ALL-ELEMENT DIGITAL MAPPING

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Abstract
This paper relates the principle and method of the plotting of the Serial All-element Maps of China with the help of the computer according to the digital terrain model (DTM) obtained from photographs. The main points are: data acquisition and preprocessing, mathematic basis of the sheet, marginal representation and the principle of the output of contours and map symbols. On the ground of the above mentioned, a program design and preliminary experiment was conducted.

Introduction

How to improve the present situation of the manual operation in the aerial photogrammetric mapping and thus get the aerophototopography and cartography completed at one-shot has been a problem of concern for all personal engaging in plotting and mapmaking. We furnished with no analytical plotter, making full use of available aerial photoplotting instruments and accessories, have conducted studies on off-line mode plotting of all-element maps by first setting up DTM from photographs and then accomplish the map with home-made computers and digital control plotters. The whole process of aerial photoplotting from the data-splitting obtained by aerotriangulation and point-plotting to marginal represe ntation is accomplished by computer other than by manual operation. During the past two years, we, combining the graduation projects of part of the students of Aerial Survey Department and the Cartography Department of our institute, conducted an experiment on the plotting of an all-element map with a photo scale of 1:18000 and a map formation scale of 1:5000. And at the same time, we made attempts at computer aided plotting of the high oblique photographs and SKYLAB framing photographs taken from a satellite.

I. Data acquisition amd preprocessing

The data needed in aerial photogrammetric plotting include data for the orientation of photos and the raw data for the plotting of the map board (e.g. elements of interior and exterior orientation, the coordinates of the control points and the sheet corner etc.) as well as data of the digital elevation model (DEM) needed for the output of the contours and the digital terrain model (DTM) of the features needed for the output of cartographic symbols.

The coordinates of the control points needed for the plotting are acquired directly by way of sheet-splitting in accordance with calculation of analysis aerotriangulation and thus output of (P,X,Y,Z), where P represents the charateristic of the control point. The point number is editted in sequence auto-

matically. And then the paper tape is produced. The output paper tape is directly entered into digital control plotter to mark the points, including the description of marks of various kinds of the points and annotation, etc. The mathematical basis established in the light of the sheet is used for the computation of the sheet corner coordinates to plot border lines and represent margins. The acquisition of DEM data is by way of stereocartographic instruments according to the profile tracing dynamic measurement. The processing of DEM data involves two steps as sollows. 1) Data editting, it is to convert the data arrangement acquired from back and forward tracing measurement in Y direction to the data arrangement in the same direction and edit it in accordance with the data mode needed by mapmaking softwares. 2) Data transformation, it is to transform the modle coordinates into the map coordinates based on the scale as stipulates and at the same time, give the consideration to improve the precision of the graphic absolute direction.

The acquisition of the DTM data is by way of static measurment on the stereo-plotter according to identified photograph and in accordance with the (P,X,Y,Z) output, where P represents the characteristic code and classified code.

The processing of DTM data is as follows. 1) Data editting, the requirements for the data structure is editted by map symbols program, e.g. the classifying of the characteristics of various kinds of the features. Taking the land boundary as example. Its exterior outlines can be divided into independent side, common side and substitution side. But the symbols disposed in the inner of the exterior outlines are quite various such as the symbols of a paddy field or a garden, etc. The disposition of symbols are divided into regular and irregular forms. And what has become an even more complicated problem is how to settle properly the correlation between the various kinds of the features. 2) Data transformation, it is just as above mentioned. 3) Data sectioning, this processing can guarantee that all the features are reflected in the map.

II. Mathematical basis of sheet and marginal representation

In the conventional operation, in order to use digital plotter instead of coordinatograph to draw margins, latitude-longitude lines, kilometer square grids and other elements outside the map (e.g. magnetic-north line , slope table)and marks etc, first of all, we must study and analyse the feature of serial maps of China.

The Gauss-Krüger projection is used for serial maps of China and the longitude difference 6° or 3° composes one projective zone.Every zone is divided into sheets according to the latitude-longitude line, fixed latitude-difference and longitude-difference,furthermore the large-scale sheet is inserted in the small-scale sheet, every sheet has a definite sheet number. Therefore, it is very regular.

