pointing BIH 1984 protocol polar (CTP), X BIH 1984 axis point of intersection zero meridional and equatorial axis Y and CTP, Z, X axis of coordinates.

The 2000 national geodetic coordinate system origin in the inner earth, Z axis for International Earth rotation Bureau (IERS) reference pole (IRP), X axis IERS reference meridian plane (IRM) and the intersection of the equatorial plane perpendicular to the Z axis, Y axis and Z axis and X axis to form right orthogonal coordinates [2].

Assuming that there are WGS-84 coordinates O_A-$X_AY_AZ_A$ and 2000 national geodetic coordinate system O_B-$X_BY_BZ_B$, the realization of the O_A-$X_AY_AZ_A$ coordinates under the O_B-$X_BY_BZ_B$ coordinates of the steps is:

First through the coordinate origin translation, so that the origin of the coordinates of OA and OB Secondly, through the rotation angle, to achieve the conversion of the O_A-$X_AY_AZ_A$ under the O_B-$X_BY_BZ_B$ coordinates to the coordinates of the conversion. The mathematical formula can be used to express the conversion process as follows[3][4][5]:

$$\begin{bmatrix} X_B \\ Y_B \\ Z_B \end{bmatrix} = \begin{bmatrix} T_{X_{AB}} \\ T_{Y_{AB}} \\ T_{Z_{AB}} \end{bmatrix} + (1+m_{A,B}) R_3(\omega_{Z_{A,B}}) R_2(\omega_{Y_{A,B}}) R_1(\omega_{X_{A,B}}) \begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix} \tag{1}$$

In form:

$$R_1(\omega_{X_{A,B}}) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\omega_{X_{A,B}} & \sin\omega_{X_{A,B}} \\ 0 & -\sin\omega_{X_{A,B}} & \cos\omega_{X_{A,B}} \end{bmatrix}$$

$$R_2(\omega_{Y_{A,B}}) = \begin{bmatrix} \cos\omega_{Y_{A,B}} & 0 & -\sin\omega_{Y_{A,B}} \\ 0 & 1 & 0 \\ \sin\omega_{Y_{A,B}} & 0 & \cos\omega_{Y_{A,B}} \end{bmatrix}$$

$$R_3(\omega_{Z_{A,B}}) = \begin{bmatrix} \cos\omega_{Z_{A,B}} & \sin\omega_{Z_{A,B}} & 0 \\ -\sin\omega_{Z_{A,B}} & \cos\omega_{Z_{A,B}} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Taking into account the usual case, two different benchmark rotation between the 3 Euler angles of X, Y, and Z are very small, so the Bursa sand model can be simplified as [6][7][8]:

$$\begin{bmatrix} X_B \\ Y_B \\ Z_B \end{bmatrix} = \begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & -Z_A & Y_A & X_A \\ 0 & 1 & 0 & Z_A & 0 & -X_A & Y_A \\ 0 & 0 & 1 & -Y_A & X_A & 0 & Z_A \end{bmatrix} \begin{bmatrix} T_X \\ T_Y \\ T_Z \\ \omega_Z \\ \omega_Y \\ \omega_X \\ m \end{bmatrix} \tag{2}$$

2.2 Seven parameter solution

When doing the space coordinate transformation, if the public control point observation number n greater than 3, according to the seven parameters of least square method in the bursa model, respectively is 3 T_X T_Y, T_Z translation parameters and rotation parameters, X, Y, Z (also known as the 3 Euler angle) and 1 scale parameter m, after verification, seven parameters are correct.

The software has certain practicability, it makes the WGS-84 geodetic coordinate system and the 2000 national geodetic coordinate system can be converted to each other, according to user needs, to achieve a single point conversion and batch data conversion, and ensure the reliability. VBA is easily links its database, and easy to deal with the mass data.

3. Program design

This program is designed to make the WGS-84 geodetic coordinate system and the 2000 national geodetic coordinate system can be converted to each other, and can also calculate the four parameters and seven parameters.

