

GEO-PLOTTER - A SOFTCOPY MAPPING SYSTEM FOR LOW COST DIGITAL MAPPING PROCESS

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ABSTRACT

We developed a softcopy mapping system "Geo-plotter" as a solution for low cost digital mapping. The features of this system are 1) total digital process from orientation to digitizing, editing, logical data verification and creation of DEM / orthogonal images, 2) combination of digitizing and editing, 3) applicable to not only center projected images but also line sensor images, 4) no requirement for order-made devices, 5) easy operation. Evaluation tests through 1/2500 digital mapping show that the orientation and mapping accuracy are equal to existing analog or analytical plotters. Total processing time for digitizing and editing is reduced by 30%.

1 INTRODUCTION

Recently, due to rapid development of computer system, it is possible to construct practical digital mapping system on PC-based environment. At the same time, high-resolution satellite images with 1m spatial resolution are available in digital format, which requires mapping systems to be totally digital. Since softcopy mapping system is the solution for total digital mapping, we have developed a softcopy mapping system "Geo-plotter" that can realize low cost map digitizing processing.

In this paper, we present the configuration, main features of Geo-plotter and the evaluation results. This system is largely composed of four modules: 1) project management, 2) aerial triangulation (orientation) and image rectification, 3) digitization and edition and 4) logical verification of map data. This system can also create meshed DEM and orthogonal images. Experimental results of 1/2500 digital mapping with real world images (simulated images) show that 1) the mapping accuracy is equal to existing systems, 2) little experiences are required for operators, 3) overall processing time is 30% less than existing plotting instruments.

2 CONCEPT AND CONFIGURATION

2.1 System Concept

System concept is as follows.

The system

- 1) enables consistent digital processing from the orientation to digitizing, editing and inspection.
- 2) positively incorporates as many automatic digital processes as possible.
- 3) realizes user friendly GUI so that mapping becomes also possible for amateur worker.
- 4) realizes orientation and mapping for high-resolution satellite images.

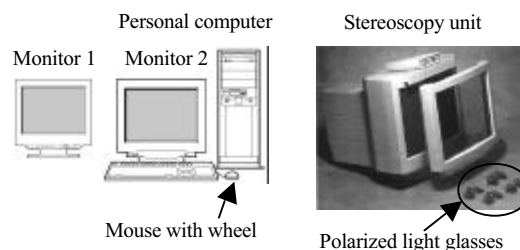


Figure 1. System configuration

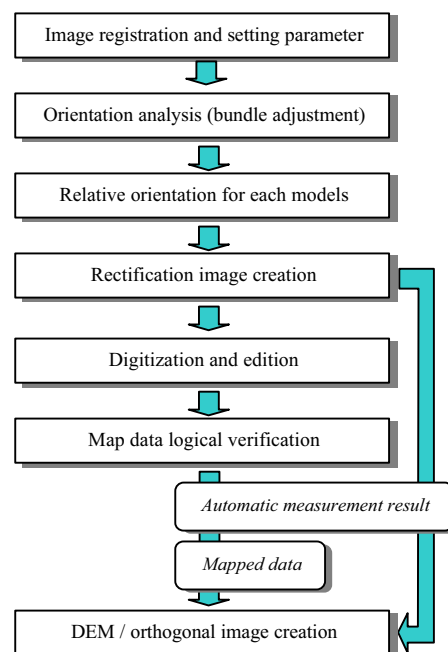


Figure 2. Process flow

2.2 System Configuration and Process Flow

Geo-plotter is composed of 1 personal computer with Microsoft Windows95/98/NT, two monitors (available even in one monitor), two video cards (PCI), mouse with trackball (for xy-axis control) and wheel (for z-axis control), and stereoscopy unit. No order-made device is required. A configuration image is shown in Fig.1. The process flow in this system is shown in Fig.2.

