SRCM: A CAREFREE SENSING AND EMENDING COORDINATE MODEL FOR FRAMING TOPOGRAPHIC MAPS

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ABSTRACT:

In order to avoid the negative effect of the complicated coding rules, multiform framing types, many kinds of coordinate systems and the various map scales on evaluating the real coordinates of framing topographic maps, this paper will propose the ***S***hifting Residue Compensation Model (SRCM) to intelligently evaluating and emending the real coordinates of framing topographic maps which exist the coordinate translation error. Besides, this article will use abundant DWG vector mapping files and the practical project demand as examples to verify the validity and correctness of the SRCM .The results from the experiments show that the SRCM can be quite satisfactory, while calculating and adjusting the digital mapping edge. The proposal of the SRCM can not only avoid the negative effect of coding rules, framing types, coordinate systems and map scales on evaluation and emendation of the map coordinates, but also can sense in advance whether the map coordinates are true or not. Meanwhile the SRCM provides a new solution for the map pretreatment.

1. INTRODUCTION

The framing topographic maps are necessary data to GIS engineering and Geo-Science analysis. However, the coordinate error is inevitable while the map passing by graphic vector, coordinate and scale transformation, linear segmentation, and format conversion. Therefore, in order to improve the accuracy and reliability of topographic map data, eliminating all kinds of coordinate errors will be regarded as the main task (Meng, 1996; Hua, 2000).

In China, the coexistence of a variety of complex factors leads pretreatment of topographic map for coordinates to become very complex and cumbersome. Firstly, up to now, China has two kinds of statutory coordinate systems（Xian-80 and BJ-54）(Yang, 2005). Secondly, eight kinds of map scale (1:5000, 1:10000, 1:25000, 1:50000, 1:100000, 1:250000 and 1:1000000), two framing types (trapezium framing, and rectangle framing based on coordinate grid-line) and two coding rules (new rule adopted after 1991 and old rule adopted before 1991) coexist in China (Zou and Pan, 2005; Tian and Liu, 2005; GB/T139892-1992). Finally, in China, different departments or industries, according to their own needs, are using lots of framing topographic maps, with differ coordinate systems, map scales, standards of framing and coding rules.
In view of this situation, in order to solve the problem of map coordinates for the share use of topographic, many scholars have launched a number of related researches. Tong discussed accuracy analysis of scanned map image correction (Tong and Zhou, 2003). Tong analyzed and launched all kinds of distribution tests for the number of errors by manual map digitalization (Tong and Shi, 2000). Wang proposed a new method to correct digitized topography map, by using geometric constraint based on the indirect adjustment (Wang and Wang, 2000). Din analyzed the precision of the four acquisition map methods, which are introduced in his paper and included integration of indoor and field, manual digitiser input, automated scanning input and aerial photogrammetry mapping (Din, 2002). Huo used the method of collecting the x and y coordinates data from the text file which is exported by drawing point objects in a drawing (Huo, 2007). In addition, the straight line and right angle methods were proposed to improving the accuracy of map digitalization (Najeh, 1995; Song, 1996).In fact, the two methods approached balancing calculation. Based on the two methods, Liu obtained the correct values (residue) to evaluate accuracy and control quality of a digital map with the aid of balancing calculation. Then, Tong further released the rectangular linear model, parallel linear model, distance model and area model (Tong and Liu, 1998).

These algorithms and models mainly aimed at some deformation characteristics or focused on the mathematic algorithms of transform between the standards of framing and the coding rules of framing topographic maps, but evade the problems - how to discard such as coding rules, map scales and other the complex burthen during the process and how to sense in advance whether the map coordinates are true or not. Meanwhile, in practice of GIS projects and geo-science analysis, the coordinate translation error is main obstacle to middle or terminal users of map data. For instance, when we need recode some desultory framing topographic maps which exist uncertain translation error, based on the real coordinates, sensing and adjusting the coordinate translation error should be regarded as the key mission,.

