

Software Interface Design for Photogrammetric Data Input to the Automap System

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ABSTRACT: Digitization for capture of cartographic data forms an important phase of automated cartographic process. Flexibility and speed of digitization are two major parameters used to assess the capability of any automated cartographic system. Current practice advocates direct digitization from stereo photogrammetric models in order to ensure utmost throughput and accuracy of input data.

In India, the Automap computer assisted cartographic system, presently available in the Survey of India and the Naval Hydrographic Office, is essentially a computer controlled fair mapping process in which the input of graphic map data is achieved through an on-line process of manual digitization of maps or photogrammetrically plotted map manuscripts. This form of data input makes the process extremely time consuming and also results in some loss of accuracy inherent in any "free-hand cursor" method of digitization. However, the overall performance of the Automap system is significantly improved when the photogrammetric data from analog stereoplotters is acquired in digital form and directly fed into the cartographic data base of the Automap.

The authors have designed a software interface which preprocesses the photogrammetric data acquired on magnetic tapes with the help of EK-22 data acquisition system in order to merge it into the cartographic data base of Automap.

INTRODUCTION

THE CONCEPT of map making has undergone a total transformation with the interesting and exciting development in the field of computer assisted cartography. In pace with this modern development, the Survey of India had acquired a computer assisted cartography system called "Automap." This system, configured around a PDP-11/34 computer, captures map data through free-hand cursor method of manual digitization using an Altek digitizer, edits the captured data using interactive edit programs and a graphic display terminal, and finally outputs data selectively through magnetic tape into a Kongsberg automated drafting system for the preparation of color separated scribed negatives for final map printing. It also has the facility for producing a two-color output called a verification plot through use of a Calcomp plotter, which is primarily to help in editing work.

This particular version of the Automap has no direct interface with photogrammetric plotters for direct data transfer. Hence the graphic products of the photogrammetric plotters have to undergo the same tedious and time consuming process of manual digitization before being merged into the cartographic data base. This also results in some loss of accuracy. Should the map data be captured in digital form during photogrammetric plotting and input directly to the Automap through a software interface, there would be a considerable saving of time.

In order to fulfill this basic need, a methodology has been experimented with in which an analog stereoplotter and Wild EK-22 data acquisition system have been considered as the hardware model to define an off-line data entry work station for the Automap. For this implementation, the necessary software interface has been developed. Programming in FORTRAN 5 for this purpose has been completed. The interface has already been tested with real data and is now operational.

DATA CAPTURE THROUGH DIGITIZATION IN AUTOMAP

In the present form of the Automap, as outlined in the preceding section, line originals such as field survey sections and printed maps are used as input material. The digitizer station, consisting of an Altek digitizer with freehand cursor, transfers positional data, i.e., the x and y coordinates of points on the map, to the Automap. Using a VT-100 CRT terminal, feature identification attributes called Feature Code (FC) and Feature Modifier (FM) are added to the positional data. Such attributes

are basically to establish linkages for entry into the three levels of static data files, namely, the feature definition table, the symbol definition table, and the matrix definition table, which define the draw characteristics of the feature for final output. A series of commands are available at the digitizer station to facilitate data entry in a flexible way, i.e., open, point, check, enter, again, text, bearing, spot, etc.

ANALOG PLOTTER WITH EK-22 DATA ACQUISITION SYSTEM

In a photogrammetric analog plotter the three-dimensional model of the terrain is realized making use of a pair of overlapping aerial photographs. Any topographic feature visible in this three-dimensional model can be tracked in the x , y , and z directions by means of a measuring mark. Tracking of the measuring mark is controlled by a mechanical tracking system.

The Wild EK-22 data acquisition system, when coupled to the mechanical tracking system of the plotter, can register the spatial coordinates of points and record them sequentially on a magnetic tape and/or on a teletypewriter. A detailed description of the EK-22 system can be found in the *Manual on EK-22 Data Acquisition System* (M/s Wild, Heerbrugg, May, 1978-PZ 417e). For any data point in addition to its x , y , and z coordinates, a point number "N" allowing up to 16 digits also is registered.

As shown in Figure 1, the point number N has two halves, digits 1st to 8th to be indicated on the front panel and 9th to 16th on locations 8th to 1st on the control panel. Furthermore, the 1st to 4th or 5th to 8th digits on the control panel could be set to zero at a time by pressing reset switches left or right, respectively.

