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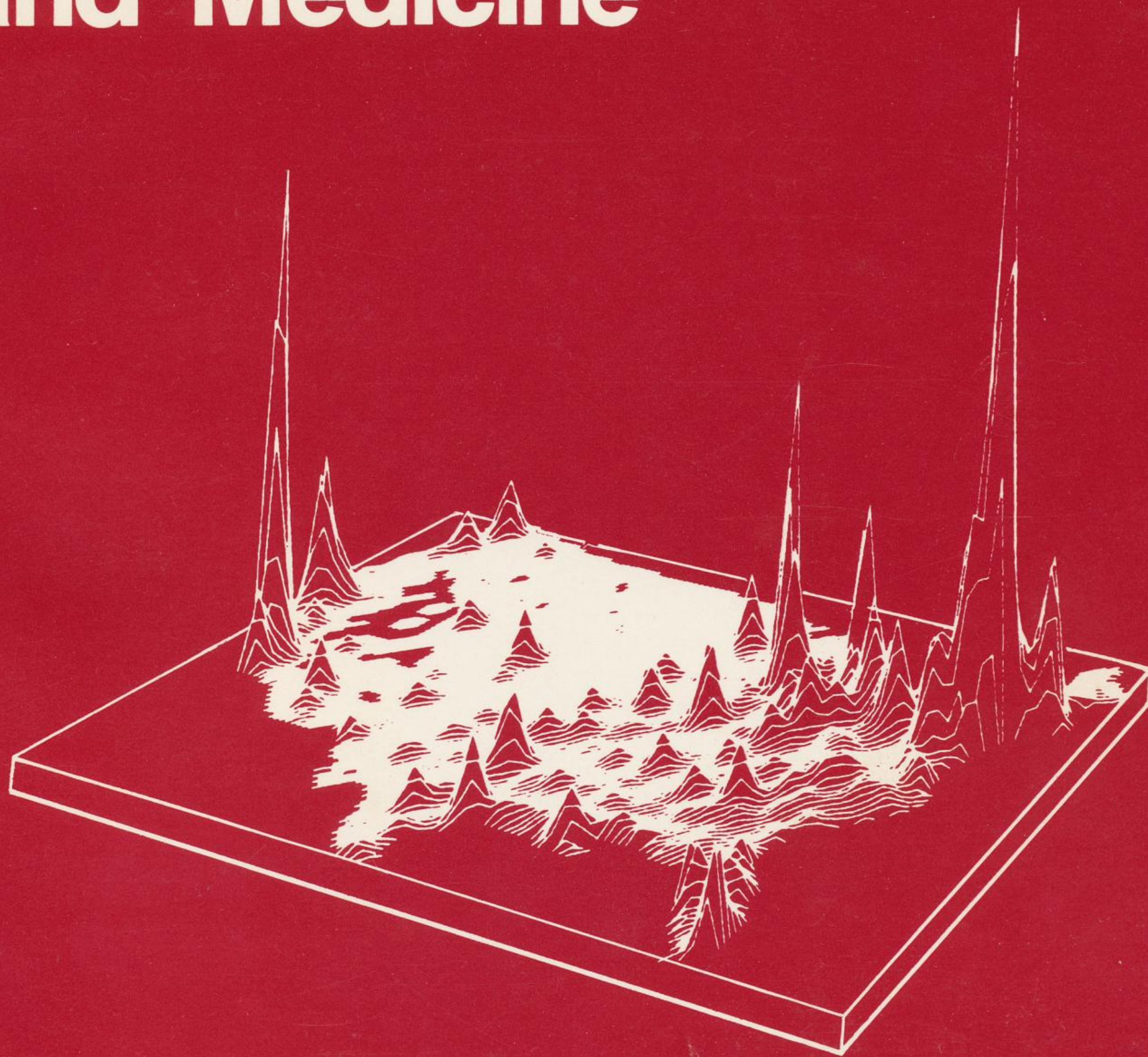
Laboratory for Computer Graphics and Spatial Analysis

Computer Mapping In Education, Research and Medicine



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Computer-Based Instructional System For Teaching Thematic Mapping

by Paul R. Baumann

PROBLEM ENVIRONMENT

This computer-based instructional system has two primary objectives: (1) to introduce students to the decision-making processes associated with developing thematic maps, and (2) to induce students to use thematic maps as a tool for geographic research and as a means of spatial communication. As one of the few common denominators in geography, the map can be used in most geography courses, but often students are not given the opportunity to learn how to make or how to use maps. The main problem appears to be insufficient time to make maps. To produce maps using traditional techniques, students often spend a considerable amount of time and effort with drawing or "coloring in" procedures — generally considered "busywork" by students — and very little time learning how to formulate their decisions regarding the development of their maps. Also, students only have time to create one or possibly two maps in a course; consequently, they find it difficult to study the impact of various decisions on their maps or to utilize the map as a research tool or as a means of communication.