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In order to avoid effectively the negative effect of coding rules, framing types, coordinate systems and map scales, and eliminate the coordinate translation error, this paper proposes SRCM to intelligently evaluating real coordinates of framing topographic maps. At the same time, this article choose DWG vector mapping files as experiment data to verify the validity and correctness of the SRCM. The results from the experiments show that the SRCM can be quite satisfactory, while calculating and adjusting the digital mapping edge. The SRCM can not only avoid the negative effect of coding rules, framing types, coordinate systems and map scales on evaluation and emendation of the map coordinates, but also can sense in advance whether the map coordinates are true or not. Meanwhile the SRCM provides a new solution for the map pretreatment..

2. IDEA FOR SRCM

2.1 Theories of SRCM

The coexistence and mutual influence of various coding rules and many kinds of map scale, as the main factors, make the acquisition, conversion, correction of the map coordinates complicated. Moreover, seeking the relation between standard sample and calculated map to establish interrelated arithmetic mode become the primer task.

There are the following characters in practice. Firstly, every map shows as rectangle or square shapes in such as ArcGIS, MapInfo, MapGIS or AutoCAD Map and other GIS platform. Secondly, the x-axis or y-axis difference distance between a point of every map belonging to one group consisting of maps with constant width-high and the homonymy point of the standard sample map is multiples of the constant width or high. Thirdly, all maps of one group has unified arithmetic model of spatial position relation between them and the standard sample map.

Based on the above theories and characters, the SRCM can be described as the following formulae.

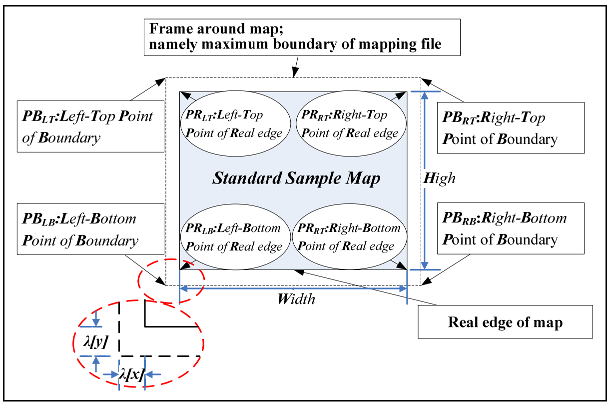

Figure 1. The reference points are located on the standard sample map

$$PR'_{LB}[x,y] = PB'_{LB}[x,y] + \lambda[x,y] - \Delta\delta[x,y] \tag{1}$$

$$\Delta\delta[x,y] = MOD\left(ABS\left(\frac{PB'_{LB}[x,y] + \lambda[x,y] - PR_{LB}[x,y]}{[Width, High]}\right)\right) \tag{2}$$

Where

$$Width = ABS\left(PR_{LB}[x] - PR_{RB}[x]\right) \tag{3}$$

$$High = ABS\left(PR_{LB}[y] - PR_{LT}[y]\right) \tag{4}$$

And the constant offset at Left-Bottom Point

$$\lambda[x] = ABS\left(PB_{LB}[x] - PR_{LB}[x]\right) \tag{5}$$

$$\lambda[y] = ABS\left(PB_{LB}[y] - PR_{LB}[y]\right) \tag{6}$$

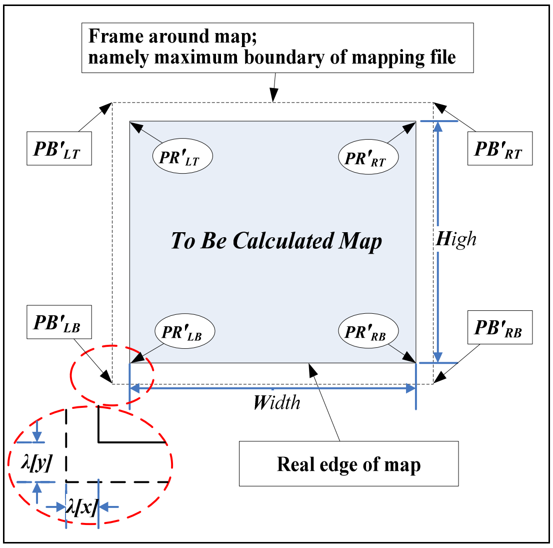

Figure 2. The reference points are located on the treated map

Where:

- ***PB***$_{XX}$: the reference point; one of the four points of ***Maximum Boundary*** of **<u>standard sample map</u>**, as to a GIS or Graphic platform. The ***PB***$_{LB}$ denotes the Left-Bottom Point, the ***PB***$_{LT}$ denotes the Left-Top Point, the ***PB***$_{RB}$ denotes the Right-Bottom Point, and the ***PB***$_{RT}$ denotes the Right-Top Point. ***PB***$_{XX}$[x,y] refers to X and Y coordinate of corresponding point.
- ***PB'***$_{XX}$: the reference point; one of the four points of ***Maximum Boundary*** of **<u>calculated map</u>**. The XX symbol has the same significance as that of ***PB***$_{XX}$.
- ***PR***$_{XX}$: the reference point; one of the four points of ***Real Edge*** of **<u>standard sample map</u>**. The XX symbol has the same significance as that of ***PB***$_{XX}$.
- ***PR'***$_{XX}$: the reference point; one of the four points of ***Real Edge*** of **<u>standard calculated map</u>**. The XX symbol has the same significance as that of ***PB***$_{XX}$.

- ***Width*** and ***High***: the scale gene (default is the real graphics width and high of maps belonging to a certain group).
- ***λ[x,y]***: an known and constant offset distance(no error offset); the distance between the Left-Bottom Point of the ***Maximum Boundary*** and the ***Real Edge*** at the x-axis and y- axis in the above picture.
- ***MOD***: redundant function.
- ***ABS***: absolute value function.
- ***Δδ[x, y]***: the sense gene.

Through the above formula, we can see that the following characters.

(1)The sense gene ***Δδ[x, y]*** is only related to the known four parameters: $PB'_{LB}[x, y]$, $PR_{LB}[x, y]$, ***[Width, High]*** and ***λ[x, y]***. Moreover, the PB_{XX} and PB'_{XX} can be obtained by GIS or graphic platform interface.

(2)The entire process has nothing to do with the coding rules, the map scales and other complex factors, but only with the spatial relation given by the standard sample map. Thus, we can determine the following.

If Δδ[x, y]=0 then

$PR'_{LB}[x, y] = PB'_{LB}[x, y] + \lambda[x, y]$

Else if $\Delta\delta[x, y] \le [Width, High]/2.0$ ***then***

$PR'_{LB}[x, y] = PB'_{LB}[x, y] + \lambda[x, y] - \Delta\delta[x, y]$

Else

$PR'_{LB}[x, y] = PB'_{LB}[x, y] + \lambda[x, y] - \Delta\delta[x, y] + [Width, High]$

End If

Then, the sense gene and the correlation between the map belonging to one group and the standard sample map can be determined. Here, the sense gene ***Δδ[x, y]*** denotes validity of the map coordinates and decides whether the map coordinates need to be adjust or not. At last, the real edge of a map can be obtained by the sense gene, any reference point and the scale gene ***[Width, High]***.

2.2 Achievement process of *SRCM*

2.2.1 Using standard sample map to fix PR_{XX} and calculate PB_{XX}

The PR_{LB}, PR_{LT}, PR_{RB} and PR_{RT} are artificially appointed. The PB_{LB}, PB_{LT}, PB_{RB} and PB_{RT} can be obtained by GIS or graphic platform interface, such as the ***extmin()*** and ***extmax()*** functions in AutoCAD.

2.2.2 Using standard sample map to obtain the scale gene *Width ,High, and constant offset λ[x,y]*

The parameters ***Width, High*** and ***λ[x,y]*** can be obtained by the (3)-(6) formulas.

2.2.3 Using GIS or graphic platform interface to obtain the PB'_{XX} of the calculated maps

2.2.4 Calculating the sense gene *Δδ[x,y]* value to obtain the PR'_{XX} the calculated maps

2.2.5 Using the real coordinates to adjust the map coordinates

If Δδ[x,y]=0 then

Doing nothing

Else if $\Delta\delta[x, y] \le [Width, High]/2.0$ ***then***

Selecting (0, 0, 0) as the based point to move the map from (0, 0, 0) to the point (-Δδ[x], - Δδ[y], 0)

Else

Selecting (0, 0, 0) as the based point to move the map from (0, 0, 0) to the point (Width-Δδ[x], High- Δδ[y], 0)

End If

Then, the flow chart can be described as the following picture.