This regularity provides a favourable condition for automatically establishing the sheet mathematical basis and autoscribing the marginal representation. We are able to find the latitude and longitude and the scale of the sheet according to the sheet number.

$$\lambda = f_1(N)$$
$$\varphi = f_2(N)$$
$$M = f_3(N)$$

where: λ, φ is latitude and longitude respectively
N is sheet number
M is scale of the map

consequently, Gauss-Kruger projection is used,

$$x = F_1(\lambda, \varphi)$$
$$y = F_2(\lambda, \varphi)$$

The geographical coordinate (λ, φ) of the sheet is converted into the planimetric rectangular coordinate (x,y). Again, the coordinates(x,y) are used to calculate the latitude-longitude grids, rectangular coordinate grids, marginal tables and marks etc. Their general function representation can be shown as follows:

$$x' = f(x,y)$$
$$y' = f(x,y)$$

From above, if sheet number is known, the mathematical basis of the sheet and some contents of marginal representation can be calculated, thus, the goal of auto-scribing is reached.

III. The principle of contours output

The contours outputted according to DEM include contours formation, smoothing, intercepting-sheet and annotations. For the formation of contours, we set " the high being on the grid point of the right side" and the continuous tracing of the trends of the contours as a principle.Every grid-eye lines where contours entering are determined as OA lines, as shown in Figure 1. If the height of the grid point O and A is Z and Z_A respectively the height of contours must be meet the following formula:

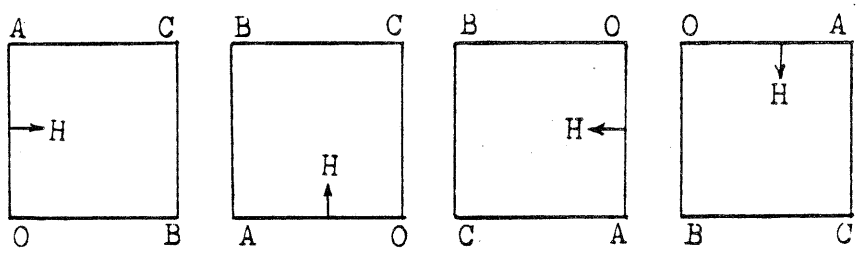

Fig. 1

(a),(b),(c),(d), in Figure 1 illustrate the four cases of entering side of open curve around DEM (west, south, east and north) respectively, where (a) represents the entering side of the closed curve too. Due to the adhering to the principle of "the high being on the grid point of the right side," in tracing of the contours, it can not occur the phenomenon of omission and repetitions. And at the same time, it is very convenient to realize the automatic lettering of the height of contours according to the cartographic symbolization that "the head of letters must point to the mountain peak". The coordinate of the point crossed by the contour and the grid line is computed by means of linear interpolation.

The smoothing of the contours is obtained by using tensile spline function. During the experiment, we find that the description of the terrain features is improved effectively and flexiblely by controlling tensile coefficient.

The height of contours are annotated with the method of data compression and data separation. The coordinates of two points and marke of eifting and falling pen are packed into one unit. In this method, the storage roon can be saved a lot.

The intercepting sheet of contours is to guarantee the plsition of the plot pen starting to plot and ending in or on the marginal lines correctly. As the range of DEM is usually a bit larger than that of sheet, the rectangle of interior and exterior link-up sheet is ueed to complete the three kinds of decision in order to save calculation workload.

IV. The principle of outputing the cartographic symbols
According to the pre-processed DTM data (p,x,y,z), we can find out what kind and which grade the features belong to, then scribing the corresponding symbols in the right place. Now, let's start from analysing the chracteristics of the symbols of topographic maps of our country and study the output method.

The symbols of topographic maps of our country are characterized by their geometric patterns and symbolized graphs, therefore, they are resolvable.These geometric and resolvable characteristics provide a good condition for processing the output symbols, thus realizing resolution storage, concentrated managment and combination output of symbols.

