GIMMAP: A (MINI)COMPUTER-ASSISTED CARTOGRAPHY SYSTEM

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Introduction

The Kansas Geological Survey requires a general-purpose, computer-assisted cartography system for construction and maintenance of a state-wide cartographic data base. The purpose of this data base is to support production of single copies of specialized working maps; for production of general-purpose maps that will be published; and for resource analysis in the State of Kansas. The system being developed is called GIMMAP, for Geodata Interactive Management, Map Analysis, and Production. It is designed to operate in a minicomputer environment, a constraint which has promoted the development of an efficient, compact, and modular system. GIMMAP is written in FORTRAN, contains no module in excess of 32K (16-bit) words, and relies on random-access disk files. At the Kansas Geological Survey, the system operates with a manual digitizing table, a minicomputer, a vector display device, a flatbed plotter, and a printer-plotter with hard-copy unit.

The design of GIMMAP began with Dr. Tho Trang Cao at the Bureau de Recherches Géologiques et Minières (BRGM) in Orléans, France. Graph-theoretic techniques were employed to implement the initial system, which was based on topological data structures parallel to those of Peucker and Chrisman (1975) and others. These initial experiments resulted in the production of color-separation materials for two high-quality geologic maps of areas in France (Cao, 1974, 1976).

Development of GIMMAP at the Kansas Geological Survey began in 1977, when Cao served as Visiting Research Scientist at the Survey. In collaboration with this author, Cao produced the present extended design and began implementation of the basic computer-aided cartography system. An experimental geologic map of the Lawrence West 7.5 minute quadrangle is currently in press. At the present time, the logical and physical extension of the GIMMAP system, as described in this paper, continues in parallel as a cooperative effort between BRGM in France and the Kansas Geological Survey.

Current Capabilities

GIMMAP currently includes facilities for data input, data base construction, interactive editing, and data retrieval for a single document (Fig. 1 and Fig. 2). Standard 7.5 minute US Geological Survey topographic quadrangle maps are used as the basic input source for the geographic base. The extended data structure (Cao, 1978) employs a topological approach similar to one developed independently at the US Geological Survey by Mitchell and others (1977).

GIMMAP uses a simple format for the input of data (Cao, 1978). The suggested digitizing procedure eliminates unnecessary practices required in other systems, such as the entry of header information, line or node numbers, and left-right codes. It also eliminates the digitizing of zone identification marks, and multiple digitizing of zone boundaries.

The graphical data base is created primarily in batch mode. A small amount of operator interaction is required for syntax editing. Duplicate-node detection and resolution, and duplicate-arc detection are automatic, but are guided by operator-selected thresholds.

The data base is edited interactively by means of a graphical display device and a software module which provides the following capabilities:

1. Deletion or addition of points, arcs, and zones.
2. Node matching (connection of arcs).
3. Selective display by feature type.
4. Positional correction of nodes or interior points.

5. Splitting an arc at any interior point (node creation).
6. User-selected, scanning, zoom window.
7. Rotation, translation, or scaling of arcs.
8. Multi-level operator error protection.

The treatment of zones such as geologic formations includes the automatic assembly of boundaries (Cao, 1978). The zone treatment facility also provides for:

1. Zone coding (coloring) and linkage for efficient retrieval.
2. Labelling and marking for symbology.
3. Generation of left-right codes for boundary arcs.
4. Calculation of perimeter lengths, areas, and minima and maxima.

A recent extension provdes for the grouping of features by graphically connected components or by arbitrary, user-selected collections. Such collections may be based on feature type, location, name, code, or other attribute values. This extension includes updating capabilities analogous to those for zones.

A retrieval facility for the production of maps or the creation of "clean" digitized data files allows multiple selection by feature type, collection, name, location, code, or attribute value. This facility provides options for scaling, translation, and addition of fiducial marks and map titles. Options will soon be available for projection, shading, symbolization, contouring, and selection of line type, color, and width.

Current Developments

In the effort to extend GIMMAP to provide a flexible and comprehensive retrieval package from the user viewpoint (Fig. 3), current developments are concentrated in three areas. The first is to provide software for the construction of higher level, graphical data bases, such as county and state maps, from the primary data base. Such a facility will accommodate efficient, multi-level input and retrieval, and will include intermap editing, latitude-longitude conversion, feature generalization, and inter-map patching (concatenation) of features.

The second area of development is a facility for the capture of data from non-standard documents, and incorporation of this data in all levels of data bases. Such a facility is essential since most geologic and resource maps are not generally available on the standard quadrangle map bases.

The third area of development is in the construction of a relational data base system for cartographic attribute data. The data base will be accessed with a graphical query language founded on the "Query-by-Example" language developed by Zloof (1977), providing the full capabilities of relational calculus. This relational system will provide feature or attribute retrieval for analysis or map production with selection by relation, attribute, attribute values, multi-relation manipulation, or statistical evaluation of graphical or attribute data.

Conclusions

GIMMAP is designed to meet the requirements of a comprehensive cartographic system, as detailed in the recent survey by Nagy and Wagle (1979), with additional facilities for attribute data and analysis. GIMMAP is modular, is written in FORTRAN, and unlike many other systems, is designed for operation on a minicomputer.

The basic system has been implemented and successfully tested on a limited production basis at the Kansas Geological Survey and at the Bureau de Recherches Géologiques et Minières. A GIMMAP user's manual is being prepared for publication in the Series on Spatial Analysis of the Kansas Geological Survey.

Current extensions of the system include construction of multi-level data bases, incorporation of non-standard data, and a graphical, relational data base system for cartographic attribute data. Completion of these goals will provide a general-purpose, computer-assisted cartography system for the minicomputer environment.