It is easier to set any digit on the 8th to 1st locations of the control panel due to the special design of key board as compared to setting of the digits on the front panel. For this reason

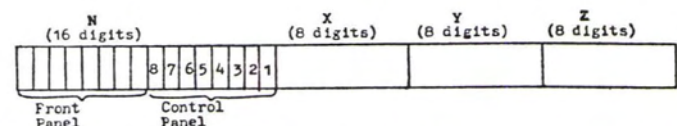


FIG. 1. Output of the EK-22 Data Acquisition System (the last eight digits of N correspond to locations 8th to 1st on the control panel).

the last eight digits of N , which correspond to locations 8th to 1st on the control panel, have been used for subsequent data structuring. These data can be registered on a magnetic tape point-by-point by pressing a switch, or automatically in the time/distance mode at a 0.01 to 9.99 sec/mm interval. The digitization can be done in a number of sessions by marking an end-of-file, at the end of each session, with the help of the end-of-file switch provided in the system.

The above existing facilities of the EK-22 data acquisition system have been used in the experimentation to provide pointers for structuring of data during preprocessing.

AUTOMAP DATA TYPE AND DATA BASE STRUCTURE

DATA TYPE

Automap recognizes feature data or text data as one of the following four types:

- *Single-Point Feature*: Features such as a tree, temple, well, etc., in which only one point needs to be defined positionally.
- *Two-Point Feature*: Certain other features (which need definition in terms of orientation in addition to position, such as a culvert, isolated hut, directional arrow, etc.) which need, in addition to a point for position, another point to define their orientation.
- *Multi-Point Feature*: An area feature such as a village block, garden fence, forest boundary, etc., whose outline is defined in position by a sequence of points joined by straight lines. It also includes curvilinear features such as a road, stream, contour line, etc., that are defined by a series of points and joined through straight lines or smooth curves (which is indicated by the value of Feature Modifier as 0 or 1).
- *Text data*: A string of ASCII characters defined along a straight or curvilinear alignment with facility for left, center, or right justification.

A feature is classified with the help of word(3) and word(4) of a 16-word index entry. Both word(3) and word(4) having zero values indicate that the feature is a spot height. Zero in word(3) and 1 or 2 in word(4) indicate a one- or two-point feature while non-zero values in word(3) and word(4) indicate a multi-point feature. A non-zero value in word(3) and zero value in word(4) indicates text data.

DATA BASE STRUCTURE

The map data are stored in two direct access files, namely, the chart directory file and a chart file (the automap internally refers to a "map" as a "chart"). There is only one chart directory file in the Automap. The information about each map is stored in one record (120-word long) of this file.

Data for each map are stored in separate chart files. A chart file has two main parts, namely, the data area, where the multi-point and text data are stored, and an index entry area, where necessary index entries for each feature are made over a 16-word field (1 word = two 8-bit bytes). The index entry area is also used to store complete data for one-point and two-point features. The first record of the chart file is the file control record, which contains, among other things, the total number of records in the chart file, the next available data record, and the next available sequence number of the index entry. The structure of the chart file is given in Figure 2. The records of the chart file are 128-word long. The description of the contents of the records of the chart and chart directory files can be obtained from the INCLUDE library of the Automap.

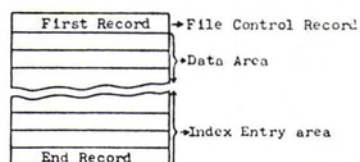


FIG. 2. Structure of the chart file.

NONCOMPATIBILITY OF ANALOG PLOTTER DATA AND AUTOMAP DATA

As explained in the third section, data recorded from the analog plotter through Wild EK-22 system on a magnetic tape consists of an identification number (N) and the x , y , and z coordinates of the data point. On the other hand, the coordinates x and y for a data point in Automap data base are stored in chart units in integer form. (The value of a chart unit corresponding to the scale of the map is already known to the Automap, viz., for a map at 1:10,000 scale 1 chart unit represents 0.3 metres while for a map on 1:50,000 scale 1 chart unit represents 1 metre.) Moreover, for stereoplotter data there is no distinction for different data types, nor are there special keys like FC, FM, etc., to distinguish the different features being digitized. There are many more such differences in the two data sets which have to be removed before stereo plotter data could be merged into the Automap data base.