This instructional system uses the computer to draw maps rapidly and in quantity for students. With this computer system, much of the "busywork" is eliminated, allowing students to concentrate their efforts on the decision-making aspects of map construction.

In addition, students can use this instructional system to construct maps for the purpose of researching a topic or as a means of communicating ideas spatially. Again, the time-consuming procedures involved in drawing maps plus the failure to understand the decision-making processes curtail the proper construction of maps by students in many geography courses. Once students possess some comprehension of how to develop a map, they can use this computerized instructional system to create maps on many various subjects of their interest with relative ease and in a short time. By removing the time-consuming, laborious procedures associated with map construction, this system permits students to become involved with the map as a tool for geographic research and as a way to communicate ideas and information spatially.

THE COMPUTER MAPPING SYSTEM

Data Banks

This computer-based instructional system consists of a series of interlinking modules: data banks, a retrieval-transgeneration program, and two mapping programs (Figure 1). Each data bank contains data on a select number of key variables within a particular geographic area and the coordinate package needed to construct the different types of maps for the geographic area. Two data banks already exist, each containing around 55 variables. One data bank is on New York State with its 62 counties as subdivisions, and is used in an introductory geography course to instruct students in the decision-making aspects of mapping. The vast majority of the students in this course are from New York State. Working with a familiar area helps the students to associate patterns on their maps to other phenomena. The second data bank is on the urbanized area of San Antonio, Texas, with its 143 census tracts, and is utilized in an urban geography course to help students study the intra-urban spatial patterns of a typical large American city.

These data banks contain a limited number of variables because of logistic problems in making raw data in printed form available to each student. Key variables, mainly in the absolute form, have been selected since the transgeneration option of the retrieval-transgeneration program permits new variables to be formulated out of existing variables in the data bank. For example, from the variables — number of houses and land area — in the San Antonio data bank, housing density data can be derived for each census tract. Thus, from a few key variables thousands of new variables can be formulated.

The ease with which a data bank can be constructed gives the system its greatest flexibility in terms of course use. An instructor can design a data bank on any topic or area for which adequate data exist. Therefore, a data bank can be developed on any particular area or topic that an instructor wants to deal with in a course. An instructor's manual has been developed for this system explaining in detail how to build a data bank.[1] Properly supervised, a part-time work-study student can gather and code all the information needed for a data bank in one semester.

Retrieval-Transgeneration Program

The retrieval-transgeneration program forms the initial program in the system. Its main purpose is to retrieve data from the data bank. For each student map, a parameter information deck is developed containing various specifications relating to the construction of a map. These decks are read by this program in order to select the appropriate variables from the data bank. The data plus the parameter decks are placed on temporary disk files based on map types. At this point, the next phase in the system is ready to be executed.

This retrieval-transgeneration program also allows one to construct new variables based on variables already existing in

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[1] P. R. Baumann, ***Introductory Manual on Thematic Mapping: Instructor's Manual***, Project COMPUTe (Hanover, New Hampshire: Dartmouth College, 1976).

