An AutoCAD-Based Mapping System for Encoded Stereoplotters

James A. Rogers
North Pacific Aerial Surveys Inc., 4241 "B" St., Suite 101, Anchorage, AK 99503
Robert M. Bennett
ComRim Systems Inc., 560 E 34th Ave., Anchorage, AK 99503

ABSTRACT: Microcomputer CAD technology can be applied to the growing field of digital mapping through an encoder interface to existing analog stereoplotters. One such approach, developed by DAT/EM Systems, links the stereoplotter directly to the AutoCAD software. The use of low cost, general purpose PC equipment for photogrammetric data capture is discussed.

INTRODUCTION

THE GROWING ADOPTION of automated mapping and geographic information systems technology is causing increased demand for digital maps. For sake of both efficiency and accuracy, it is often desirable to avoid manual digitization operations, particularly when developing new maps. Thus, the ability to produce digital maps directly from aerial photography is a common requirement among photogrammetric firms and their clients.

The cost of digitally capable analytic stereoplotters has prevented some mapping organizations from producing digital maps from photography. The advent of the low cost microcomputer offers new, lower cost alternatives to dedicated analytic stereoplotters.

In recent years, software designed to support computer aided drafting (CAD) operations has become popular. One commercial software package in this regard is AutoCAD, from Autodesk, Inc. A mechanism for connecting existing encoded stereoplotters to AutoCAD is described in this paper. This approach affords mapping firms or agencies with a comparatively low cost means for directly producing digital files from stereo aerial photography.

BACKGROUND

In mid-1985 three photogrammetric firms – Sierra West, Kenney Aerial Mapping, and North Pacific Aerial Surveys – were experiencing a growing need for the ability to directly produce maps from aerial photography in a digital format. Having an existing investment in encoded stereoplotters, a solution was sought which would utilize these older devices in the era of digital mapping. After a review of commercial offerings, it was decided to begin development of an on-line digital mapping system based on a low cost IBM AT running AutoCAD.

At that time, AutoCAD was able to accept two-dimensional coordinate input from a variety of digitizing tablets, mice, and various other pointing devices. It was not, however, able to accept corrdinate input from a stereoplotter. Thus, research began into a way to attach a stereoplotter to AutoCAD.

A device was found which would convert the phase quadrature pulses emanating from a stereoplotter's encoders into the microcomputer. Work then began on custom software which would complete the link to AutoCAD.

During the years that the system was in development, the selected CAD package was also undergoing enhancements of its own. With the release of AutoCAD's ADE-3 option (which allowed three-dimensional data to be collected), the mapping package could now collect the Z coordinate as well as the X,Y values. With later enhancements in AutoCAD such as AutoLISP (an internal programming language), and substantial speed increases, the package began to rival the high priced multi-user systems which prompted its initial development. The last addition AutoCAD made, critical in the package development, was the Advanced Driver Interface (ADI). Designed to allow developers to write custom drivers for their peripherals, the IBM computer could finally be interfaced directly with the stereoplotter (Figure 1).

The completed Digital Mapping System was introduced at the spring 1987 National ASPRS/ACSM convention in Baltimore by DAT/EM Systems, a company formed by the three companies responsible for its development.

The equipment utilized for the system is outlined in Figure 2.

The Digital Mapping System can be setup on any three-axis encoded stereoplotter. Computer hardware required includes an IMB AT or compatible with 640 KB of memory and a hard disk, a high resolution graphics card and color monitor, a menu pad, and an encoder interface board. Because AutoCAD will run on a variety of computers and peripheral devices, numerous configurations are possible. Dual screen configurations are supported in AutoCAD, allowing one monitor to be used for graphics and another for text. Flatbed or drum plotters are used to print out final manuscripts.

The term "AT or compatible" encompasses a wide range of computers operating at various speeds. For data collection with the Digital Mapping System, a standard IBM AT is sufficiently fast. Subsequent editing of the resulting digital map benefits greatly from a "fast" computer. An optimum configuration is to run a standard IBM AT at the data collection station and employ a faster machine, such as a 80386-based computer, for a separate editing station. Computers of this type are available from a variety of manufacturers.

OPERATION

The Digital Mapping System operates in a manner analogous to the creation of pencil manuscripts. AutoCAD's graphic screen serves the purpose of the flatbed plotter or pantograph found on analog mapping systems. Experience has shown that the most difficult part of training compilers on a microcomputer Digital Mapping System is understanding the Disk Operating System (DOS). Aside from file maintenance operations using DOS, digital map creation parallels the compiler's normal procedures closely. Knowledge of stereoplotter operation is more critical than computer expertise.