3 MAIN FEATURES

This system is constituted of four representative modules and additional applications. Representative features of this system are as follows.

3.1 Project Management Module

Project management module is used for progress management and preparation of necessary information (Fig.3).

In this stage, digital images and related information such as camera parameter or photo scale are registered and models are determined, which are used as a unit of digitizing or editing. It allows locating the approximate relationship of photos and photographing sites on a scanned orientation map through GUI. This information is also used for initial parameters on orientation analysis. If necessary, models can be divided for multiple workers and after finishing the work, it can also merge the results (distributed and cooperative digital mapping). The progress status on each model can be also checked.



Figure 3. Project management module

3.2 Orientation Analysis Module

Orientation analysis module calculates three-dimensional coordinate transformation parameter by aerial triangulation (Fig.4). In our system, bundle block adjustment is applied. Orientation process is executed automatically for determination of fiducial mark's positions and relative orientation, and is processed semi-automatically for absolute orientation. This module is applicable to not only center-projected images but also line scanner sensor images such as high-resolution satellite images.

For the next digitization process, relative orientation are carried out for each models again and the rectification images are created.

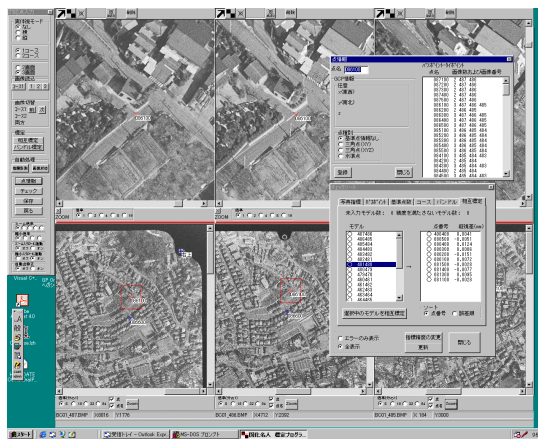


Figure 4. Orientation analysis module

3.3 Digitization and Edition Module

Digitization and edition module is the key module in this system.

Besides the functions of traditional analog or analytical plotting instruments, this module also has many useful functions because of our total digital solutions. The characteristic features of this module are listed as follows.

1) Handling of large images with limited memory

For practical digitizing, the size of high-resolution satellite images or aerial photographs scanned at high resolution can reach several hundred Mbytes. In this system, we adopted an image handling approach which is based on original file and independent of data size.

2) Unification of digitization and edition process

Digitization and edition processes are usually separated because analog plotters or analytical plotters are very expensive and therefore only a few units are available. Geo-plotter allows combination of two processes, because images and plotted lines, or map data are displayed on the same view (stereo view if necessary). This helps to shorten verification process. Unlike conventional approach, editing and digitizing process can be performed parallelly.

The main functions of plotting and editing are as follows.

- a) Basic functions such as copy, move, delete, display of data on selected layers, and so on.
- b) Parallel line creation and right angle correction for digitizing or digitized lines.
- c) Line integration and corner cutting for intersections within specified area.
- d) Automatic height calculation of existing digitized objects in which only x and y coordinates are known. This technique is based on geometric constrain condition and image matching (Fig.6).
- e) Undo and redo.
- f) Reference of adjoining area. The referenced data cannot be edited directly but can be viewed or linked.

Fig.5 shows control / setting and digitization / edition screen of Geo-plotter.