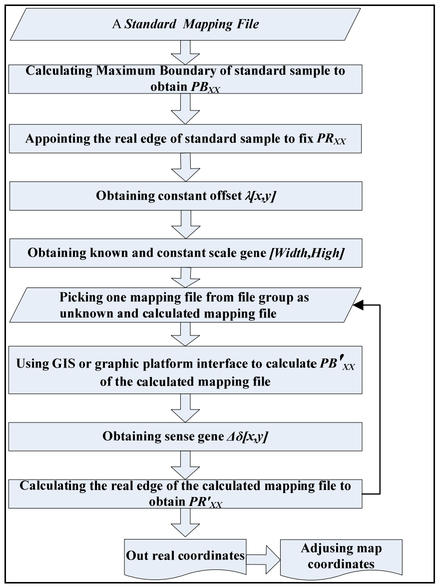

Figure 3. The flow chart shows achievement process of SRCM

3. VERIFICATION OF SRCM

This paper takes the DWG vector maps as experiment data and the practical project demand as experiment process to verify the validity and correctness of the SRCM and obtain the results. A practical demand should be expressed as the followings.

(1)Some desultory maps which only exist uncertain translation error need to be recoded, according to their real coordinates.

(2)The map filename has nothing to do with the original coordinates and the coding rule.

(3)The real map coordinates need to be adjusted while the map filename being renamed.

(4)The whole process cannot relate to the coding rule, framing type, coordinate system and map scale of adjusted map file.

(5)The whole process needs as little as artificially, even automatically and in batches performed.

(6)The only one can be ensured that the map file groups have been ranged by the same width and high of map.

3.1 Experiment process

Based on the data and demands, the software is developed with the aid of the SRCM theories and ideals.

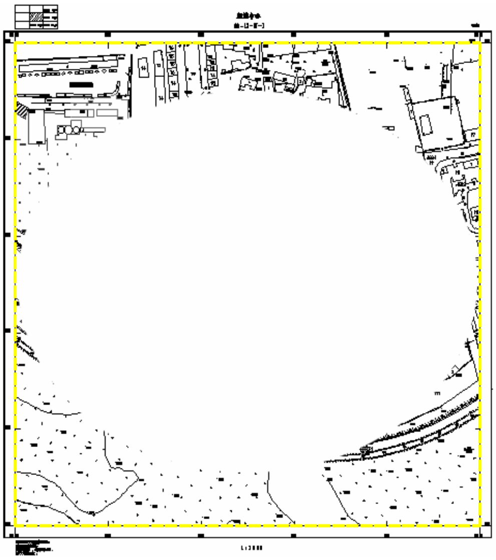

Figure 4. This is standard sample map. The yellow region denotes the real edge of it. There is map frame around surrounding region.

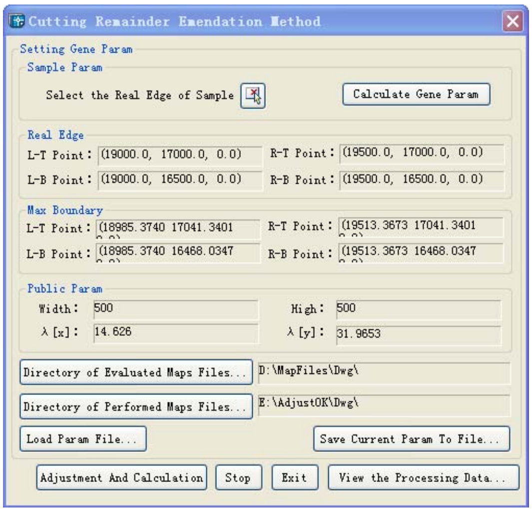

Figure 4. This is one dialog of SRCM software. The SRCM model can help user to almost automatically realize the requirement

Step1: Using the ***"Select the Real Edge of Sample"*** button to select the real edge of standard sample map.

Step2: Using the ***"Calculate Gene Parameter"*** button to obtain all essential parameters.

Step3: Setting input directory, output directory and other assistant parameters.

Step4: Using ***"Adjustment And Calculation"*** button to automatically perform the ***SRCM*** process.

At last, the results (See APPENDIX A) from the experiments show that the ***SRCM*** can be quite satisfactory, while calculating and adjusting the digital mapping edge.

