MICROCOMPUTER MAPPING SYSTEMS FOR LOCAL GOVERNMENTS

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ABSTRACT

Computer mapping provides various assistance in data analysis and decision-support functions for local public or private sectors who need tools to research spatial data. A generic mapping system not only can present and manipulate different types of areal data, but also can assist intelligent decision-support algorithms.

Local governments have a wide variety of operational and managerial functions which are related to land information. Computer mapping technique, such as thematic mapping, entity overlay, surface interpolation, data conversion, and contour mapping, can be implemented in a microcomputer environment to provide flexible, inexpensive, and intelligent ways to support land information management and policy making.

INTRODUCTION

One of the primary functions of local governments is to monitor area development by establishing appropriate land policy. The goals, mostly from an economic stand point, are to maximize the utilizations of natural resources and to allocate proper resources to proper locations. Conceptually, there are three groups of variables involved in the decision making process: political, social/economic, and physical environments. The policies are established based on the numerous iterations of inter- or intra-confrontations and reconciliations among these three variables.

By understanding the procedures and factors involved in policy making, the information used by the policy makers and the tools to determine alternatives then can be specified. Political environment is always uncertain, but aggregated information is always needed to represent the majority interests. Social/economic environment, which describes the structure and the characteristics of different human factors, has balancing functions for different interests and behavior; physical environment represents the resources with fixed natural locational characteristics and changable artificially added-on values.

Computerization of operational and managerial functions of these environments within a local government has been widely accepted after the "User Friendly" microcomputers were marketed. New technology has upgraded the applications from the level of word processing to information management, and even higher level of policy analysis and decision making.

Computer mapping has been used as a decision-support tool because it presents information in an aggregated and easily understandable form. Direct impact from graphic output prompted further input of in-depth rethinking and reconsideration to the cycle of decision making process. Two dimensional and three dimensional images are more acceptable to human intelligence than linear data when dealing with two dimensional or three dimensional world.

Projects experimenting computer mapping capabilities were done on IBM PC XT and Radio Shack TRS 80 Model 16 microcomputers. Operating systems were MS DOS 2.0 and TRS DOS 4.2.6 from IBM and Radio Shack respectively. BASIC was the language. The target area was the Enterprise Zone in the City of Cleveland, Ohio, covering 41 census tracts. Geographic data base had 1100 points, 500 line segments, and 70 polygons. Attribute data base was downloaded from 1980 census data. Net storage space consumed by cartographic data was 33K bytes.

Based on the essential functions of local government agencies, three categories of mapping applications - mapping for land use planners, assessors, and utility managers, will be discussed.

MAPPING FOR LAND USE PLANNERS

Because of the complexity of the physical environment and a great variety of land-related information land use planners have to deal with, different kinds of maps are frequently used, such as topological, thematic, soil, 2-dimensional surface, 3-dimensional contour, etc. Inside this complicated world, planners not only have to remember the physical characteristics, but also to understand the interrelationships among physical elements, vertically and horizontally. How to store and retrieve different types of map efficiently and to use those maps together to construct the base of decision making are the major issues here.

Vector Maps

Topological maps, street maps, administrative boundary maps, planning area boundaries, zoning maps, railroad and water, land use maps, etc. are presented in vector form because precise boundary descriptions are required in planning operations.

Digitizer was used to store the source maps into vector form. Scanning and downloading remote sensed data were not considered because of the limitations of facilities and the computing power of microcomputers. The map output was on a 6-color pen plotter in vector format(See Figure 1). The system also overlays attribute information, or social/economic figures on top of geographic boundaries and become thematic maps(See Figure 2). These maps can be "manually" overlayed to obtain integrated information of the land. Planners then have the ability to integrate more or digest more knowledge to make decision.

Figure 1: Vector Map (Boundary)

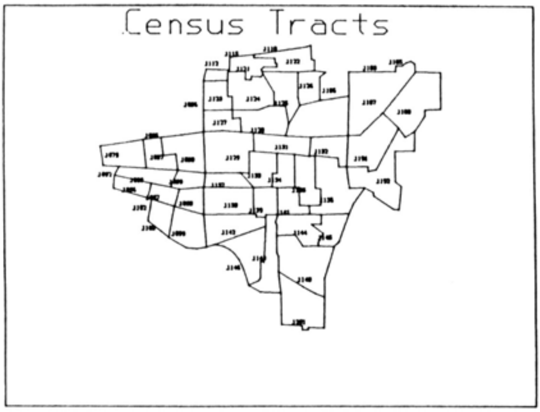


Figure 2: Vector Map (Thematic)