3.1 Flow chart

Above the flow chart, (1) Has seven parameters for the measurement area, you can directly coordinate conversion, if the measured area without seven parameters, you can enter the coordinates of the common point to solve the seven parameters.

(2) To enter the coordinates of no less than four common points, calculated according to the seven parameters of the Bursa model.

(3) Test for the reliability of the seven parameters, if the residual error within the allowable range, the calculation is correct; if the residual is too large, then we should check the coordinates of the public point of the input is correct.

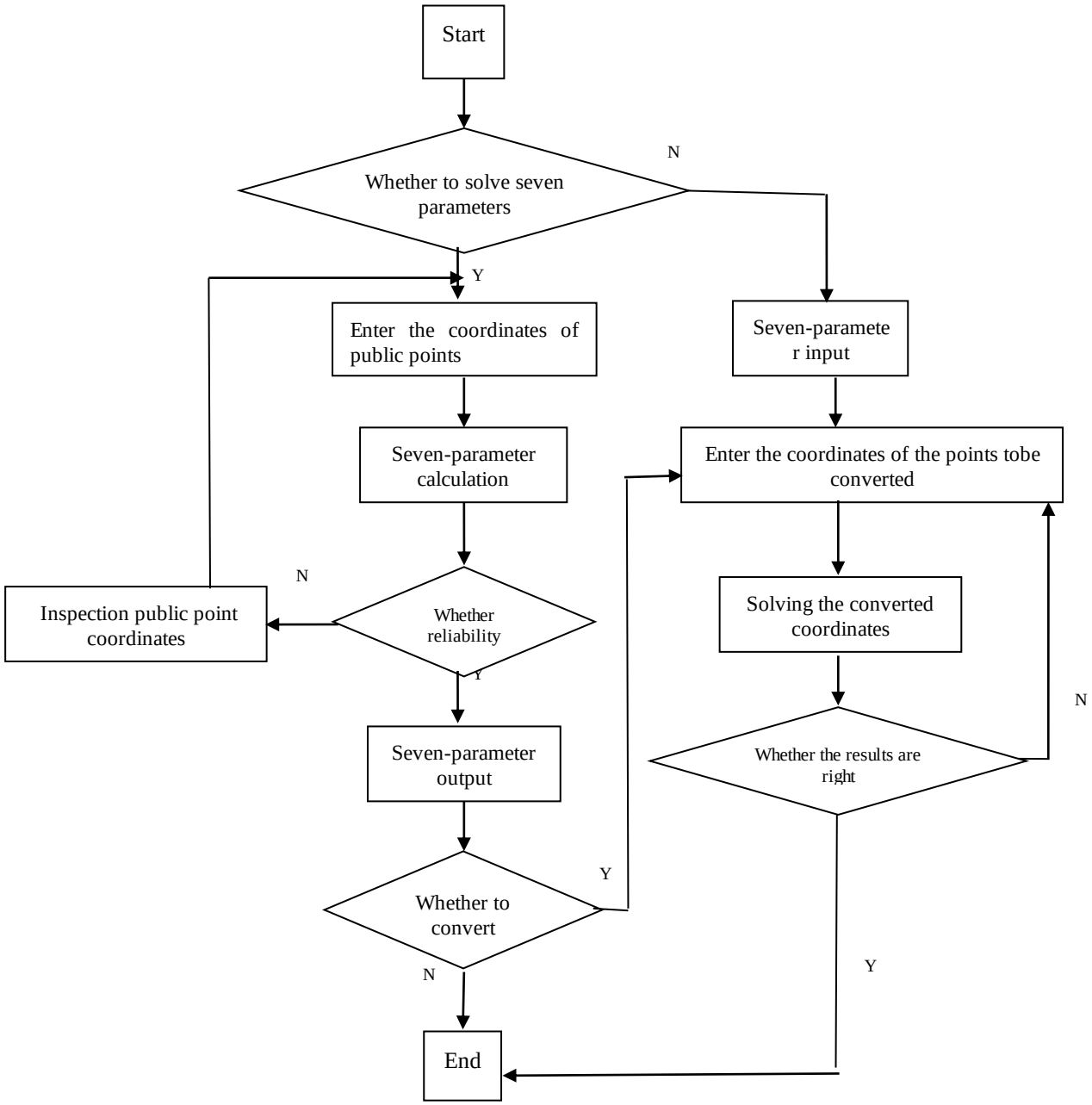

Fig.2 flow chart of Bursa calculation of seven parameters

3.2 Main module code

Seven parameter calculation process is more important, is the core part of the independent research and development module, the calculation of the seven parameter code is as follows.

```
Option Compare Database
'////////////// Calculation of seven parameters ////////////////////
Private Sub Cmd_cal_Click()
    Dim i As Integer, j As Integer, k As Integer
    Dim n As Integer    ' Number of common points
     Dim A() As Double   ' coefficient matrix
```

```
Dim P() As Double 'right array
Dim L() As Double 'constant term matrix
   Dim rs1 As ADODB.Recordset
   Set Conn = CurrentProject.Connection
   Set rs1 = New ADODB.Recordset
   rs1.Open " Seven parameter calculation of space right angle coordinate common point", Conn, adOpenDynamic, adLockOptimistic
   rs1.MoveFirst
   n = 0
   Do While Not rs1.EOF
      n = n + 1
      rs1.MoveNext
   Loop
   ReDim A(1 To 3 * n, 1 To 7)
   ReDim P(1 To 3 * n, 1 To 3 * n)
   ReDim L(1 To 3 * n)
   ReDim CX(1 To 7)    ' seven parameters
   rs1.MoveFirst
   i = 1
     Do While Not rs1.EOF
      k = (1 + (i - 1) * 3)
      A(k, 1) = 1: A(k, 2) = 0: A(k, 3) = 0: A(k, 4) = 0