Once relative orientation is complete on the stereoplotter, the compiler enters the AutoCAD drawing editor. To calibrate AutoCAD to the desired ground coordinate system, an absolute

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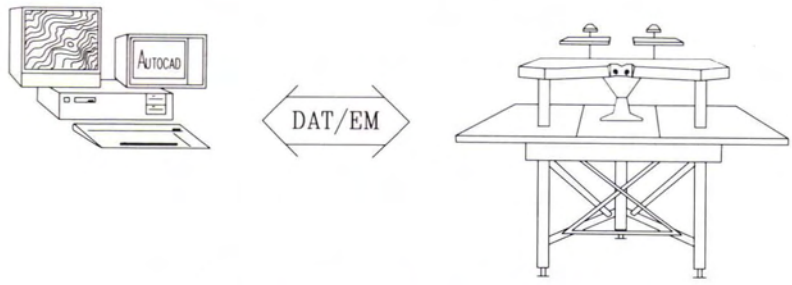

FIG. 1. Microcomputer interfaced with stereoplotter.

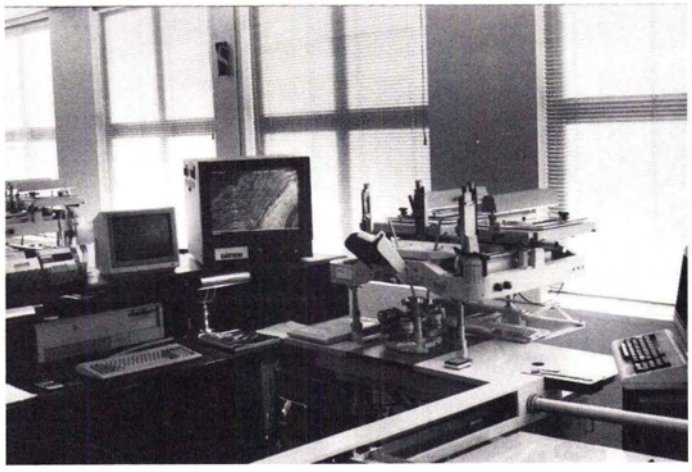

FIG. 2. Typical installation joining a Kern PG-2 with an IBM AT compatible computer.

orientation procedure using a least-squares solution is invoked. Computed residuals are displayed to confirm the current registration along with adjustments for Omega and Phi settings.

Once the compiler is satisfied with his set-up, mapping can begin. As the diapositives are moved in the stereoplotter, the crosshairs on the graphics display move, showing the current position on the map. With each movement of the stereoplotter, the *X,Y,* and *Z* coordinates are tracked. A single foot pedal is used for standard pen up and pen down line creation on the AutoCAD display, allowing contours to be drawn as they would be on a conventional system.

A menu pad is provided, allowing the operator to work without knowledge of AutoCAD command sequences. Each key on this pad invokes a different mapping function. Symbols such as lightpoles or antennas are selected by pushing the appropriate key on the menu pad. Each tap of the footpedal then inserts the symbol into the map. Another menu pad key allows spot elevations to be added by depressing the foot pedal. The current *Z* value is displayed adjacent to the resulting spot tick. If desired, operators can assign their own custom map functions to the keypad.

Once compiled, the resulting model can be edited. At this stage, AutoCAD's graphic editing functions are invoked. Map features can be moved, text placement adjusted, and contours re-shaped interactively. AutoCAD's "zoom" facility can be used to enlarge individual sections. Edge-ties are facilitate by calling up adjacent model edges during the editing process. Exact mathematical matches between connecting and intersecting map features are facilitated, allowing plot back at any scale. Map legends, title blocks, border, and coordinate gridding are added as a final editing step.

A hardcopy drawing of the edited manuscript is then produced on a pen plotter. Line types and output scale can be defined at this stage. Line weights in AutoCAD are held to zero, allowing line thickness to be defined by plotter pen width. With current plotters producing liquid ink mylars, plot quality can approach that of scribed sheets.

The completed drawing file is stored on diskette or tape for future reference. Because the file is an AutoCAD drawing, others can use this product directly on their own AutoCAD system. Translators may be used to convert the AutoCAD to other CAD or GIS formats such as Intergraph or ARC/INFO.

EXPERIENCE WITH SYSTEM

Once compilers and editors have learned the digital mapping procedures, throughput on a stereoplotter will substantially increase over conventional penciled manuscript mapping. Production experience has shown that it is most efficient to perform all clean-up editing on a separate off-line station. This allows the compiler to concentrate on data collection, releasing him from the need to re-draft (heavy up), as would be necessary on a conventional map.

A recent photogrammetric mapping project completed in Keyes Point, Alaska demonstrated the utility of the Digital Mapping System. This 1:2400-scale mapping project utilized 2-foot contours. The final map for this project is shown as Figure 3. This product was compiled on a Kern PG-2 stereoplotter attached to a 640K Sperry IT microcomputer running AutoCAD Version 2.6. The map was plotted using a Hewlett Packard DRAFTMASTER II drum plotter on mylar with liquid ink pens to define line weights. The resulting digital map file occupied 382,000 bytes. The system remains efficient with manuscripts as large as 1,000,000 bytes in size.

