

## DEVISING AND REALIZING OF DIGITAL MONO-PLOTTER

Da-zhao FAN, Bao-ming ZHANG, Rong LEI, Ming-yao QI, Hai-tao GUO

Institute of Surveying and Mapping, Information Engineering University, Zhengzhou, 450052, China  
fandazhao@371.net

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### ABSTRACT:

Digital Mono-Plotter (DiMP) is a system which can determine the dimensional position and the character of grand features by means of computer's analysing and processing, on the basis of single digital imagery and relief data already being provided. DiMP can display the digital image on the computer screen. Users can collect grand features data directly on the screen by means of mouse and keyboard and convert them to terrain data. Further more, DiMP can edit the terrain data. As a result, we get original terrain data, which can be used to product maps through symbolizing process, or be adapted by other map publishing systems through data format transformation. In addition, DiMP can translate relief data into DEM. The former edition of DT-1 has been widely used by many surveying departments.

### 1. INTRODUCTION

The hardware of DiMP is mainly composed of PC, digital scanner, digital graph-plotter and so on. The software is made up of computer operation system Pwindows2000 (or PWindows98) and applied software—mono-image mapping software. Figure 1 shows hardware condition of DiMP.

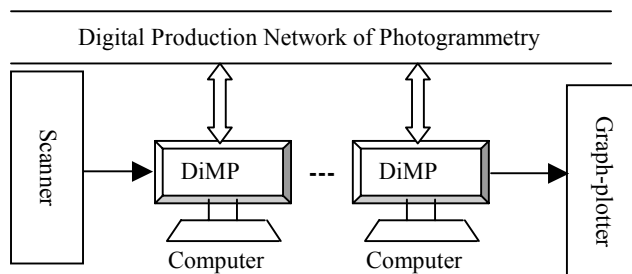


Figure 1. DiMP's hardware condition

DiMP can display the digital image on the computer screen. By means of mouse and keyboard, users can collect grand features data directly on the screen and convert them to terrain data based on DEM. Further more, DiMP can edit the terrain data. As a result, we get original terrain data, which can be used to product maps through symbolizing process, or be adapted by other map publishing systems through data conversion. In addition, DiMP can translate relief data into DEM.

### 2. BASIC THEORY

The most important task of DiMP is to attain grand features of digital maps through single digital photo. Its basic theory is the theory of single image orientation, and its basic formula is shown in formula (1) and formula (2).

$$\begin{aligned} x &= -f \frac{a_1(X - X_s) + b_1(Y - Y_s) + c_1(Z - Z_s)}{a_3(X - X_s) + b_3(Y - Y_s) + c_3(Z - Z_s)} \\ y &= -f \frac{a_2(X - X_s) + b_2(Y - Y_s) + c_2(Z - Z_s)}{a_3(X - X_s) + b_3(Y - Y_s) + c_3(Z - Z_s)} \end{aligned} \quad (1)$$

$$\begin{aligned} X &= (Z - Z_s) \frac{a_1x + a_2y - a_3f}{c_1x + c_2y - c_3f} + X_s \\ Y &= (Z - Z_s) \frac{b_1x + b_2y - b_3f}{c_1x + c_2y - c_3f} + X_s \end{aligned} \quad (2)$$

where  $f$  = focal length  
 $x, y$  = image coordinates  
 $X_s, Y_s, Z_s$  = ground coordinates of projection center in ground coordinate system  
 $X, Y, Z$  = object ground coordinates in ground coordinate system  
 $a_i, b_i, c_i (i=1,2,3)$  = direction cosine

The theory of point orientation of using single digital photo can be described as formula 3.

$$(x, y, Z) + (\text{interior and exterior orientation elements of the photo}) \rightarrow (X, Y, Z) \quad (3)$$