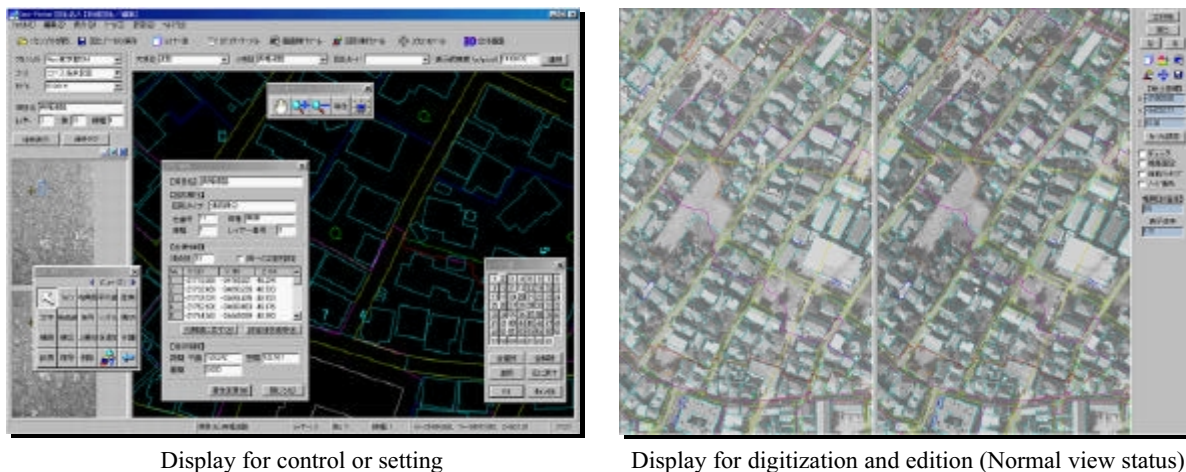


Figure 5. Digitization and edition module

3) Edition of 3-D and 2.5-D map data

Geo-plotter enables edition of digitized 3-D map data and existing 2.5-D map data, with a 2.5D to 3-D conversion program, which automatically interpolate the values of contour's (2.5-D) altitude to calculate altitude information of ground objects. Using stereo observation unit, digitization and edition can be performed in the same way as analog or analytical plotters.

4) Map category specification by table selection

The digitized object's category is specified through selection of category table, which defines the attributes of each category by layer, color, line width, line type and mapping mode for digitizing (Fig.7). This method can considerably reduce human errors at digitizing process.

5) Orientation analysis and digital mapping for high-resolution satellite images.

We have implemented the orientation analysis, which through experiments with real world data (simulated images), is proven to be applicable to both center projected and line sensor images. Similarly, digital mapping is also possible.

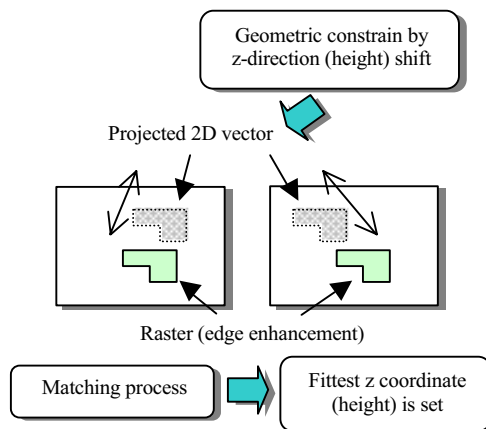


Figure 6. Concept of automatic positioning for existing 2D digitized objects

3.4 Map Data Logical Verification Module

Map data logical verification module is used for getting rid of casual mistakes, and therefore ensuring proper data processing for GIS applications. Digitized data are checked logically, with the highest priority for duplications, crossing of nodes and invalid level points. Logical check is also executed during digitization on each element (digitized data), but in this module, errors based on the mutual relationship between elements are checked rigidly.

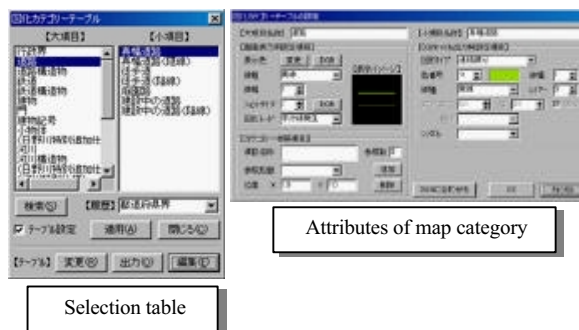


Figure 7. Map category

3.5 Additional Applications

Geo-plotter has the function for automatic creation of meshed DEM and orthogonal images. In orthogonal image creation, digitized map data corresponding to specified map category can be used as break-lines. In addition, when the specific region for orthogonal image creation is specified, necessary images and DEM data are automatically selected and processed.