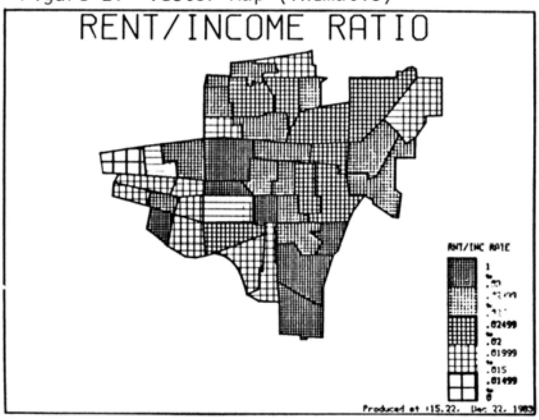
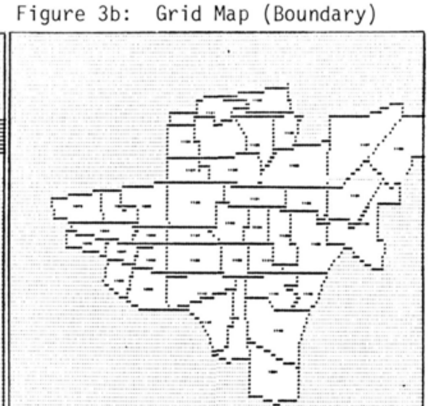


Figure 3a: Grid Map (Thematic)

Figure 3b: Grid Map (Boundary)



Grid Maps

Grid maps are used when area boundary precision is not essential. Some examples are regional planning and environmental impact studies. The advantages of a grid map are efficiency of processing, ease of vertical overlays, and fast in other spatial search applications. Two basic techniques are used:

Vector-to-Grid Conversion: A vector-based map can be displayed as a grid format by a conversion process. The conversion consists of two steps: boundary conversion and infilling conversion. Grid map then can also present either the boundaies or thematic infilling. The method used to present different combinations of grid maps (see Figure 3a and 3b) is the logical manipulation of Set theories.

Set Functions: The logic functions in Set theory are AND, OR, NOT, XOR, etc. If a polygon on a grid plane can be recognized as a "Set", then by using logic functions to manipulate the Set with other Sets will result in some polygon overlays. For example, Set A and Set B are shown on Figure 4a and 4b respectively. Figure 4c, 4d, and 4e are the OR, AND, XOR functions implemented to Set A and Set B. Same applications of this Set manipulation are used to present the grid maps on Figure 3a and 3b. This technique create a quick solution for polygon overlay problems. For microcomputers, we need solutions to overcome complicated geo-processing problems.

Surface Processing

Trend Surface is generated by using the altitude of known control points to interpolate other unknown points. Planner can comprehend the prospective view of the whole area by just knowing the characteristics of limited key locations. Two dimensional surface is usually presented in grid form (Figure 5a). Three dimensional surface is usually in vector form (Figure 5b). This processing is time consuming based on the factors of surface resolution and weighting and scaling algorithms.

Contour Maps are valuable for land planners because slope, orientation, and terrian roughness are some key factors affecting the suitability of development in many cases. The maps can be presented in two dimensional or three dimensional forms. Two dimensional maps need other forms of intelligence to configurate the slope and the true impacts of physical terrain. Three dimensional maps, although have better visibility, carry disadvantages of slow processing and difficulties of integrating with other spatial information(Figure 6).

MAPPING FOR ASSESSORS

In the United States, there were 13,439 assessing units or jurisdictions operating under local governments in 1979, and 77.7% of local tax revenue, or 29.5% of total local revenue was generated from property taxes. The importance of property taxes, as well as the importance of modernization of assessement operations, has been emphasized in local