In light of the above discussion, a necessity was felt to make available the essential facilities of the Automap digitizer station to the photogrammetric operator so that, along with his normal work during plotting in a stereoplotter, he would be able to provide the necessary keys for the structuring of the data during the subsequent preprocessing phase. While doing so, it was also felt that frequent entries to be made on the EK-22 system would cause undesirable interruptions to his work. It is, therefore, essential that only a minimal part of the operator's attention should be allowed to be diverted to such data structuring activities, thereby enabling him to concentrate mainly on the otherwise strenuous job of stereoplotting.

FORMATTING OF N

Out of the various commands that are available at the Automap digitizer station for data entry, only the following essential ones are incorporated by the photogrammetric operator through the manipulation of the last eight digits of N corresponding to locations 8th to 1st on the control panel:

- *ENTER Command*: The 4-digit feature code (FC) is keyed in at 4th to 1st locations. Only the 4th character of the feature modifier (FM) needs to be keyed in at the 5th location (since other characters of FM are generally zeroes).
- *AGAIN Command*: The first point of a new feature is indicated by a non-zero digit in the 8th location. For all other points this value is zero. A feature after a break or discontinuity is also treated as a new feature for this purpose.
- *SPOT Command*: The digit 1 at the 7th location indicates that a z value is to be utilized for defining spot height. Otherwise, the location has 0 digit.
- *DATA Type*: The 6th location is used for this purpose; 0, 1, and 2 indicate multi-point, single-point, and two-point features, respectively.

Thus, all the essential commands of a digitizer station are incorporated by the photogrammetric operator during plotting by manipulating the eight digits on the control panel of the EK-22. The above formatting of N has been done keeping the convenience of the operator in mind and for providing the essential linkages which are later used by a preprocessing program to develop the index fields for all data points. During the experimentation, it was seen that the above formatting was accomplished by the operator only after a little training. Figure 3 shows the resultant formatting of the last eight digits of N .

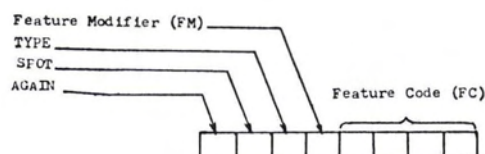


FIG. 3. Last eight digits of N as recorded on magnetic tape.

A SOFTWARE INTERFACE FOR DATA INPUT TO AUTOMAP

After capturing the map data on a magnetic tape from the analog stereoplotter, the data are read into the PDP-11/34 system of Automap. These data are then merged into the data base of the Automap by program EK22 which has been developed for the purpose. The program preprocesses the magnetic tape data and then stores those data in the chart file of the Automap. The various steps for this are described below.

CREATION OF THE CHART FILE

The map is first "initialized" (to any scale) through the system manager (SM) of the Automap software defining the chart name, name and planimetric coordinates of two to six control points, and scale. As a result of the initialization, corresponding entries for the map are made by the Automap in one of the records of the chart directory file. A chart file of the desired size, which is empty at the moment, is then created using the SM. Plotter data from the magnetic tape is preprocessed as described below before being dumped in the chart file starting from the second record onwards with suitable index entries starting from the last record backwards. Some entries, such as the next available sequence number of the index entry, etc., are also updated in the first record of the chart file.

PREPROCESSING ALGORITHM

The algorithm of the preprocessing program EK22 is briefly discussed below, outlining the main steps that are involved in structuring of the photogrammetric data received from the EK-22 system on a magtape:

- (1) Define two buffers, namely, the Index buffer to accommodate eight sets of index entries and the Data buffer to accommodate data for multi-point feature type, each of 128 words.
- (2) With the help of the ground coordinates and the photogrammetric model coordinates of the control points available in the first file of the tape, compute the four parameters for the similarity transformation.
- (3) Read data for one point from the magnetic tape and assign values to x , y , and z for the data point. Transform these coordinates using the four parameters computed in step 2. Reduce the transformed x and y to chart units corresponding to the scale of the chart, and z to ground metres (nearest to 1 m).
- (4) Parse the point number N to assign values to AGAIN, SPOT, TYPE, FM, and FC using the last eight digits of N as explained earlier.
- (5) Check for AGAIN command to define whether the data are for a new feature or are part of the previous feature.
- (6) Assign values to various fields of the Index Entry for the data point, if it is a one-point feature; and store the values in the Index buffer. In case of a two-point feature, this step is completed only after processing the next data point, while, for a multi-point feature, after the last of the data points forming the feature has been processed. For multi-point feature only, enter x , y coordinates (in chart units) of each point in the Data buffer.
- (7) Copy Index buffer into the next available Index Entry record of the chart file when the Index buffer is filled up completely at the end of step 6. Copy the Data buffer into the next available Data record of the chart file when the Data buffer is filled up. Both the Index and Data buffers should also be copied into the respective next available records of the chart file after the last point of a multi-point feature has been processed.