4 EVALUATION TEST

Geo-plotter was tested at our 10 subsidiaries for evaluation of 1/2500 digital mapping and improvement requirements were reported and incorporated during version up (Fig.8). The test sites were selected from urban area and mountainous area respectively. Fig.9 shows an example of mapping test.

As a result of evaluation test, it is proven that 1) mapping accuracy is the same as existing plotting instruments, 2) Amateur worker can operate with minimum training on specific mapping operation, 3) Reduction of process time for digitization and edition is estimated as about 30%.

In other application examples, Geo-plotter is proven to be able to detect and digitize the collapsed ground.

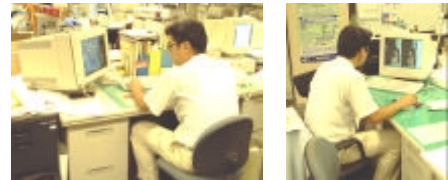
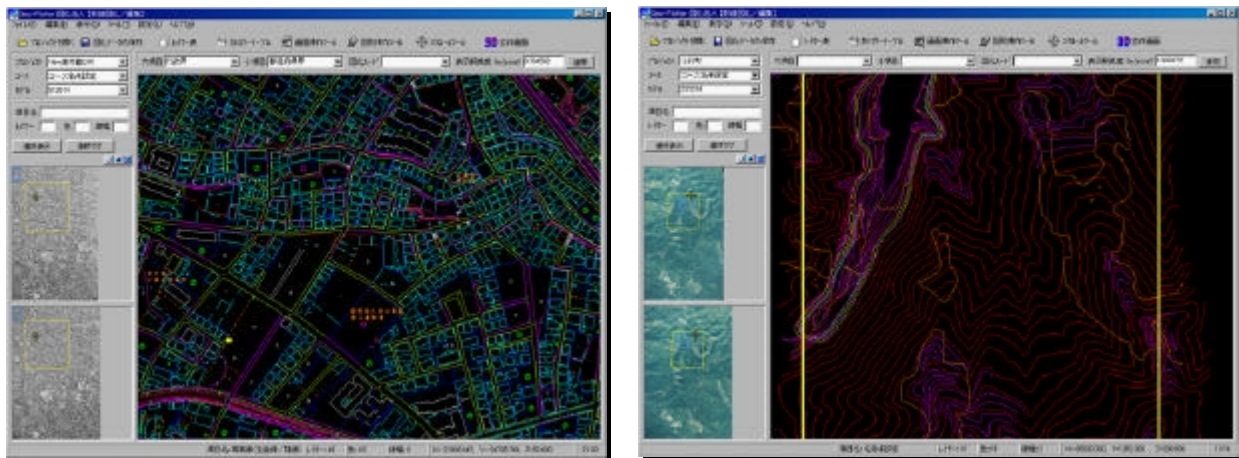


Figure 8. Working scene



(a) Urban area

(b) Mountainous

Figure 9. Examples of test mapping

5 CONCLUSIONS

We developed a softcopy mapping system “Geo-plotter”. Geo-plotter is an economical system composed of only commercial devices, enables distributed and cooperative digital mapping, combines digitization and edition with lesser data check processes.

From evaluation test, it is confirmed that the accuracy of orientation and mapping is the same as existing plotting instruments. In addition, total processing time for digitization and edition is reduced by 30%.

Results of this system are applicable to sight simulation, car navigation, city development consulting and so on.

ACKNOWLEDGMENTS

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