A GIS WORKSTATION-BASED ANALYTICAL PLOTTER

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ABSTRACT

Today's high performance analytical plotters are typical stand-alone, single-user systems. Though they serve as intelligent 3-D data acquisition stations to geographical information systems, the link between them is usually limited to data transfer. Because their hardware and software platforms are different, no sophisiticated interactions with GIS workstations on the system level take place. In the future we expect a much closer integration of analytical plotters into GIS systems. This entails sharing similar design concepts, data structures, user interfaces, etc. The integration is greatly facilitated by the separation of the real-time loop processes from application software as well as by the rapidly decreasing cost of high-performance UNIX workstations. In this paper we describe the design concepts and the development of basic analytical plotter software, such as orientation, closely integrated on Intergraph's GIS workstations. A generic interface supports different analytical plotters without the need for hardware or software modifications.

KEY WORDS: Analytical Plotter, System Integration, GIS.

1. INTRODUCTION

The introduction of the *plate processor* was a major milestone in the continuous development of the analytical plotters. Dedicating a special processor to instrument specific tasks significantly improves plotter operation and dramatically decreases the involvement of the host computer, thus freeing up computer power for the applications. Prior to this development the host computers had to run the mapping application software and at the same time maintain the plotter operation *real-time loop*. This inefficient structure required special interfaces and was demanding on the host (e.g., complex software). Separating the real-time loop from the application program brought new flexibility and opportunity to the design. Most important, the mutual dependency of the plotter hardware and the host computer disappeared. In the past the host computer was an integral part of the analytical plotter and so was the proprietary application software. Customers had little choice in using third party mapping programs. With the new design, the situation started to change. First, alternative hosts and an increased software selection were offered. Finally, analytical plotters became peripheral devices. Modern plotters can easily connect to any computer platform.

The never stopping, continuously advancing computer technology is the main driving force for development in many, quite different, application areas. It was the case with the plate processor of the analytical plotters. Currently, GIS technology is getting a big boost. On a theoretical level, the GIS is a database with spatial context. The compact definition can be detailed if technical aspects of the implementation are considered. The hardware components are off-the-shelf products: high capacity central mass storage with servers, fast local and wide-area networking and powerful user workstations. The software picture is more complex, including standard packages like networking, database management, 2- or 3-D graphic packages, etc. What makes a real GIS different from a big database system is the customization. The layered database is organized on the spatial – geographical – relation providing application optimal data access. A key issue is the user interface and data exchange, mainly importing data into the GIS. We believe that on the data input side analytical plotters should be considered as a main source among others. In this context, the analytical plotter is used as an intelligent front-end data acquisition system connected to an information processing system. It is important to note that plotters not only send but also receive data. The core information system can host not only GIS but other applications like CAD engineering. We think the key point of the above-outlined development path is the common user interface. The software engineering is undoubtedly the focus of this decade. Many signs of major standardization have already appeared, like windows systems with the same look and feel, networking protocols, etc. This standardization should reach the applications. The user working in a GIS should be able to use an analytical plotter with minimum extra effort. This can be easily achieved by using the same computer hardware platform – workstation – and providing an identical user interface for the plotter program. This way the need for learning the specifics of the analytical plotter is minimized.

The turning point in the evolution of analytical plotters was in 1987, when Carl Zeiss, Inc. introduced the P-Series Planicomp analytical plotters (Hobbie, 1987). All three members of the P-Series family had built-in plate processors with additional coprocessors to support real-time computations. The first systems comprised an HP 1000 workstation and the PHOCUS application software. These pioneering instruments had an IEEE-488 (HP-IB) interface for host communication which later very dramatically influenced the future of the instrument. Back then workstation and PC prices differed a lot. It was clear from the beginning that a low cost PC-based configuration should be developed. In 1987, Carl Zeiss Inc. donated a full fledged P1 instrument to the Department of Geodetic Science and Surveying at The Ohio State University. As a result of the good cooperation, a PC-based stereo orientation program, called PCAP was developed by the authors. The program was based on, at that

time yet completely unknown, user interface, Microsoft Windows (Zilberstein *et al.*, 1989). Later DEM (Toth and Schenk, 1990, 1992) and aerotriangulation (Toth and Schenk, 1991) data acquisition application programs were added. The wide selection of the mapping products offered by many vendors also contributed to the opening of a new market niche for the PC-based P3 analytical plotters.

