

DEVELOPMENT OF A PC-BASED DIGITAL PHOTOGRAMETRIC SYSTEM

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ABSTRACT:

A PC-based digital photogrametric system has been developed. This system has a three dimensional (3D) display module with liquid crystal shutter glasses. This system can extract DEM automatically from digital stereoscopic images, and display it on a 3D display together with stereoscopic images, and then check it and correct it semi-automatically. A high accuracy DEM can be extracted by this low cost digital photogrametric system without troublesome handicraft which is necessary in the case of using analytical plotters.

KEY WORDS: Digital photogrametric system, 3D display, Personal computer, DEM, contour line

1. INTRODUCTION

Topographic maps are usually made from stereo-photographs using analytical plotter. Even in the case of digital stereoscopic images, which can be get from SPOT satellite, analytical plotter is usually used. But, in this case, digital images at first must be transformed to photographs on film or paper because analytical plotter can not treat digital images directly. It is a disadvantage of this method that the form transformation spends extra time and money, and causes new distortion of images. Therefore, it can be said that a digital photogrametric system is better than an analytical plotter to make topographic maps from digital stereoscopic images. The purpose of this research is to develop a digital photogrametric system which has high accuracy and enough practicality. In order to be used in this system, a new type of 3D display module has been developed, which has an ability to display both stereoscopic images and stereoscopic graphics simultaneously by using liquid crystal shutter glasses. This module can be used as a powerful man-machine interface of stereoscopic images, and errors of stereo-matching can be corrected easily with this module. Using this module, a low cost and high accuracy PC-based digital photogrametric system has been developed. This system is expected to be able to treat not only SPOT stereoscopic images but also JERS-1 (Japanese Earth Resources Satellite-1) stereoscopic images which may be able to get in this year (1992).

2. DEVELOPMENT OF A 3D DISPLAY MODULE

Recently 3D display has been very much developed especially in the field of 3D graphics. One of the representative way of 3D display is now time-sharing method. By using this method, stereoscopic graphics can be displayed on only one display and the cost of the 3D display can be reduced very much. In this research, a new kind of 3D display, named a 3D display module here, has been developed. The function of it is shown in figure 1. This module has the ability to display stereoscopic images in frame memories together with stereoscopic drawings in VRAM (Video Random Access Memory) using time-sharing method. In figure 1, left image and drawing, and right image and drawing are overlaid respectively and displayed on a display. The observer can get a stereoscopic view by using liquid crystal shutter glasses, the shutters of which are synchronized with the

display.

The hardware components of the 3D display module is shown in figure 2. In the figure, VRAM 1 and VRAM 2, which are included in the personal computer, memorize the stereoscopic drawings. The selection of VRAM 1 and VRAM 2 is performed by GDC (Graphic Display Controller) by using the bank selection method. Frame memory 1 and frame memory 2, which are two additional boards, memorize stereoscopic images. CRT display displays two overlaid images one by one, one is the image in frame memory 1 overlaid with the drawing in VRAM 1 and the other is the image in frame memory 2 overlaid with the drawing in VRAM 2. Shutter glasses control board, which is an additional board, produce signals to open the two liquid crystal shutters on liquid crystal shutter glasses one by one synchronized with the CRT display. "Device driver" is the software to control all of the processings of this module.

The most significant feature of this module is that it has an ability to draw 3D drawings on stereoscopic images, and can be used as a powerful man-machine interface of stereoscopic images.