Suppose that  $X$  and  $Y$  have been given,  $Z$  can be interpolated in DEM. However, as DEM is organized through ground coordinates, we cannot interpolate  $Z$  just through image pixel coordinates  $x$  and  $y$ . The way to resolve this problem is to give an original elevation value  $Z_0$ . Using  $x, y$  and  $Z_0$ , the computer can calculate a pair of values  $X$  and  $Y$ , according to formula (2).  $X$  and  $Y$  are used to interpolate  $Z$ , which can be used to calculate  $X$  and  $Y$  once more according to formula (2), and so on. Until the deviation of the last two  $Z$  is smaller than the given tolerance, compute process is end. This method is a

iteration process. The DEM interpolated method is combined the double linear interpolation with mobile curly plan interpolation. In actual compute process, image pixel coordinates  $x$  and  $y$  are computed by scene coordinates  $x'$   $y'$ .

### 3. CHARACTERISTIC

#### 3.1 Automatically Manage Various Data Files

DiMP divides the storage area into system area and users area for the convenience of management. The system area is used to store the system programs and system parameters, all programs and data in which is automatically generated when the system software is running. Users are not allowed to modify or delete them. The user area is used to store surveying parameters and all kind of other data. DiMP will store data and parameters into different sub areas according to their different types. In actual operation, once users select or input map name, image code and work content, the system will load all the correlative formation automatically, and store operation results into corresponding files.

#### 3.2 Strong Features Revision Function

DiMP has various ground features revision function. It can use new images to revise old grid map and old vector map. The new images can be orthophotos or generic photos, aerial photos or satellite photos, such as SPOT, IRS-1, etc. We can overlay images with old map on the computer screen and edit old map according to newly images. In this way new digital maps can be acquired quickly. To old paper-map, we transform it from vertical projection mode into center projection mode firstly, then make it transparent overlaying with new photos. Based on this way, we can edit transparent map on the computer screen directly according to new photos. After editing, we transform the map data from center projection mode into vertical projection mode. According to requirement, the new map can be print with some output equipment or saved in digital mode in the computer. In this way new digital maps can be acquired quickly.

Figure 2 shows displaying an old vector map on a new photo. Figure 3 shows displaying a raster vector map on a new photo. Figure 4 shows displaying an old raster map on a SPOT image.



Figure 2. Display vector map on new photo

#### 3.3 Automatic and Semiautomatic Processing Means

DiMP applies two matching algorithms, in initial matching of frame point of automatic interior orientation, which are correlation coefficient algorithm and genetic algorithm. Then LSM is used for precise matching of frame points. In order to minish range of searching and improving speed of orientation, DiMP provides to a new method to orient frame points roughly. In the process of single image resection in space, according to the ground coordinates of ground control points (GCP) and the image coordinates of the first two GCPs, DiMP can automatically drive the photograph to the nearby place of the next GCP in photograph, so that users can measure it conveniently. In the process of features collection, DiMP allows users to automatically collect detached buildings and semi-automatically collect lineal features.

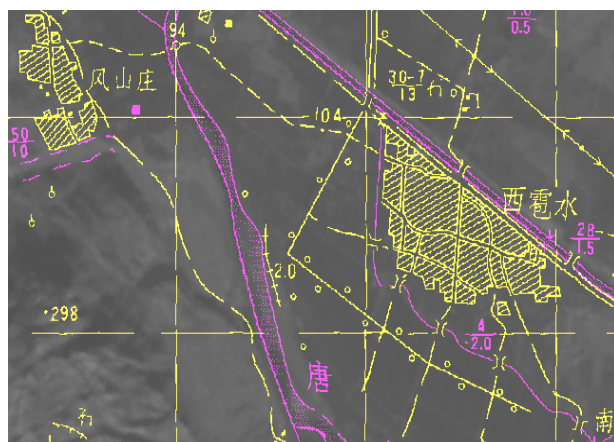


Figure 3. Display raster map on new orthophoto



Figure 4. Display old raster map on SPOT image

#### 3.4 Visual Management in Operation Process

DiMP can identify operation process by checking the data files in user area and describe it in figure mode. By means of Visual management, users can know how much work has being done and how much has not finished. Furthermore, it can inquire, copy, and transmit data files as request.