2. FUTURE OUTLOOK

The introduction provided a short analysis about trends in the development of the analytical plotters. In this section some current development issues are addressed.

Hardware Changes

Probably the most important interface standardization of analytical plotters is the general acceptance of the serial line as a link to the host computer. For example, Zeiss P-Series instruments offer an alternative serial interface. The Leica SD 2000 plotter interface is exclusively based on the serial line. The SD 2000 real-time processor, unlike the Zeiss plate processor, is accessible by the user. Most of the planned upgrades for older analytical plotters will also use the serial line as the communication interface. The motivation for the serial line interface is simply because it is the only interface which is available on almost any computer platform. While a PC can easily be interfaced to IEEE-488 or other standards, this is not true for UNIX workstations (thereafter called workstation), where the serial line is basically the only economical option.

The internal operation of the analytical plotters is based on model and photo coordinate systems. Currently most of the driver programs, which connect the plotter to the application programs, have to transform the input data from model to ground coordinates on the host. With the increased processing capabilities of plate processors, this computation can take place on the plotter. On newer systems it is very likely that the absolute orientation can be downloaded to the plate processor.

The recently introduced softcopy workstations (Kaiser, 1991) create a very good alternative to the analytical plotters. We think the new systems will not compete directly with analytical plotters but instead expand the market (Schenk and Toth, 1992b).

Software Issues

Prices for workstations have dropped considerably. Entry level workstations and fully loaded PCs are now in the same price range. Many applications justify the use of the more powerful workstation for performance reasons. Workstations are expected to increase their market share, but PCs will dominate for quite some time.

Much less but more expensive application software is available on workstations, compared to PCs, because the market is smaller and the hardware is quite different. This is the main reason why system developers try to work with platform independent software environment. Concerning the key component of the application programs – the graphical user interface – the above-mentioned demand led to the wide acceptance of the X Window System. This standardization is very likely in the mapping applications. A good illustration of this process is that the Intergraph Corporation, which is a one person workstation hardware manufacturer and software vendor and has its own windowing system, has started to offer its products on the X11 platform. Concerning the applications, the X11 protocol is very generic and therefore toolkits have been developed and used to make program development easier and faster. Using the same toolkit for different applications results in a similar feel and look which is very good for the user. Based on recent surveys, the OSF/Motif environment is likely to dominate.

The standardization of the analytical plotter hardware interface is not likely to be followed by a similar move in the interface software protocol because such a standardization is probably not in the interest of plotter manufacturers. Luckily, this does not preclude the use of the same orientation or mapping application program on different analytical plotters. This trend offers the user increased flexibility.

3. INTERPRO ANALYTICAL STEREOPLOTTER INTERFACE

Several reasons led to the development of an Interpro workstation based orientation program:

- Our analytical and digital photogrammetry laboratories have gone through major changes during the last few years. Currently, we have more workstations than PCs. All the major workstation brands are represented, although almost half of them are from Intergraph Corporation.

- We do most of our research on Intergraph workstations and have acqiured the knowledge to develop application programs.

- For various reasons we needed to integrate our Zeiss P1 analytical plotter into the Intergraph MicroStation environment.

- We have had good experiences with the PC-based PCAP program.

A major design objective was to use the Intergraph I-form-based windows system to provide the user with the well-known look and feel of other Intergraph mapping applications. Another objective was to avoid unnecessary hardware dependency on the analytical plotter interface because we plan to connect our workstations to other analytical plotters. In the following, the major building blocks of the program are described. For more details, interested the reader is referred to (Stereoplotter Interface/Analytical (SPI/A), 1992).

Stereoplotter Interface/Analytical (SPI/A) Overview

The SPI/A software provides the user with the capability to measure points and to perform the interior, relative and absolute orientation of a stereopair on the Zeiss Planicomp P-Series analytical plotters. In addition, SPI/A provides forms for data entry and editing. The major functions include:

- Input and edit system configuration, project, model, camera, control point, and analytical plotter control data through forms.