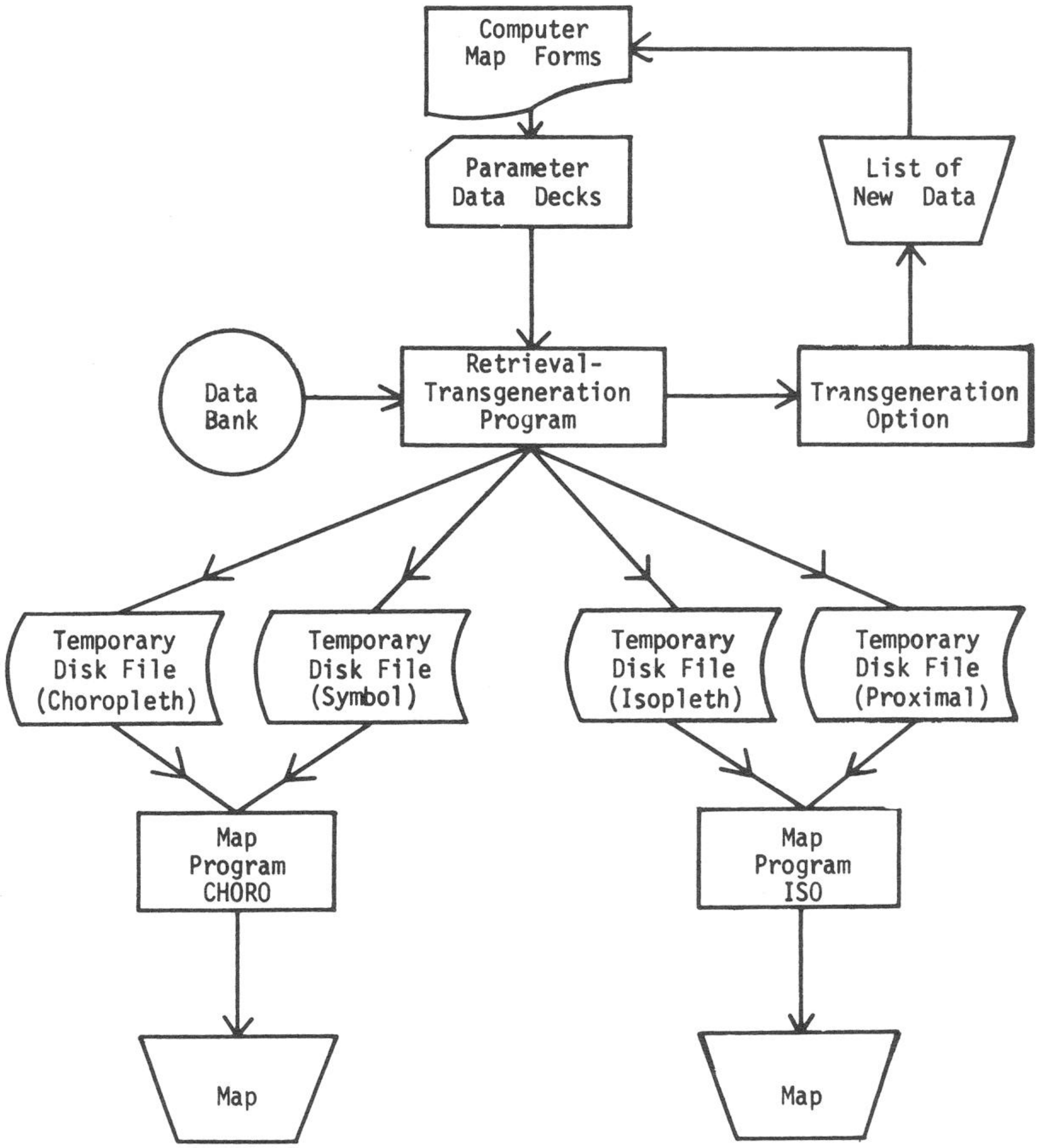

Computer
Map Forms
Parameter
Data Decks
List of
New Data
Data
Bank
Retrieval-
Transgeneration
Program
Transgeneration
Option
Temporary
Disk File
(Choropleth)
Temporary
Disk File
(Symbol)
Temporary
Disk File
(Isopleth)
Temporary
Disk File
(Proximal)
Map
Program
CHORO
Map
Program
ISO
Map
Map

Figure 1.

the data bank. This option permits addition, subtraction, division, multiplication, and involution of one variable or constant to another variable. Other mathematical operations can be added easily if the instructor so desires. Only one operation can be performed with each transgeneration step. Presently, this system allows three transgeneration steps but the number can be expanded. This procedure is designed along the same approach as the Biomedical (BMD) transgeneration system.[2]

To illustrate the use of the transgeneration option, let us say that a student wishes to make a map showing the percentage of Negroes but finds that no such variable exists in the data bank. However, total population and Negro population are available. In the first transgeneration step, the total population is divided into the Negro population and the results are stored under a temporary identification number. Next, the results are multiplied by 100. Two mathematical operations are used; thus, two transgeneration steps are required. Since a new variable is being formed, a data list must be made available before any meaningful decisions can be made concerning the map. Therefore, in terms of output for transformed data, the system produces either a data list, a map based on either default options or specified parameters, or both a list and a map.

Mapping Programs

Once the retrieval-transgeneration phase is completed, the two map programs may be executed. These programs produce line printer-type maps as output. Although other output devices such as digital pen plotters, cathode-ray tubes (CRTs), electrostatic printers, and computer output-on-microfilm (COM) units make more visually appealing and more precise maps than the line printer, these devices are not present at many computer facilities; whereas the line-printer forms one of the standard output devices available at almost every computer installation. Also, the line printer can produce a large number of maps relatively fast in comparison to some of these other devices.