      A(k, 5) = -1 * rs1!A_ Z: A(k, 6) = rs1!A_ Y: A(k, 7) = rs1!A_ X
      L(k) = rs1!B_ X - rs1!A_ X
      A(k + 1, 1) = 0: A(k + 1, 2) = 1: A(k + 1, 3) = 0: A(k + 1, 4) = rs1!A_ Z
      A(k + 1, 5) = 0: A(k + 1, 6) = -1 * rs1!A_ X: A(k + 1, 7) = rs1!A_ Y
      L(k + 1) = rs1!B_ Y - rs1!A_ Y
      A(k + 2, 1) = 0: A(k + 2, 2) = 0: A(k + 2, 3) = 1: A(k + 2, 4) = -1 * rs1!A_Y
      A(k + 2, 5) = rs1!A_ X: A(k + 2, 6) = 0: A(k + 2, 7) = rs1!A_ Z
      L(k + 2) = rs1!B_ Z - rs1!A_ Z

      i = i + 1
      rs1.MoveNext
   Loop
      '//////// Structural power
      For i = 1 To 3 * n
         For j = 1 To 3 * n
            If (i = j) Then
               P(i, j) = 1
            Else
               P(i, j) = 0
            End If
         Next j
      Next i
   Call InAdjust(A, P, L, CX)
```

```
    CX(4) = CX(4) * 180# / PI * 3600: CX(5) = CX(5) * 180# / PI * 3600: CX(6) = CX(6) * 180# / PI
* 3600
    CX(7) = CX(7) * 1000000
    txt_PYX = Format(CX(1), "0.0000"): txt_PYY = Format(CX(2), "0.0000"): txt_PYZ = Format
(CX(3), "0.0000")
    txt_XZX = Format(CX(4), "0.00000"): txt_XZY = Format(CX(5), "0.00000"): txt_XZZ = Format
(CX(6), "0.00000")
    txt_CDBM = Format(CX(7), "0.00000")
    rs1.Close
End Sub
```

3.3 Table structure

There are 3 tables in procedure, the structure of each table is shown in table 1-3. You can see clearly the structure before and after the public space coordinate point table and the seven parameter conversion Cartesian point table structure. Keep the public data can be calculated with seven parameters to seven parameter calculation of space rectangular coordinate public point table; table seven parameters through space coordinate conversion before and after the conversion of the seven parameters of the space rectangular table, can achieve data conversion before the call and calculation of data storage[9].