- Perform interior, relative, and absolute orientation.

- Generate ASCII protocol files of project, model, camera, control point, and analytical plotter data.

- Generate detailed orientation reports.

- Generate ASCII files of measured points in various formats for later use in other applications.

- Dynamically display carrier, photo, model, or ground coordinates.

- Drive to points in the model.

- Create a standard orientation data interchange file to accept orientation results generated on systems other than SPI/A, or to pass SPI/A orientation data to other systems.

- Driver to connect the analytical plotter to the Micro-Station.

SPI/A Workflow

Activating SPI/A, a control bar is displayed. The button functions of the vertical bar reflect the typical workflow in a top-down fashion. The control bar shown in Fig. 1. has four groups:

- System, project, and model data management functions.

- Camera, control point, and plotter definition functions.

- Interior, relative, and absolute orientation functions.

- Other utility functions.
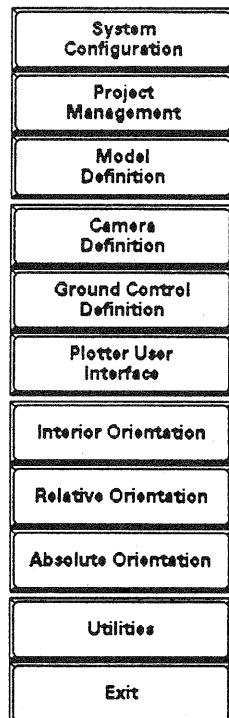
Figure 1.

SPI/A Data Management

SPI/A has its own data management system. The orientation data is organized into projects. A project usually contains the stereo model of a flight mission. The project definition form (Fig. 2.) contains only very generic parameters.

Figure 2.

The most important part of the project definition is the so-called system control definition (Fig. 3.). It sets parameters for adjustment procedures and defines the measuring style.

Figure 3.

Finally, specific information of a stereo model is entered in the model definition file. The form (Fig. 4.) has a generic definition field to define the control point file and other verbal information, two identical fields for the two photographs, and two fields for the orientation and adjustment status.

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Figure 4.

SPI/A Definition Files

Definition files are organized independently from the projects since they are most likely used in other projects. The camera form (Fig. 5.) is used to enter data from the camera protocol. Different subforms are used for fiducial coordinate or distance entries and for camera distortion data.

Figure 5.

The ground control form is used to edit control point information. An import function lets the user transfer control data from ASCII files (Fig. 6.).

Plotter definition files are used to customize the analytical plotter. The operator can freely configure the input devices and set automatic recording parameters.

Figure 6.

SPI/A Orientations

The operation of the three orientations is based on the well-accepted concept introduced in the Zeiss P-Series PC orientation program (Schenk and Toth, 1989). The adjustment computations automatically take place whenever there is any change in the measurement data. As a result, the operator's task is reduced to measuring the points and to analyzing the results. On the forms, the residuals and other transformation parameters always reflect the most recent adjustment results.

A very useful feature of the system is the "drive to" support. That is, the system drives automatically to points to be measured. For example, in the interior orientation the system drives to all fiducial marks. With every measurement the predicted positions become more accurate. Another example is the relative orientation, where the system drives to the von Gruber locations. In order to let the absolute orientation drive automatically to control points at least two XY control points must be measured (either in the relative or in the absolute orientation).

The functionality of the orientations can be seen in the forms shown in Fig. 7-8. Whenever the instrument is in point recording status, a small form is displayed which shows the actual P-Cursor button assignment and the stereo model coordinates.