The one mapping program creates choropleth and symbol-type maps and is a modified version of Morton W. Scripter's CMAP, renamed CHORO for this system.[3] The other mapping program, ISO, forms isopleth and proximal-type maps and was developed specifically for this system.[4] Both programs employ the scan line approach used in CMAP to create map outlines and map cosmetics. A scan line contains the required coordinate data to produce a single map row by the line printer. With each line printer row being processed independently, only the coordinate data needed to produce a single row on the map must be stored in the computer's memory at any one time, eliminating any dependency on large and more expensive computers.

This system is capable of producing either one or hundreds of maps in one operational run. The amount of time to produce a map depends on the hardware and software systems, the type of map, and the size of the map. Isopleth maps generally take longer than other map types. If a large operational run which might require a considerable amount of time is anticipated, the run can be done in several phases or divided into several small runs.

The State University College at Oneonta possesses a Burroughs B 4700, a medium-size computer, with 200 KB (core bytes) or 400 KD (decimal digits) of memory. All three programs used in this system are written in FORTRAN IV and do not employ any special software or hardware features which might limit their use to the Burroughs systems. The size of the three programs ranges from 36 KB to 68 KB. At this size, the system can handle up to 500 data values per map. If the number of data values were reduced to 100, which can be accomplished by changing the size of certain variables in the DIMENSION statements, the size of the largest program can be decreased by 68 KB to 49KB.

INSTRUCTIONAL PROCEDURES

Before making any maps, either with or without the aid of the computer, students must be introduced to the importance and the role of maps. They must know how and when to use maps. To provide students with a certain level of map appreciation and understanding, a series of lectures is given on maps and map essentials. Also, a student manual, developed under a Project COMPUTe grant, is used to complement these lectures and to illustrate for students how to use the computerized aspects of this system.[5] Although drafting processes and techniques are discussed, the major emphasis in the lectures and the manual is on decision making, especially in the area of map content. Most students are not likely to become professional cartographers, but many of them are likely to be using and interpreting maps at various times in their lives. Therefore, they need to understand how different decisions influence a map. Students interested in pursuing map making in greater depth are encouraged to take a regular cartography course.

During a laboratory discussion session, students receive computer map forms (Figure 2) and a booklet which contains an outline map of the study area and its subdivisions, tables of the data available in the data bank, and the needed information to code the map forms. A computer-map form must be completed for each map. The information on the form is keypunched by a trained student to form parameter decks. It is not desirable to have each student keypunching his/her own material because of the number of potential errors generated by inexperienced keypunchers. Also, the time and effort to train students to do keypunching would distract them from the main objectives of this instructional system. Once the completed forms are returned to the instructor, the turn-around time is generally 24 hours. Students may submit as many forms at one time as they wish; however, they must recognize that the number often governs the length of the turn-around time.

In filling out the computer map forms, students face many decisions relating to the contents of their maps. First and most important, they must select their topic and decide if they are making their maps for the purpose of geographic research or to communicate a spatial theme. These decisions set the path for subsequent decisions. Next, they must search the data bank to find out if any of the variables can be used to produce their maps. Consequently, they must decide how to relate data to topic. Once a variable is selected, the next decision concerns

[2]W. J. Dixon, ed., ***BMD Biomedical Computer Programs***, University of California Publications in Automated Computation No. 2 (Berkeley: University of California Press, 1968).

[3]M. W. Scripter, "Choropleth Maps on Small Digital Computers," ***Proceedings*** of the Association of American Geographers (Washington, D.C., 1969), pp. 133-136.

[4]P. R. Baumann, "ISO: A FORTRAN IV Program for Generating Isopleth Maps on Small Computers," ***Computers and Geosciences***, 1978, Vol. 4, pp. 1-10.

[5]P. R. Baumann, ***Introductory Manual on Thematic Mapping: Student Manual***, Project COMPUTe (Hanover, New Hampshire: Dartmouth College, 1976).