4. CONCLUSIONS

At last, the results from the experiments are compared with the real data, which proves that the SRCM is reliable and efficient. Then, the results of this study can be summarized as follows.

- The SRCM can effectively eliminate the translation error, as well as avoid the negative effect of coding rules, framing types, coordinate systems and map scales.
- The SRCM can sense in advance whether the map coordinates are true or not.
- With the SRCM, the calculating and adjusting process can be automatically preformed.
- The SRCM can ensure the validity and precision of experiment result.

Moreover, because of the strong generality of SRCM ideas and theories, there are other great advantages.

- The optimized arithmetic model can apply to any framing topographic maps, which have constant high and width of maps in the world.
- The ideas and methods of SRCM can be spread to deal with the raster map.
- The SRCM can sense the rotation and other distortion of map, too.
- The SRCM can be not only performed on AutoCAD but also performed on other graphic or GIS platforms.
- If the width or high of maps belonging to a group has greatest common divisor β[x,y], the scale gene [Width,High] can be shrunk to N*β[x,y] and N can be obtained in advance. Therefore, the grouping range can be expanded for processing in batches more maps.

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APPENDIX A

Process Data of Adjustment...

Process Data of Adjustment and Calculation

Original File	Max Boundary Points(Z=0)				λ		Width	High	Δδ		Real Edge Points(Z=0)				New File
	L-B-X	L-B-Y	R-T-X	R-T-Y	X	Y			X	Y	L-B-X	L-B-Y	R-T-X	R-T-Y	
A0001-0001	18985.374	16468.0347	19513.3673	17041.3401	14.626	31.9653	500	500	0	0	19000	16500	19500	17000	190-165
A0001-0010	18485.374	16468.0347	19013.3673	17041.3401	14.626	31.9653	500	500	0	0	18500	16500	19000	17000	185-165
A0001-0011	19492.410	16468.0347	20020.4033	17041.3401	14.626	31.9653	500	500	7.036	0	19500	16500	20000	17000	195-165
A0001-0100	19986.158	16468.5407	20514.1513	17041.8461	14.626	31.9653	500	500	0.784	0.506	20000	16500	20500	17000	200-165
A0001-0101	18485.374	15968.0347	19013.3673	16541.3401	14.626	31.9653	500	500	0	0	18500	16000	19000	16500	185-160
A0001-0110	18985.374	15968.0347	19513.3673	16541.3401	14.626	31.9653	500	500	0	0	19000	16000	19500	16500	190-160
A0001-0111	19485.374	15968.0347	20013.3673	16541.3401	14.626	31.9653	500	500	0	0	19500	16000	20000	16500	195-160
A0001-1000	20041.772	15969.1077	20569.7653	16542.4131	14.626	31.9653	500	500	56.398	1.073	20000	16000	20500	16500	200-160
B0001-0001	18485.601	17539.7127	19013.5943	18113.0181	14.626	31.9653	500	500	0.227	71.678	18500	17500	19000	18000	185-175
B0001-0010	18985.374	17469.7287	19513.3673	18043.0341	14.626	31.9653	500	500	0	1.694	19000	17500	19500	18000	190-175
B0001-0011	19485.374	16968.0347	20013.3673	17541.3401	14.626	31.9653	500	500	0	0	19500	17000	20000	17500	195-170
B0001-0100	19996.36	17468.3757	20524.3533	18041.6811	14.626	31.9653	500	500	10.986	0.341	20000	17500	20500	18000	200-175
B0001-0101	18985.374	15468.1777	19513.3673	16041.4831	14.626	31.9653	500	500	0	0.143	19000	15500	19500	16000	190-155
B0001-0110	18455.604	16968.2107	18983.5973	17541.5161	14.626	31.9653	500	500	470.230	0.176	18500	17000	19000	17500	185-170
B0001-0111	19340.835	15376.9467	19868.8283	15950.2521	14.626	31.9653	500	500	355.461	408.912	19500	15500	20000	16000	195-155
B0001-1000	19985.374	15227.3047	20513.3673	15800.6101	14.626	31.9653	500	500	0	259.27	20000	15500	20500	16000	200-155

Figure 5. The results of experiment