1. Resolution Storage

All of the symbols can be resolved into several basic patterns, the quantity of which is much less than that of the symbols and which are characterized by their simple geometric figure. Thus, the basic patterns of symbols or their parameters can be stored into the computer. For example,the point symbols are shown in Fig. 2. All the symbol information can be stored into the computer as a file. This file can be divided into three parts: list, sub-information and main information.

The list of information is the orderly intergration of the codes and storage address of information of the symbols and is used to find the information of symbols.

The sub-information is the intergration of the information of the similar common patterns and is called by the main information.

The main information is the intergration of the address of the sub-information and of various parameters of symbols and the order of symbolic combination, from which all the information are resulted.

The line symbols and area symbols can be treated by the same way as the point symbols.

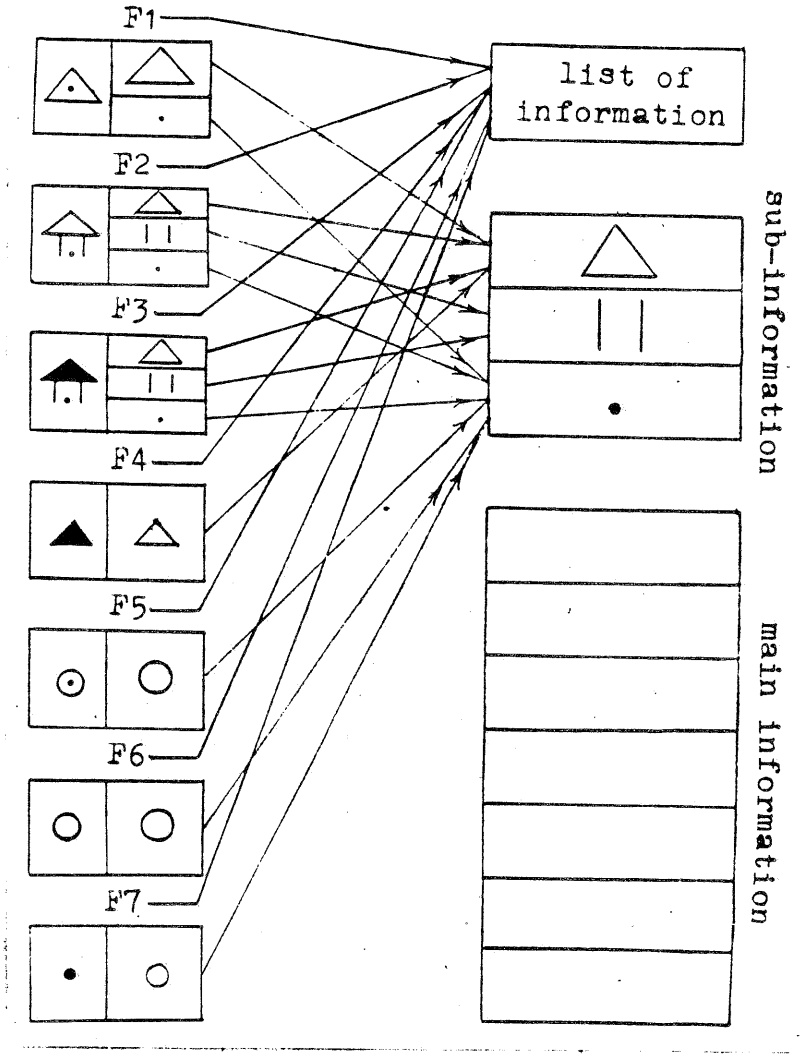

Fig. 2

2. Concentrated managment and combination output of symbols

The information mentioned above are managed by a program, which can distinguish between the symbolic codes given by users and pick out the corresponding symbols and the address of the main information in the list. Then the sub-information can be found by means of the main information. At last we combine and calculate all these data and output symbolic graphs at the predetermined place.

Conclusion

It has been an extremely significant experiment on the cooperation of our aerial photographers and cartographers. It has not only provided the preliminary experiences for opening up the way to aerial photogrammetrical digital mapping according to chinese characteristic, but also provided the basis for digital image processing.

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