State University College
Oneonta, New York
Department of Geography

Item Code:	Name:	Trngen. Output:	Map Type
_ _ _ _	_ _	_	_
[3 - 6]	7 - 36	37	38

Transgeneration:	X_k	Code	X_i	$X_{j\ or\ c}$
TRNGEN	_ _ _ _	_ _	_ _ _ _	_ _ _ _ _ _ _ _ _ _
TRNGEN	_ _ _ _	_ _	_ _ _ _	_ _ _ _ _ _ _ _ _ _
TRNGEN	_ _ _ _	_ _	_ _ _ _	_ _ _ _ _ _ _ _ _ _
1 - 6	[7 - 10]	[11 - 12]	[13 - 16]	[17 - 26]

MAP
PARAMETERS

Number of Levels: (minimum 2, maximum 10)	Minimum Value:	Maximum Value:
_ _ _ _ _	_ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _
[1 - 5]	[11 - 20]	[21 - 30]

RANGES

1 _ _ _ _ _ _ _ _ _ _	2 _ _ _ _ _ _ _ _ _ _	3 _ _ _ _ _ _ _ _ _ _	4 _ _ _ _ _ _ _ _ _ _	5 _ _ _ _ _ _ _ _ _ _
6 _ _ _ _ _ _ _ _ _ _	7 _ _ _ _ _ _ _ _ _ _	8 _ _ _ _ _ _ _ _ _ _	9 _ _ _ _ _ _ _ _ _ _	10 _ _ _ _ _ _ _ _ _ _
[1 - 10]	[11 - 20]	[21 - 30]	[31 - 40]	[41 - 50]

SYMBOLS

1	2	3	4	5	6	7	8	9	10
_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _	_ _
[1 - 2]	[3 - 4]	[5 - 6]	[7 - 8]	[9 - 10]	[11 - 12]	[13 - 14]	[15 - 16]	[17 - 18]	[19 - 20]

TEXT
Title:
_ _
_ _
1 - 60
Source:
_ _
1 - 60
999999

999999

Figure 2.

map type. Students must decide which map type can best represent their topic and data. After determining a map type, they must make some parameter decisions, such as the number of map levels, minimum and maximum data values, ranges or intervals of map classes, and symbol patterns. These decisions affect the content of the map and are very important. Finally, the title, source, and scale are determined. Students are taught that a title should be short in length and clear and accurate in content. The form limits the length of the title. To complete this form, students must make decisions relating to their maps, which is the primary goal of this instructional system.

RESULTS AND APPLICATIONS

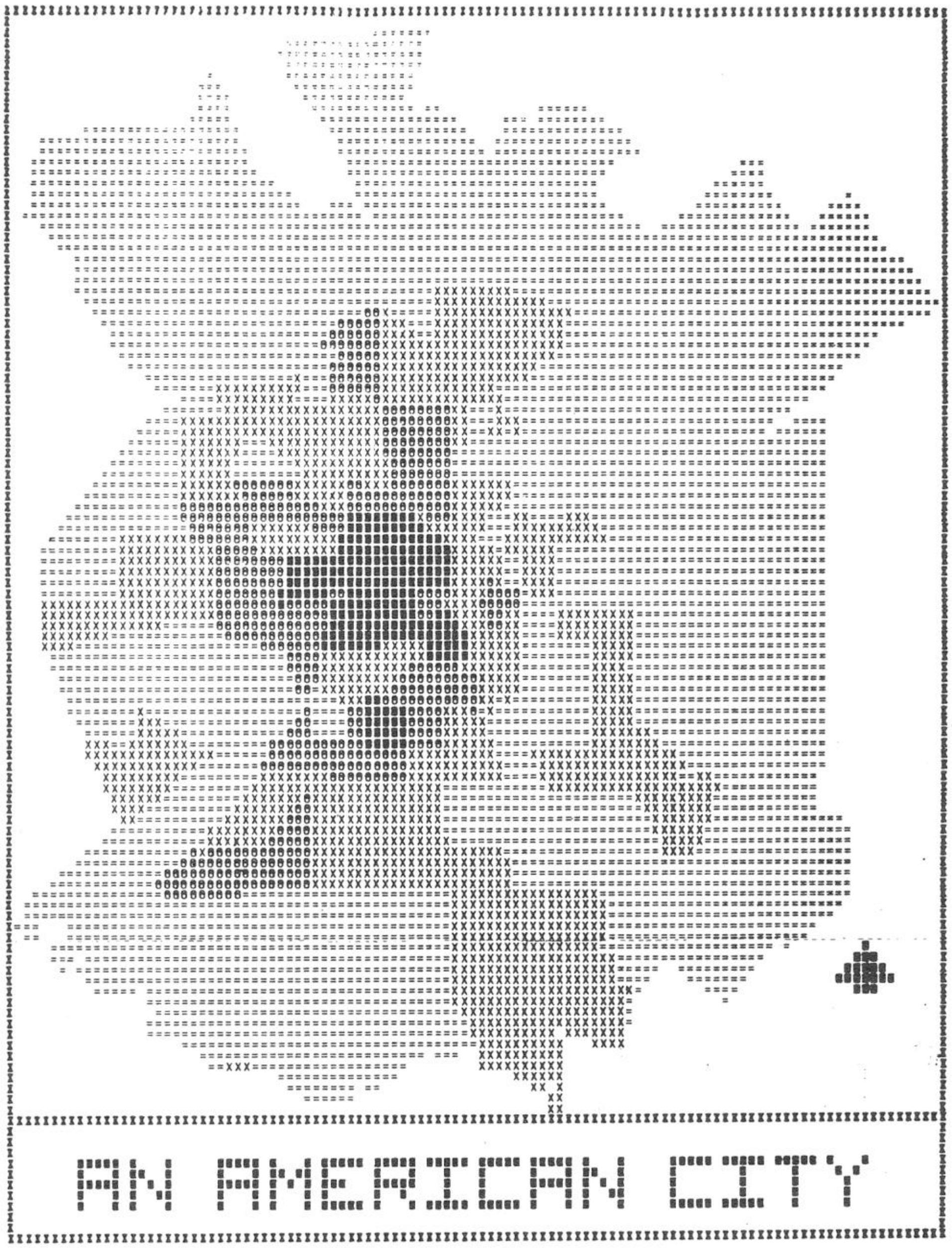
As indicated previously, this system is being utilized in an introductory geography course and an urban geography course. Students in these courses have produced thousands of maps using this system, and, from their general reactions, they have attained a good understanding and appreciation of the decison-making role in map making. In comparing these classes with earlier classes in which students had to draw and color all their maps, the attitude of students toward map making is quite different. No longer does the instructor encounter the common grumbling of map making being "busywork." With this system students produce an average of seven to eight maps in a two-week period and they generally spend less time making these maps than they would producing one map under the traditional techniques. Now the moans and groans by the students are related to the difficult task of making decisions. However, the students are more curious about the patterns on their maps and spend more time developing hypotheses and testing theories to explain these patterns. Also, due to the ease of producing the maps, the students enjoy making maps of different variables so that they can compare the spatial relationships of variables.