Figure 4a:
Set {A}

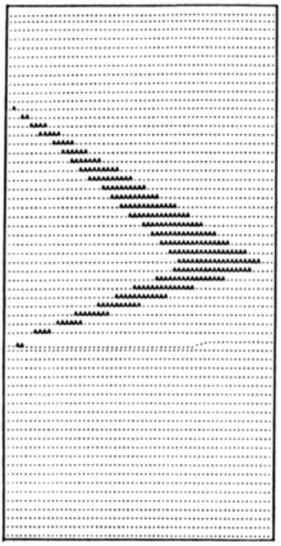


Figure 4b:
Set {B}

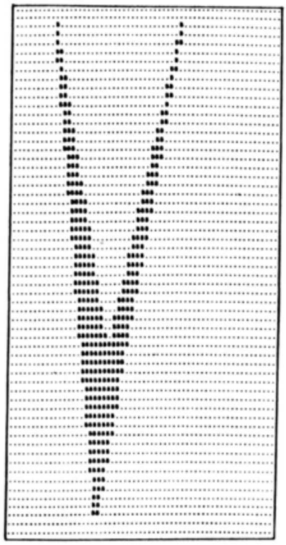


Figure 4c:
Set={A} OR {B}

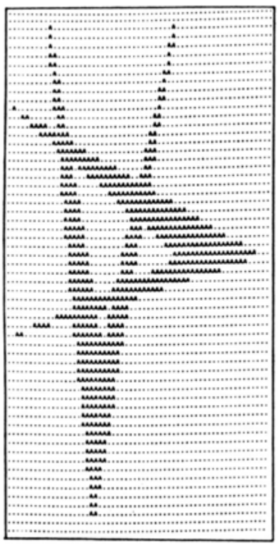


Figure 4d
Set={A} AND {B}

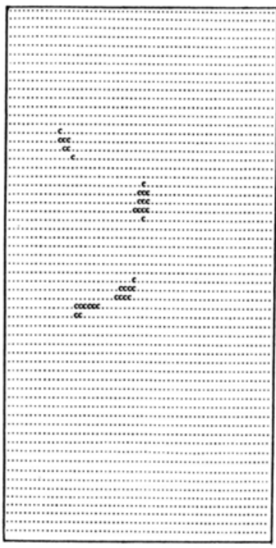


Figure 4e
Set={A} XOR {B}

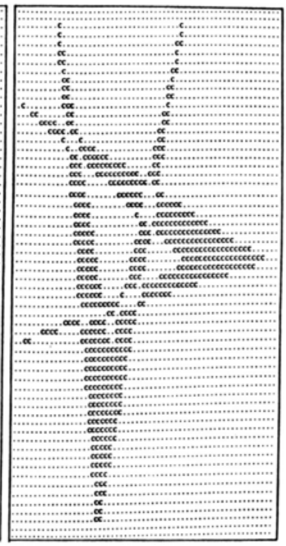


Figure 5a:
2-D Trend Surface

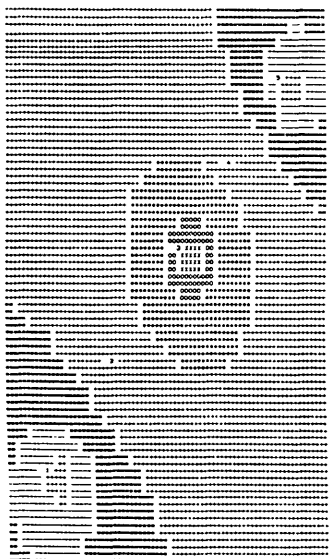


Figure 5b:
3-D Trend Surface

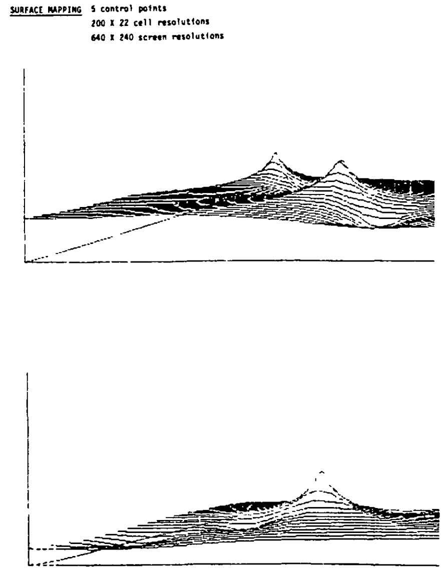
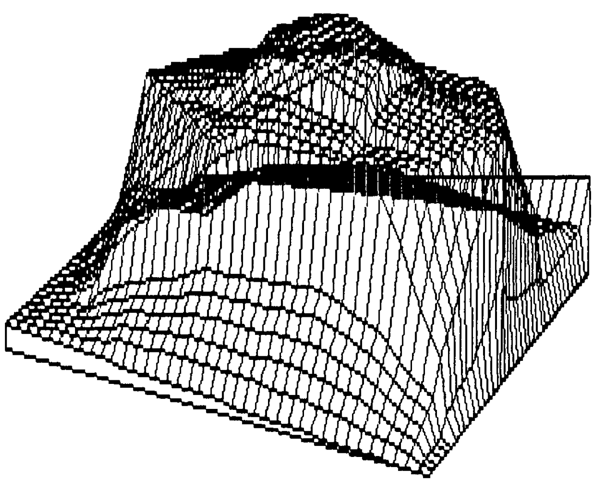


Figure 6: 3-D Contour Map



governments by using new technology to improve the efficiency and effectiveness of assesment activities.

Assessor's maps, traditionally, are used to show locations, dimensions, and configurations of individual parcels. Recently, assessors are expecting wider definitions and functions of their maps to become "a data base that informs about the land, its geographic and non-geographic attributes, and about relationships among these attributes" (Costello, M. and Garvin, L., 1982). Maintaining a good performance of a mapping system, or a "multi-purpose cadastral" system, can assist assessors in monitoring their assessment activities, such as tracing the transaction, collecting deliquencies, mass appraisal and reappraisal of properties. Computer mapping can easily presents interesting areas such as properties with tax deliquency, or properties with assessed value higher or lower than the selling price.