References

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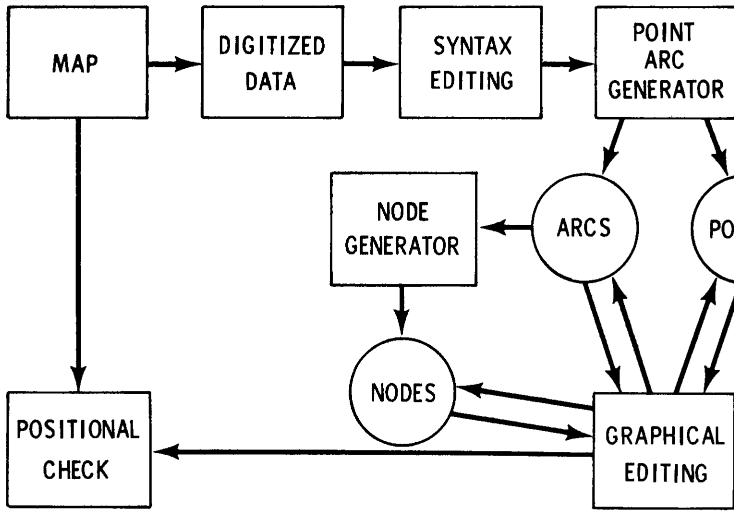
MAP
DIGITIZED DATA
SYNTAX EDITING
POINT ARC GENERATOR
NODE GENERATOR
ARCS
POINTS
NODES
POSITIONAL CHECK
GRAPHICAL EDITING

Fig. 1

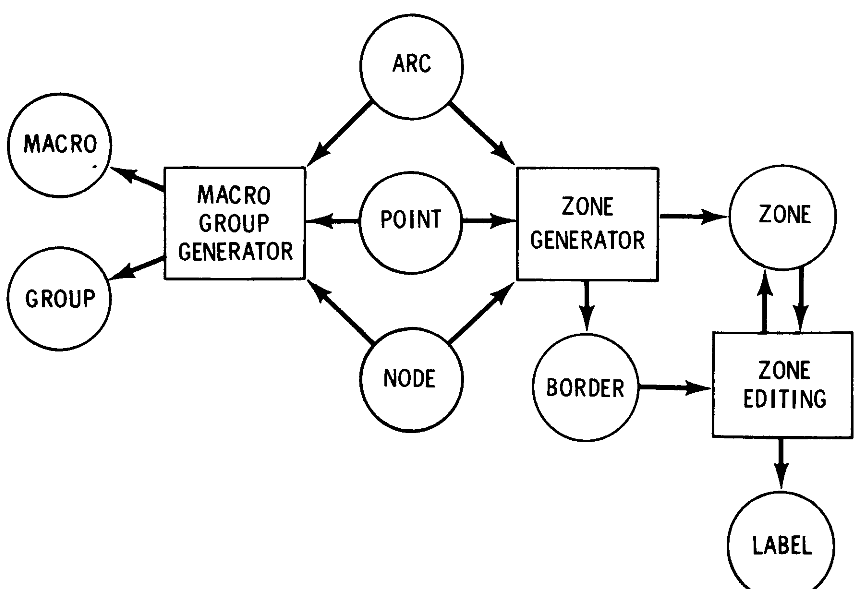
ARC
MACRO
MACRO GROUP GENERATOR
POINT
ZONE GENERATOR
ZONE
GROUP
NODE
BORDER
ZONE EDITING
LABEL

Fig. 2

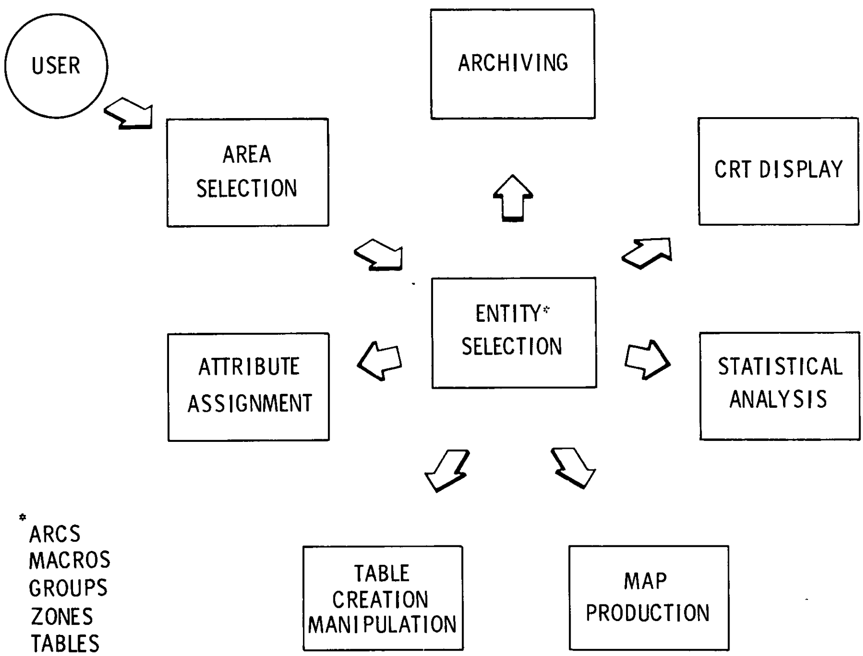
USER
ARCHIVING
AREA SELECTION
CRT DISPLAY
ENTITY* SELECTION
ATTRIBUTE ASSIGNMENT
STATISTICAL ANALYSIS
TABLE CREATION MANIPULATION
MAP PRODUCTION
*ARCS
MACROS
GROUPS
ZONES
TABLES

Fig. 3