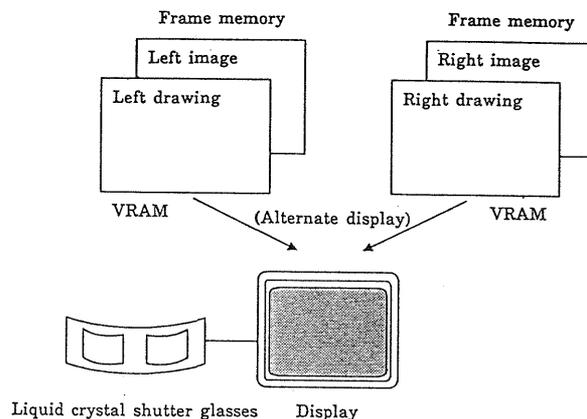


Figure 1. The function of the 3D display module

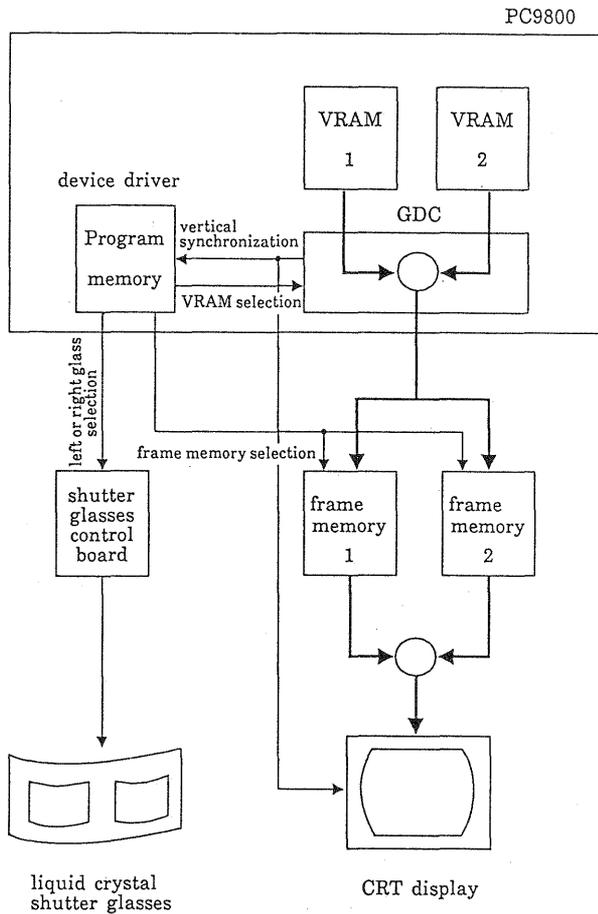


Figure 2. Hardware components of the 3D display module

3. DEVELOPMENT OF A DIGITAL PHOTOGRAMMETRIC SYSTEM

3.1 The composition of the system

A PC-based digital photogrammetric system has been developed using the 3D display module. The composition of the system is shown in figure 3. In the figure, the main processor of this system is a personal computer PC-9801 made by NEC. Two floppy disk drives which usually are included in the standard model of the personal computer, are used as input and output devices of data. A magnetic disk drive or an optical disk drive is necessary to treat a large size image. A mouse is used to move a floating mark. Liquid crystal shutter glasses are used to observe stereoscopic images, and can be increased up to 4 pieces. The three additional boards are composed of two frame memory boards and one control board for the liquid crystal shutter glasses. The two frame memory boards are used to memorize stereoscopic images.

Photo.1 shows an over-view of the digital photogrammetric system. It can be seen that this system is a very compact one.

3.2 The features of the system

The features of this system are explained as follows:

- (1) The system has a 3D display module with liquid crystal shutter glasses.
- (2) The 3D display module can display stereoscopic images in frame memories together with stereoscopic drawings in VRAM.
- (3) Large size displays for general purpose can be used in this system.
- (4) The total cost of this system is lower, about twenty thousands US Dollars, because this system is composed of a personal computer and its general peripherals.

