Reliable and Practical City Map generation at 1:1000 or 1:500 scale based on "Five control points" recification of digitized images

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Key words

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Abstract

Using high resolution image for making city map by digital rectification is simple.But five control points can correct image deformation precisely and reliable are not easy particular making 1:500 scale street view map. Nowadays, RTK-GPS becomes the definitive mapping instrument to draw 1:1000 scale maps but get some shortages. That are,

1. Operators can't have an overall impression of the mapping place.

2 Measuring points are separate so that the lines are not natural and smooth.

3. Data transmission may have 0.1% mistakes which waste time to check and are troublesome.

Given method comes as a substitute, which keeps all advantages and use RTK to definite the key points for drawing. Here are three examples for reference. The map size are extremely large and beyond the custom. (area; 60cm×70cm,80cm×180cm, 60cm×200cm) Which without any splices.

The interpolation for rectifying is surface splines which were originally developed for interpolation wing deflections of aircraft; Surface splines are a mathematical tool to interpolate a fuction of two variables. It is Base upon the small deflection equation of an infinite plate. The main adtvantages of the surface splines are that the coordinates of the known points needs not be located in a rectangular array and the function may be differentiated to find slopes. (Contributed by Harderand Desmarais 1972)

1. Introduction

It is known to all that planning programe usually use 1:2000 scale maps and the Photogrammetry system also mainly provides them. It seems to be the representative works of the large scale cartograph in large quantities but for the great changes of the time the function of cities and towns become and more diversified. The maps applied to finance or industry call for precise and complete geographical information to ensure the measures for pollutions, and security or traffic affairs could be carried out smoothly. The investment of construction of the real estate development needs to be measured and paid for on the basis of the maps.

Let's take the construction of the highway for example. If the investment is 150 million Yuan, in the area of river network and on the soft foundation building a highway in the length of 30km must carry expenditure as 30% of the total cost for the treatment of the soft ground, because the inaccurate maps couldn't help the Investors check the measurement and payment, for they are lack of detailed information and with unsatisfied elevation and density. If 10% of the content cause's quarrel millions of cash will be cost. So, obviously, it is 1:1000 scale maps but not 1:2000 maps suitable for use.

2. Brief review of making large scale map

Stiff are all familiar with the function of GPS and RTK is suitable for all measuring works, from geodetic to cadastral surveying. It can set position quickly and accurately so became the definitive mapping instrument for drawing 1:500 scale maps compared with the digital photogrammtry it enjoys extraordinary accuracy, besides that, RTK or total station digital mapping also has shortages as following:

1. Operators could't has an overall impression of the mapping place.
2. To ensure the visibility in the area with poor situation for mapping, which have to add more measuring stations.
3. The measuring points are discrete; the lines are not natural and smooth, especially when the objects have irregular form.

Now the state method comes as a substitute, which keeps all advantages while covers the shortages that are digital photo-planimetric method. In field total station are also set to

control and ensure field works. A map with elaborate drawing and high quality can be made soon.

Now the given digital photo-planimetric method is five control points to rectify digital image in 2000 Japan announced the patent "The map drawing's system and method", which is a manifestation of the state thought, But that method calls nine control points for rectification, So the given technology is much useful.

Also in the texbook there is "The photo map can be used as relief map" as well as the rules saying that in the level terrain arial photogrammetry must follow

Photo-planimetric method.

3. Theory of five control points for rectifying digital image

It is known to all that the rectification for photographs needs five control points, for it will be difficult when control points are many the requirements for figure of the point's costs time and money.

But the more control points, the easier will be the mathematical process of digital rectification. As the Japen method which found nine control points to rectifying is still beyond the capability of field works. Besides, the theory of Japanese is linear and triangle method. That is simple and can't afford to draw 1:500 scale maps.

It is difficult for five control points to rectifying and ensuring the high accuracy, for the requirement of the Interpolation's analysis feature is very strict it should be a smooth surface.

The formula derivation goes as follows:

As we know that a linear spline is the solution of an equation based upon a small deflection of an infinite beam. So the surface splines are the deformation of an infinite plate bending only. The differential equation relating bending deflection and the load of the plate is

$$D\nabla^4 W = P \qquad (1)$$

D = flexural rigidity of the plate

W (x y) = lateral deflection

P= lateral load

The hypothesis used as basis goes as following:

1 Deflections are specified at N independent points (x_i, Y_i) i =1…N Here needs to know the point loads Pi at these N points. When the load is determined, the deflection will be too. For example, if we want to know the

symmetrical deflection of the origin point when the load is P, use the equation (1)

Where $X = r\cos\theta$

$Y = r\sin\theta$

And we get

$$W(r) = A + Br^2 + (P/16\pi D)r^2.\ln r^2 \quad (2)$$

In the equation (2), A, B are undetermined coefficients while P is point load. To continue the derivation that will set two hypothesis:

1 Deflection is symmetrical at the points with load.

2 The surface splines will be flat if far away from the applied loads.

The deflection of the whole splines is the summation of the equations (2):

$$\text{Means } W(r) = \sum_{i=1}^{N} A + Br^2 + (P/16\pi D)r^2.\ln r^2 \quad (3)$$

And after deduced and combined we get

$$W(x, y) = A + Bx + Cy + \sum_{i=1}^{N} F_i r_i^2 \ln r_i^2 \quad (4)$$

Here

$$r_i^2 = (x - x_i)^2 + (y - y_i)^2$$

Equation (4) need to solve N+3 unknown quantities.

Here N = 5, so add 3 equilibrium equationsand then form 8 linear equations, and get the final answer. In this way which can correct the image point by point while avoid its translating and rotating, that is due to the function of the equilibrium equations.Formula (5) is equilibrium equations.

$$\sum F_i = \sum X_i F_I = \sum Y_I F_I = 0 \quad (5)$$

4. Function of the software

This software can work as a rectifying apparatus and make image map 50cm×50cm from aero photograph based on five control points. The name is “five points method”. It’s easy to operate, anyone who can use PC works with it smoothly: there’s no special skill for operation and the data to enter is little. It’s easy to find an appropriate PC, for any ordinary PC can do the job.

The processing steps are as following:

1 Scan the photo or image into PC

2 Enter the coordinate of the control points

3 Identify the control points on the photo or image (recognition of control points)

4 Supply mapping scale

5 Rectifications

6 Get photo map

5 Examples