The preprocessing is terminated when the end of data points is located.

MERGER OF DATA TO MAIN DATA BASE

The file created during preprocessing is readily acceptable to the Automap through the SM. We may identify this file as the data file for the photogrammetric model. This can now be edited through the station processor edit commands of the Automap software to remove gross plotting errors and also to incorporate other information, including the text. Then the file can be merged with the main chart file through the CHARTGEN module of the Automap.

TESTING OF SOFTWARE

To test the program EK22, a model was plotted on a Wild A-8 stereoplotter which is interfaced with an EK-22 data acquisition system. The photogrammetric digital output so obtained on a magnetic tape was transported to the Automap. These data were merged into the data base of the Automap using the program EK22. After some preliminary editing, which mainly consisted in incorporating text and breaking contour lines for contour values, a graphic plot of the data was obtained (see figure 4).

ADVANTAGES

The proposed interface will result in the following advantages:

- Because the Altek digitizer activity will be limited to data editing only, the processing speed of the Automap will increase considerably.
- It will enable the Survey of India to exploit the full potential of Automap capabilities.
- It will provide a faster mode of data input to the Automap.
- Such a photogrammetric data capture station will work in an off-line mode, thus enabling Automap to process data of different production units in a centralized manner.
- The data capture station is a minor modification to the existing hardware and requires only minor modifications to existing photogrammetric plotting procedures, thus facilitating quick implementation without elaborate training for operators.

CONCLUSION

The Automap presently installed at the Survey of India has only one digitizer station for conversion of graphical map data into digital form (in the present form it can acquire data only from a graphical input). This Automap configuration is only suitable to work in the R&D environment because data acquisition from a map by manual digitization is an extremely slow

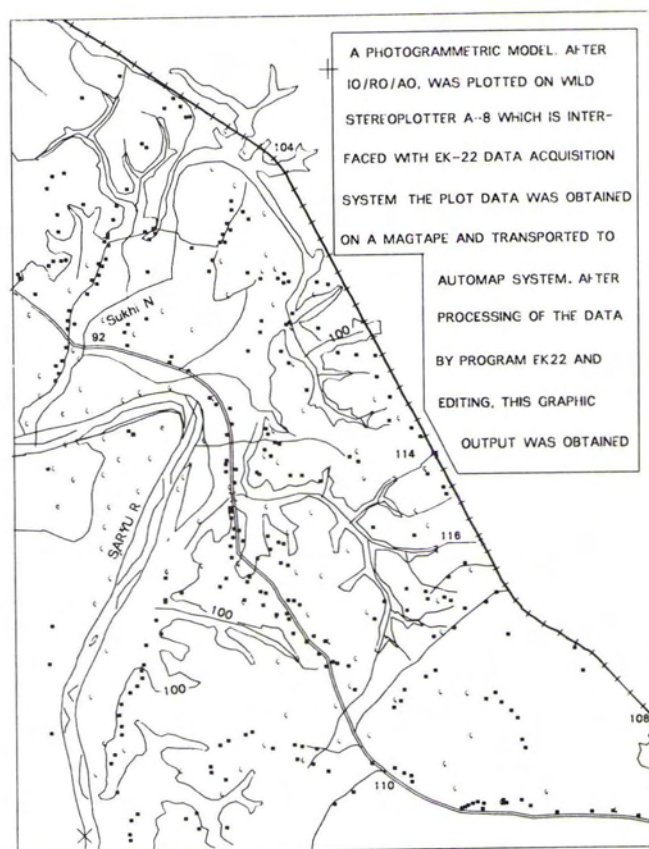


FIG. 4. A graphic plot of digital photogrammetric data (original scale 1:25,000 reduced to 1:50,000).

process. Moreover, the data capture cannot be done in a decentralized manner.

With the approach suggested in this paper, a large number of photogrammetric data capture stations could be employed off-line to acquire digital data in different production units. All the data so acquired would be transported on magnetic tapes to the Automap where it would be processed in a centralized manner. The Altek digitizer activity would then be limited to data editing only. Thus, the Automap could be geared to work in a production environment.

This would also be the first step in integrating digital photogrammetry with cartography. It would help accelerate the process of building up a proper cartographic data base with a fast updating potential.

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