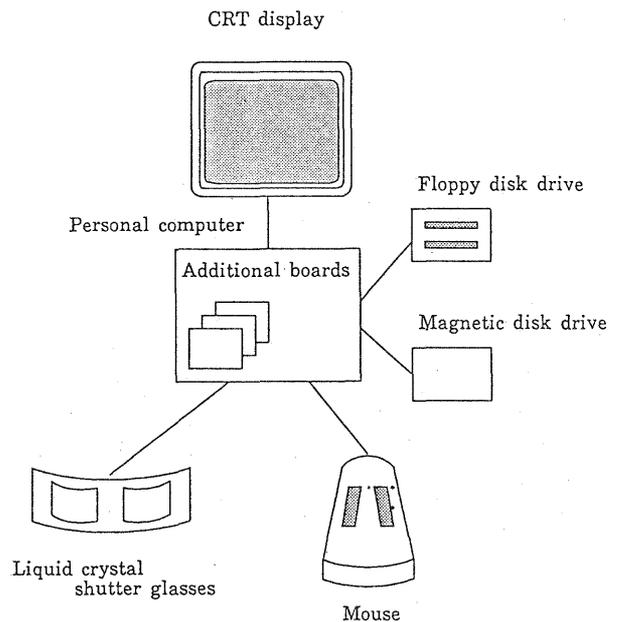


Figure 3. Composition of the digital photogrammetric system

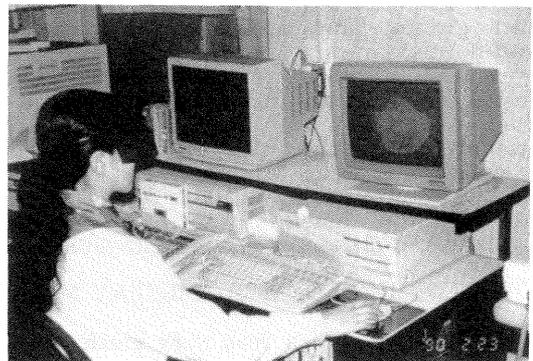


Photo 1. Over-view of the digital photogrammetric system

3.3 Some examples of the application

As it has been mentioned at previous section, this system has a powerful man-machin interface ability for stereoscopic images. In order to show this ability obviously, two applications of this system will be explained next for examples. Photo.2 shows an example of 3D position measurement. Stereoscopic images of Yaku island are memorized in frame memories and stereoscopic drawings of cross mark are memorized in VRAMs.

drawings of cross mark are memorized in VRAMs. When this image is observed through a liquid crystal shutter glasses, a pair of cross marks in this photograph are observed as one cross mark floating in the 3D Space. The position of this floating mark in the 3D space is shown in the left bottom part of the display in a style of (x, y, z). By using liquid crystal shutter glasses, the image of Yaku island in the photograph is also observed as a 3D model, and the position of any point in this model will be calculated by pointing at the point with the floating cross mark which moves according to the movement and button selection of the mouse.

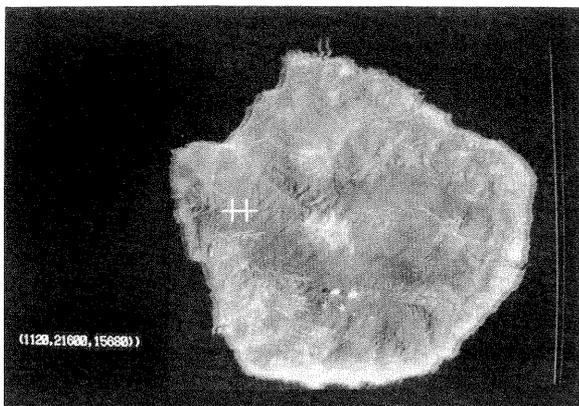


Photo.2 An example of 3D measurement

Photo.3 shows an example of manual drawing of contour lines. In this case, stereoscopic contour lines are memorized in VRAMs using graphic tools of a personal computer. The way of drawing contour lines is as follows: Firstly the height of a floating mark is adjusted using a mouse, then the floating mark is moved touching the surface of a model of a mountain and the positions of the floating mark are marked on the model of the mountain one by one by writing them in VRAMs. These two examples show that it is very easy for this system to transmit informations between a computer and stereoscopic images.

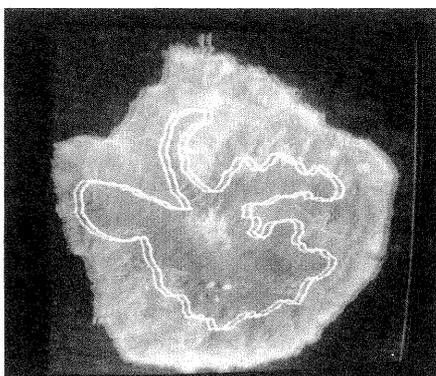


Photo.3 A contour line drawn manually

4. AUTOMATIC EXTRACTION OF DEM AND CONTOUR LINES

An automatic DEM extraction method has been developed on this PC-based digital photogrammetric system. Stereo conjugate points can be determined

by stereo-matching using a personal computer. The errors of stereo-matching, which are serious problems for automatic DEM extraction and which are difficult to be avoided by present technology, can be checked and corrected easily in this system by using the 3D display module. Figure 4 is the method of the automatic DEM extraction. Photo. 4 is a simultaneous display of stereoscopic images and stereo conjugate points determined automatically. When observed through liquid crystal shutter glasses, correct points are positioned on the surface of a model of a mountain and error points are positioned in the air or under the ground. These error points can be corrected by the mouse easily.

