COMPUTER-ASSISTED MAP COMPILATION, EDITING, AND FINISHING

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ABSTRACT

Computers have been used for a number of years in the computational phases of map production at the U.S. Geological Survey. However, except for a few early isolated attempts at producing experimental editions, the computer has not been used until recently as an aid in map preparation. Historically, computer processing power was never a major issue; even the earliest computers were capable of processing data in cartographic form. The unfulfilled goal was to produce cartographic products of sufficiently high quality at cost-effective rates. Today, due to decreased costs and increased capability of specialized computer peripherals, the goal is within reach for many mapping organizations.

INTRODUCTION

For the past several years, the cartographic research program of the National Mapping Division (NMD) of the U.S. Geological Survey (USGS) has included computer-assisted cartography development activities. Paralleling these activities has been a major effort to build, utilize, and distribute a digital cartographic data base consisting primarily of information from the 7.5-minute topographic map series. Experts estimate that, when complete, this digital data base may be the largest ever constructed.

An extensive equipment modernization program resulted in the introduction of digital equipment into the NMD's four production Mapping Centers in the late 1970's. This equipment has led quite properly to the automation of various phases of the conventional mapping process (Boyko, 1982; Powell, Osick, and Miller, 1979; Troup and Powell, 1979). Each production Mapping Center is now equipped with photogrammetric digitizing equipment, graphic digitizing equipment, automatic plotters, multistation interactive editing equipment, and minicomputers.

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The National Mapping Division is actively engaged in researching, compiling, and producing digital maps and data base products through the use of the Digital Cartographic Software System (DCASS). In this system, planimetric details, contours, and other map data are digitized from the stereomodel during map compilation. These data are collected without online editing capability, processed (file building/automatic error detection and correction of input errors) on a minicomputer, and then transferred to an interactive editing system for final offline editing and cartographic plotting. The initial map production work with this system has been shown to be cost effective when compared to manual methods. The system has the added advantage of providing digital data for addition to the Digital Cartographic Data Base.

SYSTEM DESCRIPTION

Digital data are collected offline during map compilation operations using Kern PG-2 stereoplotters which have been retrofitted with Altek AC 189 digitizers and Interstate voice data entry terminals. The digitizer captures and automatically records on magnetic tape the x-y movement of the stereoplotter tracing table. Automatic (stream mode) recordings are generated on the basis of the degree of line curvature. A recording circuit (essentially an electronic data reduction circuit) was developed by USGS and has been crucial for deleting extraneous data and allowing efficient computer processing of these stereomodel digital data sets. The voice data entry terminal, controlled by a Data General Nova 4 minicomputer, allows the stereoplotter operator to enter attributes without looking away from the stereomodel. The voice data entry terminal also reduces coding errors by prompting the operator to enter additional attributes for features requiring special symbology or labels.

Processing of digital data is accomplished on a Perkin-Elmer (PE) 3230 minicomputer (1.5 megabytes of core with four 300-megabyte disks) utilizing in the DCASS a collection of software developed in-house. DCASS consists of six major subsystems. Each subsystem, comprising one or more programs, exists for one primary function. The subsystem functions can be summarized as follows:

SS1 - file creation, loading, and error detection; transformation to ground coordinates and clipping to quad boundaries.

SS2 - joining of features within and between stereomodels.

SS3 - attribute editor.

SS4 - USGS digital elevation model (DEM) generation utilizing bilinear interpolation of digitized contours.

SS5 - digital line graph (DLG) generation.

SS6 - graphics generation (usually for verification purposes only).

The design of DCASS is based on the premise that interactive editing is a time-consuming task. Therefore, major error checking, identification, and correction is carried out in a batch mode during the file building stage. Approximately three-quarters of all errors are removed at this early processing stage.

The file building and batch processing stage of DCASS does not completely remove all types of input errors and was not designed for graphic enhancement; therefore, interactive editing is a necessary step in the map production flow. Interactive editing is performed on an Intergraph system which is supported by a DEC 11/70 (512K bytes of core with two 300-megabyte disks).

The DCASS digital files are reformatted and transferred to the Intergraph system for the cartographic editing and map finishing stage. USGS-developed map finishing software, called the Graphic Map Production System (GRAMPS), is used in conjunction with standard interactive edit commands to generate reproduction-quality color separation negatives. A brief description of the GRAMPS procedures follows.