Tab.1 the calculation of common point Tab structure from spatial rectangular coordinate through seven parameters

Field name	Field type	Field length	Decimal digits
Point name	text	50	--
A_X	number	double	4
A_Y	number	double	4
A_Z	number	double	4
B_X	number	double	4
B_Y	number	double	4
B_Z	number	double	4

Tab.2 the Tab structure from spatial rectangular coordinate before seven-parameter conversion

Field name	Field type	Field length	Decimal digits
Point name	text	50	--
X	number	double	4
Y	number	double	4
Z	number	double	4

Tab.3 the Tab structure from spatial rectangular coordinate after seven-parameter conversion

Field name	Field type	Field length	Decimal digits
Point name	text	50	--
X	number	double	4
Y	number	double	4
Z	number	double	4

3.4 Create a computing form

The seven parameter calculation form can be achieved: (1)The input point of public space coordinate calculation of seven parameters and click the command button can calculate seven conversion

parameters, as shown in Figure 3; (2) Click Import before switching to space coordinate command buttons, seven parameters can be calculated on the basis of the former converts rectangular space coordinate to convert the data input, as shown in Figure 4, then click the calculation command button and save the results of batch conversion, save the calculated data after conversion to rectangular space coordinate table and save to the Excel table, the computer saved to the specified directory.

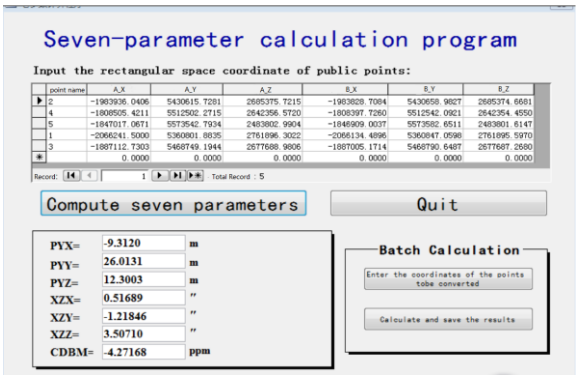

Fig.3 the interface of seven-parameter calculation

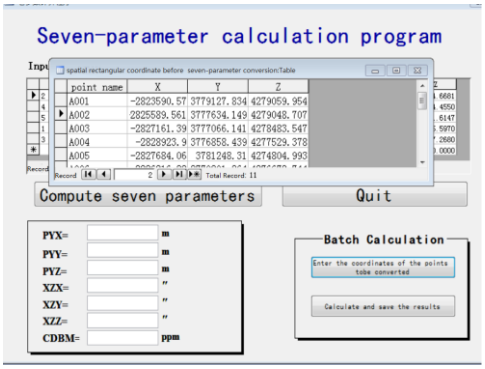

Fig.4 the interface of batch calculation

3.5 Create macros

The use of macros can achieve some auxiliary functions, procedures for the design of flexible so in the program design using macro data import and Export Group, including the use of import conversion before space coordinate can achieve seven parameter conversion will be out before the space rectangular coordinate table, macro design as shown in Figure 5 using the derived converted space; the Cartesian coordinates can achieve will save the calculated data after conversion to rectangular space coordinate table and save to the Excel table, saved to the computer in the directory specified in the macro design, as shown in Figure 6. Using the DoCmd method can be called only need in VBA, save a lot of programming[9].