Photo. 5 is an example of output contour lines of this system. These contour lines are extracted from SPOT panchromatic stereoscopic images of Mt. Minobu near Mt. Fuji in Japan.

The main features of this DEM extraction method are as follows.

- (1) The most part of the work to extract DEM from stereoscopic images is executed automatically by a personal computer.
- (2) The results of computer processing can be checked and corrected using 3D display module in order to get accurate final results.
- (3) Positions of ground control points in stereoscopic images can be determined exactly by using the 3D model of stereoscopic images on the 3D display module.

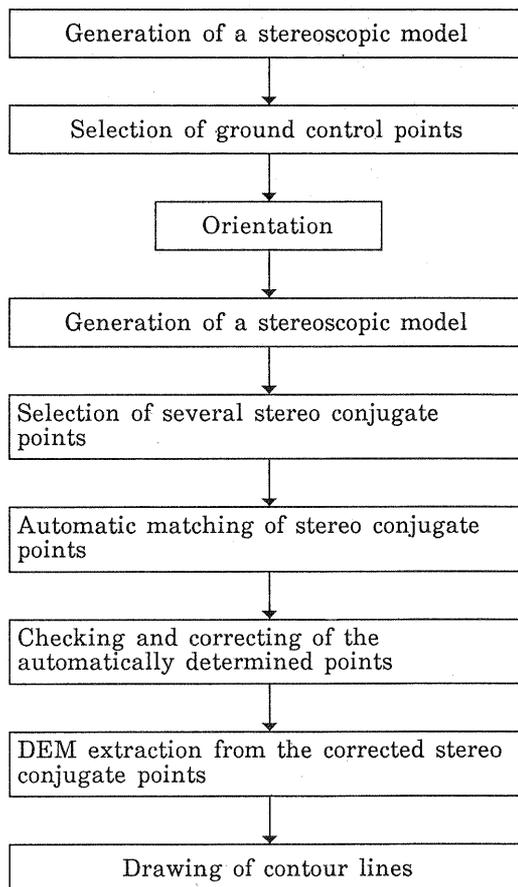


Figure 4. DEM and contour lines extraction method from stereoscopic images

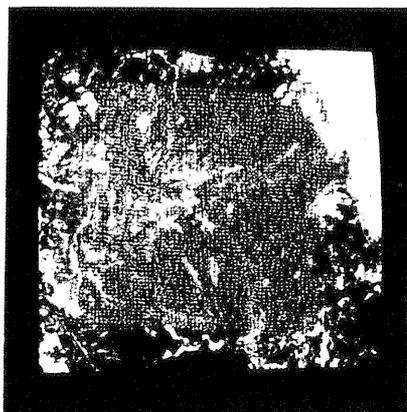


Photo 4. Simultaneous display of stereoscopic images and stereo conjugate points determined by a system automatically.

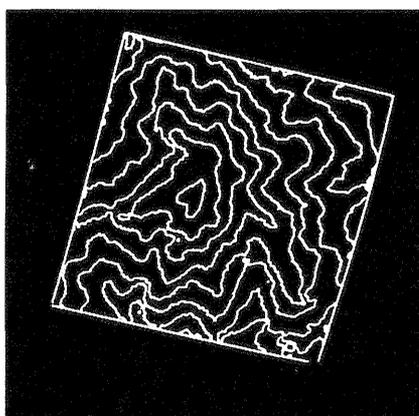


Photo 5 Contour lines extracted from SPOT stereoscopic images (100m intervals)

5. CONCLUSION

A PC-based digital photogrammetric system has been developed. The most significant feature of this system is that it has a newly developed 3D display module, which has the ability to display both stereoscopic images and 3D graphics simultaneously. This module has a powerful man-machine interface ability for stereoscopic images and can correct the errors of stereo-matching easily. Because this module displays stereoscopic images on only one display using time-sharing method, the cost of this system is very low. Digital stereoscopic images, such as SPOT stereoscopic images or JERS-1 stereoscopic images, can be treated directly, and DEM or contour lines can be extracted with high accuracy by this low cost and simple digital photogrammetric system.

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