In addition to the normal application of this system, students have made other uses of it. Some students have used the system to make maps for other classes. Several students have developed small atlases on special topics such as population, housing, transportation, and welfare. A few students have covered their maps with acetate and then have used marking pens to put other information on the maps. Usually the information is linear type data such as roads and railroads. Some students employed the system as a planning tool. For example, a map was made by one student showing what census tracts in San Antonio were saturated in terms of housing density and what tracts had growth potential. Several students have carried on experiments relating to decision making. As an example, one student made twelve maps of the same variable. Everything was constant on each map except the class intervals. When completed, the distribution of the variable differed drastically from one map to another. This type of experiment raises the question in the student's mind as to which map best represents the actual condition.

Most students taking the urban geography course are interested in the field of planning. This instructional system not only introduces them to the map as a powerful research tool and communication device for planning, but also enlightens them to the role of computer mapping and geo-information systems as planning tools. A number of these students take a course from the author entitled "Computer Mapping and Geo-Information Systems." In this course, this system is used as a model to illustrate how a geo-information system might be developed.

AVAILABILITY

The three programs used by this system are available at the nominal charge of $40 from Project COMPUTe, Dartmouth College. Figure 3 represents sample output from these programs. Eventually these programs will be available through CONDUIT, Box 388, Iowa City, Iowa 52240. In addition to the programs, the student manual and the instructor's manual can also be acquired from Project COMPUTe.



FOREIGN STOCK: MEXICAN
URBANIZED AREA OF SAN ANTONIO, TEXAS, 1970

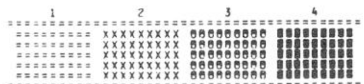
U.S. CENSUS OF POPULATION AND HOUSING, CENSUS TRACTS, 1970

SCALE I---------I
MILES 0 2

JOHN DOE

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.00	420.00	1260.00	2520.00
MAXIMUM	420.00	1260.00	2520.00	4200.00
LEVEL	1	2	3	4



G E O G R A P H Y   P R O G R A M

DEPARTMENT OF GEOGRAPHY
STATE UNIVERSITY OF NEW YORK AT ONEONTA

SYSTEM DEVELOPED BY PAUL R. BAUMANN

Figure 3.