Parcel Mapping

The components of an assessors' map, usually used for legal descriptions, include parcel boundaries, dimensions, bearings, sub-division names and boundaries, easement and right-of-way boundaries, location and name of street, parcel identifiers, street adress. Mapping these components requires accurate input and output devices in order to support legal statements.

There are two ways to input/store parcel maps: digitizing the source maps and typing geographic references from the land survey into the computers. The second method although prevents the error caused by the physical limitations of a digitizer, human errors will still occur and need additional editing.

Accuracy requirements for parcel mapping are +0.35'', +0.17'', and +0.08'' in rural area, rural and urban ring area, and urban area respectively (National Research Council, 1982). Once the source maps are accurately surveyed and recorded at these standards, computerized mapping should be able to store and display these maps with the same accuracy standards. If a microcomputer can not handle enough significant digits to process these numbers or an output device has less graphic resolution to meet the requirements, other written documentations or descriptions should be attached with the computer maps for legal purposes.

MAPPING FOR UTILITY MANAGERS

Availability of sufficient utilities is an important factor for evaluating area development priority. Sophisticated utility management systems provide operational and managerial functions of design, maintenance and construction, as well as decision functions of resource allocation. Whenever an area or a particular location needs new facilities or infrastructures, or making decision to allocate resources, utility managers must take into consideration other physical characteristics of the surrounding area, such as abutting parcels, soil types, street right-of-way, easement boundaries, and other utility systems.

Utility mapping assists managers to comprehend the physical relationships of all different utility systems and infrastructures underground or on or above the surface. The accuracy required, however, is higher than other mapping systems in terms of displaying, searching, or aggregating spatial data. Important information such as length, depth, width, capacity is crucial when engineering design and maintenance are underway.

EVALUATION OF A MICROCOMPUTER MAPPING SYSTEM

Hardware performance, software flexibility, and satisfication of user's needs are fundamental evaluation standards. Local public agencies computerize not only spatial information, but other non-spatial data as well to improve their operation, managerment, and decision making. Hardware and software are tools to achieve these goals. The data, or the knowledge accumulated from data manipulation, however, is the most valuable treasure to the agencies. Therefore, the capabilities of data transferring from machine to machine, or system to system, is another key factor in the evaluation. Generally, factors for evaluating and implementing a microcomputer mapping system are:

Cost of the Hardware and the Software:
Total hardware, including computer, storage device, printer, digitizer, and plotter, should be under $10,000. Software cost should be at the range from $600 to $3000. Software may have two parts: Attribute data base management($300 - $800) and cartographic data base management($300 - $2,000).

Portability and Compatibility:
Revolutions of revising microcomputers' hardware and software occur frequently. The system should be easily updated and upgraded without losing data, delaying users' project schedule or paying great expenses on new hardware, software and personnel training.

Abilities of Downloading Data from Large Computers:
There are many geograpgic and cartographic data files maintained on mainframe or mini computers by US Bureau of Census, USGS, etc. Intracting those files, or part of the files, to a microcomputer mapping system is essential because the redundancy of data gathering, editing, and error checking is expensive and not necessary.

Abilities of Interfacing with Other Systems:
Cartographic data and attribute data are usually maintained independently. Many attribute data base management systems are marketed with great sophistication. A mapping system can become more "knowledgeable" if interfacing with a good attribute data base management system.

Accuracy of the Mapping Data:
Mapping for different applications needs different level of accuracy. A planner's map needs moderate levels of accuracy because the maps are presenting spatial relationships or a comprehensive view of the spatial characteristics of physical elements. An assessor's map has legal responsibilities, so it needs high accuracy corresponding to field survey results and other legal statements. Utility mapping, which affects engineering operation, construction, maintenance, and capital investment, needs the highest accuracy in the mapping systems.

Storage Space:
Storage space is critical when mapping a complex area. The vast volume of cartographic data may consume the secondary storage very fast. The experiment project used 450 bytes to a polygon averagely. A 15M byte hard disk can store approximately 34,000 similar polygons.

Ease of Learnning and Implementing:
Ease of learnning and implementing in terms of map input, editing, labeling, scaling, windowing, and overlaying is important for non-technical personnel to operate the system.

CONCLUSIONS

Microcomputer mapping systems have rapidly expanded their horizon and become more sophisticated as new technologies are introduced everyday. Technically, computing speed, computer graphic algorithms, data retrieval algorithms, and adequate graphic output devices are key elements that can be improved significantly. It is important for users to keep up with the trend. Microcomputer is a tool for self-training and self-education. Realizing the purposes of using computers and computer maps, practically, is the first and foremost consideration when implementing or choosing a system. If local officials are using computer mapping for planning, operation management, and policy stratification, it is worthwile implementing or using a microcomputer based mapping system in their daily operations.

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