As the DCASS data are read onto the disk of the Intergraph system, a complete digital map including symbology and labeling is automatically generated by GRAMPS and placed in an Intergraph design file. This automatic map generation utilizes a specifications table to allow the cartographer to specify changes without requiring computer program changes to GRAMPS. The specifications table contains the necessary feature placement information for each attribute (feature) code. Each table entry consists of four sections: the design file level to place the feature on, symbol information, label information, and special case routines. Special case routines handle features which have unusual placement requirements such as double-line road casings, area hatching, depression ticks, railroad crossties, and building symbology.

Generally speaking, interactive editing of the digital map is a two-pass process. On the first pass, digital features are edited, contours are smoothed and registered, features are added and deleted, and incorrect coding is changed. The digital map is regenerated to reflect these changes, and the nondigital edits such as repositioning of labels, symbology changes, etc., are performed on the second pass.

After interactive editing is complete, all collar and interior lettering is performed on the Intergraph system utilizing a collection of user commands and Fortran routines. Type is generated from the system font library, which contains 40 different fonts.

The generation of reproduction-quality negatives is accomplished on a Gerber 4477 plotter. The GRAMPS plotting program contains an internal sort for sorting vectors according to ascending aperture sizes. Considerable plotting time is saved by this sort because fewer aperture changes are required during the plotting. The various color separates are plotted on film either as image positives or preferably as image negatives.

After the plotting of the type and color separates is complete, the final Intergraph design file is transferred back to the DCASS data base for generation of digital products such as USGS standard digital elevation model and digital planimetric files. At this time, only the landnet and boundary planimetric data are topologically structured. It is NMD's aim to investigate the feasibility of developing additional modular software for structuring other data categories such as hydrography and transportation features.

PERFORMANCE

The preparation of Provisional edition 1:24,000-scale 7.5-minute topographic maps using stereomodel digitizing and computerized map finishing techniques shows promise to become more cost effective than conventional mapping. Provisional Mapping specifications permit departures from conventional map finishing/shaping specifications. This enables acceptance of digitally derived manuscripts with a minimum of editing. Thus, for fiscal year 1982, the stereodigital compilation rate for Provisional Maps is slightly lower than the conventional compilation rate and the computerized map finishing rate is approximately one-half the conventional rate. These digital mapping operations result in a net man-hour savings because of the almost total elimination of manual scribing (when performed to Provisional Map specifications). Some contour registration deficiencies and positional shifts in congested areas are corrected by manual scribing operations.

As with many high technology operations, startup costs (hardware, software development, procedure testing, etc.) of digital mapping are difficult to justify solely for a production operation. However, map data properly digitized, formatted, standardized, and archived in a Digital Cartographic Data Base can be used for spatial analysis in many other disciplines. Another important aspect of digital mapping is the reduced production cycle as it relates to the map finishing process. Production time for a Provisional edition of a 7.5-minute quadrangle using digital techniques from start of compilation to completion of color separates off the flatbed plotter is approximately 4 months as compared to 1 1/2 to 2 years for conventional compilation and map finishing techniques.

RESULTS

The major findings of the U.S. Geological Survey's research and development of a computer-based digital mapping system for compiling and drafting map products that meet Provisional Map specifications can be summarized as follows:

- It is feasible and cost effective to integrate digital and graphic data production operations.

- A reduction in the production time of Provisional Maps can be obtained using a computer-based mapping operation.

- Optimum filtering of the digital data can be obtained using a combination of software programs and electronic data reduction circuitry.

- Use of voice for attribute entry during the compilation phase provides increased accuracy and efficiency when compared to keyboard entry.

- Development of cartographic software systems with maximum use of automatic error detection/correction is essential to minimize the need for expensive (labor-intensive) interactive editing operations.

- Map accuracy standards can be met using digital cartographic techniques.

- There is potential for improving the system's performance through use of disk-based digitizers and improved cartographic plotters.

The transition to the digital data base mapping concept and reconfiguration of the mapping process has begun. This is one facet of the National Mapping Division's development of a National Digital Cartographic Program. The program is well underway and will accelerate during this decade.

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