MicroStation Driver (SPI/D)

The SPI/D program can be loaded as an application when the MicroStation is invoked. During initialization, the program automatically downloads the current orientation into the analytical plotter and configures the input devices for MicroStation operation. In the preferred data acquisition mode – tracking mode – the position of the measuring mark drives the MicroStation mouse, and three of the P-Cursor buttons are programmed to the corresponding workstation mouse functions. Some small forms inform the user about the current operating mode, floating mark location, etc. Fig. 9. shows a map of The Ohio State University campus digitized by the Feature Collection module of the MicroStation.
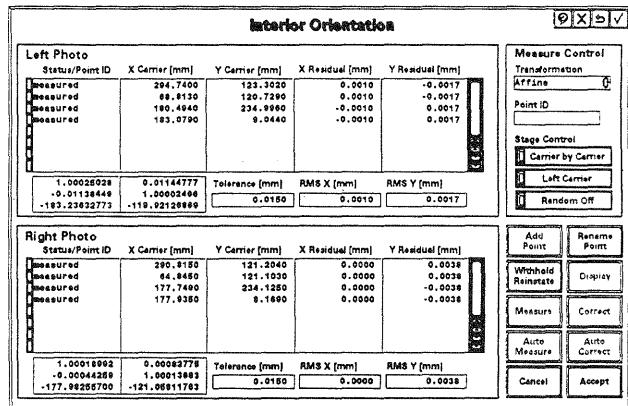
Figure 7.

Figure 8.

Figure 9.

4. DISCUSSION

The SPI/A and SPI/D programs have been tested in our laboratory. Our operators who are very experienced in using the PC-based orientation program found no reasonable difference in the user interface although the windows systems are quite different. Compared to PCAP, a noticeable performance difference was found mostly as a result of faster workstation operation. We also greatly benefit in our research (Schenk and Toth, 1992a). For example, the output data of the automatic surface reconstruction projects can be directly matched to the ground truth by driving the measuring mark to the locations and visually checking whether the point is on the surface or somewhere else.

We strongly believe that the development of the SPI/A program is an important step in the evolution toward the fully integrated geographical information systems. In the future we plan to port it to the X Window System and OSF/Motif environment.

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Zilberstein, O., Greenfeld, J., Schenk, T., and Toth, Ch., 1989. "A Modern Man-Machine Interface for the Planicomp Analytical Plotter," *Proc. AS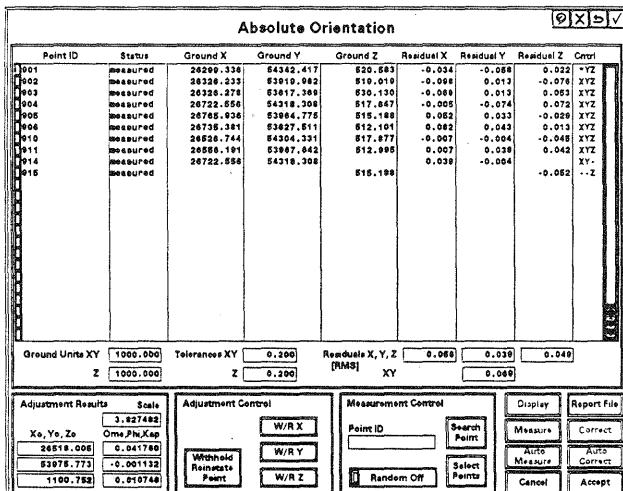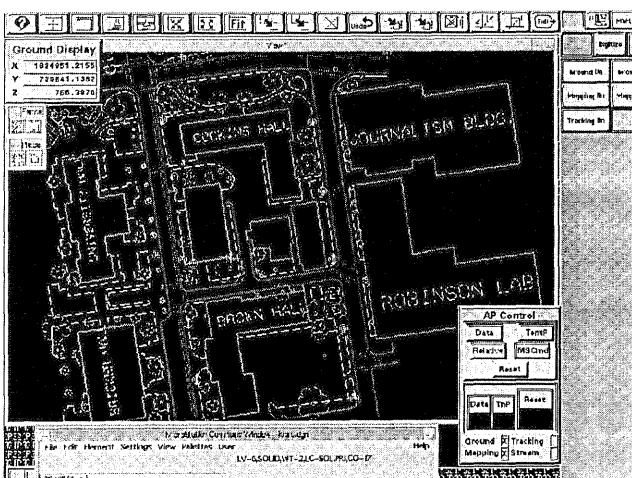PRS-ACSM Annual Convention*, vol. 1, pp. 1–9.