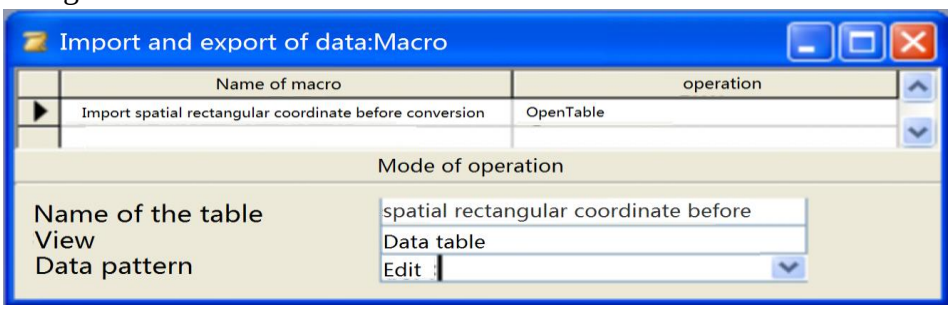

Fig.5 importing the macro of spatial rectangular coordinate before converting

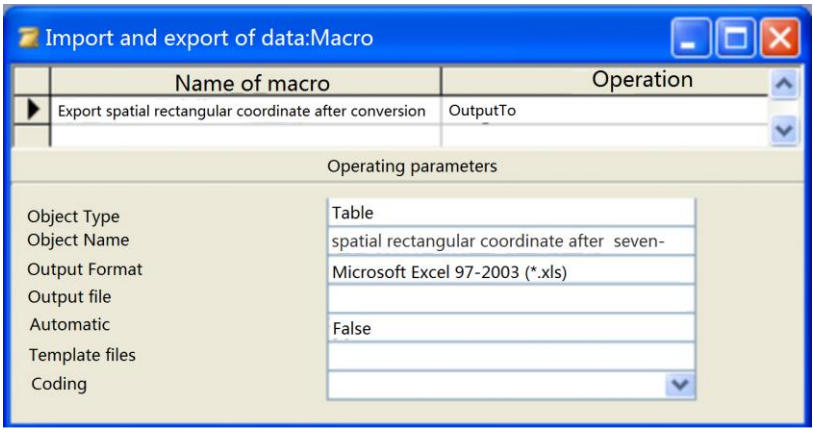

Fig.6 exporting the macro of spatial rectangular coordinate after converting

3.6 Summary

The software is able to convert geodetic coordinates can be between WGS-84 and 2000 national geodetic coordinate system, and the calculation of the four and seven parameters. The calculation process of bursa model with seven parameters is very important, it can realize the coordinate conversion between two three-dimensional Cartesian coordinate system.

4. Instance verification

In order to verify the reliability of the program, the conversion between the OA-XAYAZA and WGS-84 coordinates of the 2000 national geodetic coordinate system OB-XBYBZB, to verify all the procedures. According to the bursa model program is used to solve the calculation results of mutual control, the residual error within the allowable range, the program is accurate.

Tab.4 coordinates in the WGS-84, and BJ-54 coordinate systems

Serial number	X84	Y84	Z84	X20	Y20	Z20
1	-2066241.5000	5360801.8835	2761896.3022	-2066134.4896	5360847.0598	2761895.5970
2	-1983936.0406	5430615.7281	2685375.7215	-1983828.7084	5430658.9827	2685374.6681
3	-1887112.7303	5468749.1944	2677688.9806	-1887005.1714	5468790.6487	2677687.2680
4	-1808505.4211	5512502.2715	2642356.5720	-1808397.7260	5512542.0921	2642354.4550
5	-1847017.0671	5573542.7934	2483802.9904	-1846909.0037	5573582.6511	2483801.6147

Tab.5 the comparison of the programming and the value of an instance

Point name	Calculate data	True data	Δ
PYX	-9.3120	-9.30886	-0.00314m
PYY	26.0131	26.01370	-0.0006m
PYZ	12.3003	12.29813	0.00217m
XZX	0.51689	0.516831	0.000059”
XZY	-1.21846	-1.218477	0.000017”
XZZ	3.50710	3.506988	0.000112”

5. Summary

This is a successful attempt, after Dagushan town of Anshan city of Liaoning Province, the experimental verification, this software has a certain practical value, the use of VB,.Net, C development tools as the development language and database related procedures are difficult for non computer professionals, while ACCESS VBA is very easy to link with the database in the measurement, program design, for processing batch data has obvious advantages, but there are still shortcomings, the interface is not friendly, not powerful enough, the adjustment of the contents of the report and so on. Using single software application data is very good[10].

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