TECHNICAL NOTES

The software for the Digital Mapping System consists of multiple parts, several of which are user modifiable. The core driver is written primarily in PASCAL and Assembly language and remains memory resident. It is based on the Autodesk ADI facility for concurrent operation within AutoCAD. The driver is dependent on three external modules which handle command selection. Each of these three modules are user-definable and perform independent functions.

The MENUPAD module allows the operator to select the desired mode, such as contouring or symbol insertion, by depressing a membrane key. These functions are held memory resident and provide command sequences to AutoCAD as if typed from the keyboard. Each key can be programmed to be any desired combination of keystrokes. The MENUPAD module allows for assignment of three hundred keys with an option for adding a second MENUPAD.

An AutoCAD MENU (.mnu) file is used for entering various drawing modes. Specifically, the Button facility is employed as

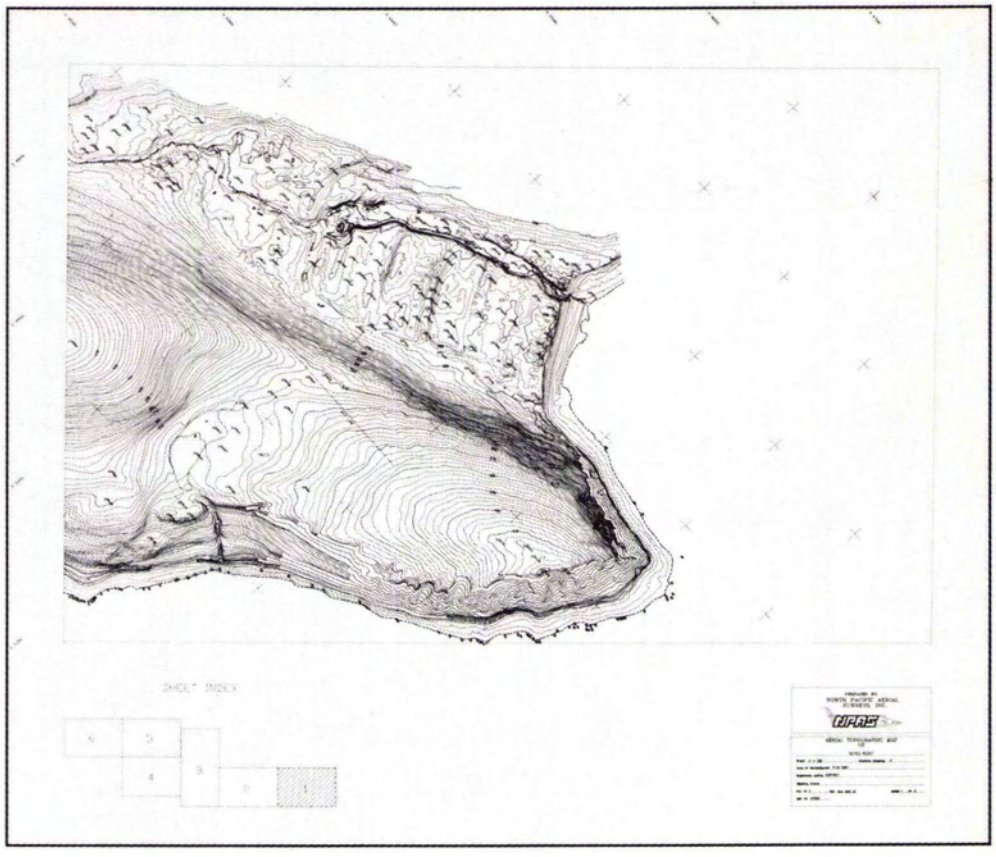

FIG. 3. Digital map of Keys Point, Alaska.

an aid in communication between the driver and AutoCAD. Consisting of a text file, the menu acts as interpreter for allowing the core driver to select additional programs in AutoCAD (AutoLISP).

When triggered by a selection on the menupad, the menu can select from the third module a set of AutoLISP routines. AutoLISP is a subset of Common LISP, adapted by Autodesk as a programming language for AutoCAD. It is implemented in interpreter form in ADE-3 versions of AutoCAD. In the Digital Mapping System, AutoLISP routines are provided for such functions as manuscript gridding, treeline scalloping, spot elevations, and symbol sizing. These routines can be modified by experienced AutoLISP programmers wishing to customize the system for specific needs.

CONCLUSION

For mapping firms to stay current with the increasing demand for digital map products, the ability to map digitally has become essential. Until recently, the cost of acquiring this capability was prohibitive for most mapping organizations. Microcomputer CAD technology has brought the price of graphics systems down considerably in the past two years. As the cost has fallen, the power of the systems has risen to the point of handling the large amount of data involved in a topographic map. By interfacing directly to an encoded analog stereoplotter, older technology can be utilized in the evolving digital era.

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