### 3.5 Online Connection Checking

When collecting features of current image, users can view existed ground features of its nearby image clearly. In this way, we can find out errors and ensure the reliability of automatical connection in succeed process.

### 3.6 Friendly Interface and Being Easy to Be Accepted

DiMP uses pwindows2000 as its operation platform. All the software program are redacted by using Visual c++6.0. The design of the system is refer to standard windows style. It provides on-line help in operation. Because DiMP is audio-visual, vivid, convenient and effective, users can master its operation in a short time.

## 4. BASIC FUNCTION MODULES

DiMP's function modules include data Preparation, data collect, map edit and plotting and data transform.

### 4.1 Data Preparation

In the module, users can input or correct the basic parameters of mapping. These parameters include map name, the number of flight course and photo, the style and distance of frame marks, GCPs, DEM data, contour data and user's information. DEM can be transformed into contour, so do contour.

### 4.2 Data Collect

Data collect can transform ground feature data on the computer screen into actual ground data. This module has functions as follows:

1. Photo inner orientation
2. Photo exterior orientation
3. Ground feature collect
4. Online edit
5. Data transform: Data transform can transform ground feature data on the computer screen into actual ground data and add them into a digital map.
6. Edge matching check. It can check edge matching between currently photo and adjacent photos.
7. Map revision. It can use old raster map and digital orthophoto map(DOM), old vector map and DOM, old raster map and digital photo, old vector map and digital photo to do map revision. Photos can be aerial photos or common satellite photos.

### 4.3 Edit and Mapping

This module has functions as follows:

1. Display symbolized map data
2. Automatic edge matching
3. Map edit
4. Ground coordinate or distance measurement
5. Vector plotting with vector plotter
6. Raster plotting with raster plotter

### 4.4 Data Transform

This module can transform map file of DiMP, which is \*.map, into DGX, DGN, MIF or ASCII file.

The basic work process of DiMP is described as figure 5.

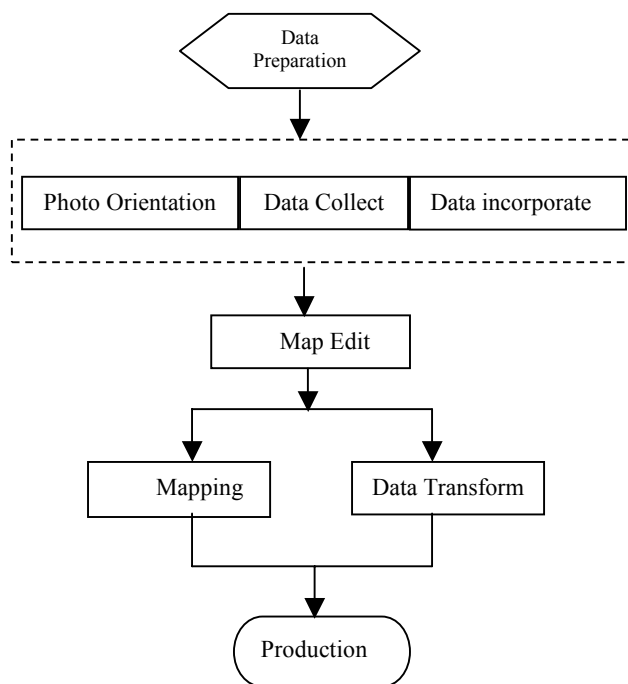


Figure 5. Basic Work Process of DiMP

## 5. CONCLUSIONS

Now, DiMP has been used by some surveying departments. Over two hundred digital maps have been produced in 2001 by means of DiMP. Because the cost of DiMP is low and the capability of DiMP is great, DiMP will have a good market.

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