MICROCOMPUTER BASED SPATIAL INFORMATION SYSTEM

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ABSTRACT

Spatial information systems consists of not only graphical capabilities, but also data analysis capability. Most systems dealing with spatial information concentrate on producing good quality hard copy output. In many instances, the hard copy is secondary to information content of the data

The hardware cost of providing high quality or cartographic quality for mapping purposes, graphics is high, thereby limiting the number of potential users of spatial information systems. This paper describes the efforts of providing a low cost, microcomputer based spatial information system.

KEYWORDS: spatial information system, geographic information system, microcomputer based spatial system, thematic mapping system.

INTRODUCTION

The term Geographic Information System has been commonly associated with cartographic mapping systems rather than actual information systems. Dueker (1978), defines an information system as "a data base with the necessary input, storage, retrieval and output technologies that is responsive to non-routine retrieval from the data base, which when used in conjunction with models and assumptions, may modify the original data base, implying the way in which the real world activities described by the data are modified". He then describes the nature of a geographic information system as a special case of an information system where the data base is composed of "spatially distributed features".

Cartographic systems are more concerned with the reproduction of digital input rather than modifying the data in any way. The various components of the cartographic system address the input, manipulation and editing of the stored information. They may also have the capability of doing simple overlay procedures by plotting two or more levels or overlays of information or sections of these overlays on a graphics device. However, existing cartographic systems have no, or limited capability for actual analysis of the information within the data base. Only the output of information already contained within the data structure is allowed.

The ability of a Geographic Information System to allow new inquiries to be made on the data contained in the data base and merge these inquiries into the existing data base is important for resource analysis purposes. However, there can be difficulties with the process of making inquiries from the data base. Manual techniques of analyzing spatial data can be slow and tedious if the map overlays are complex, or there are large numbers of overlays to be considered. The nature of the analysis which can be done with the information can also be affected by the requirements of of the resource analysis system.

For a resource analysis system where cartographic graphics is not a primary requirement, the resource professional needs rapid, simple access to the types of information to do the analyses which his projects require. In the case of evaluating the effect of flooding from dam sites on recreational potential, it is more important to know the effect of each dam site on the various levels of recreational capability by size, degree of effect and type of effect rather than just a plot of the areas which will be flooded. Another example is the combination of known tree growth factors with slope, soil type, soil fertility, drainage, solar radiation, climate and other site specific factors to attempt to predict potential forest yields over time.

GENERAL SYSTEM REQUIREMENTS

For any Geographic Information System, it is necessary to not only provide for graphics output, but also to provide a powerful analysis capability. The analysis capability is essential to fully exploit the spatial data which can require a major effort to obtain. To be accepted, however, the system must be proven to be cost effective. Even demonstrating cost effectiveness though, can prevent the purchase of a spatial information system if the entry level cost is too high, or the pay back period is too long.

It has been our experience that many more firms would use spatial information systems if they could be shown to be cost effective with a low capital investment while still allowing for future expansion as the demand for the system grows. The thought of a large capital outlay at today's interest rates is especially frightening. This concern was murmered at last year's NCGA Conference when, the question of the availability of Spatial Information Systems for less than $100,000.00 was raised more than once. This paper describes the effort and results of some of the development of a Microcomputer Based Spatial Information System with a low entry cost.

SYSTEM DESIGN CRITERIA

1. Low entry cost, yet providing a powerful analysis tool.

2. Hardware independent software to take advantage of technological advances.

3. Device independent graphics to allow ease of interfacing graphics devices.

4. Minimal operating system dependencies to increase portability.

5. Ease of operation of the system to minimize user learning requirements and to gain acceptance by the users.

Finally, for any computer based system to be widely accepted in an office, especially where there has been no previous computer experience, the system must be reliable, and introduced as a tool rather than a threat.

MICROCOMPUTER IMPLEMENTATION OF THEMAPS

A number of programs have been developed over the past six years which will accept topographic and thematic digitized data from a variety of sources and then allow the analysis and graphic display of the digital material (Collins & Moon, 1981). This system of programs is referred to as the Thematic Analysis and Mapping System or THEMAPS. These programs permit the selection and the amalgamation of the data in any arbitrary manner, thereby offering analysis capability. Digital data obtained from existing map sheets, composite overlays or from photogrammetric instrumentation and digital tapes from other data capture mechanisms can be processed and then queried using complex relations or mathematical modelling techniques. The output from the system consists of tabular reports on the results of the queries and device independent graphics calls.

Although originally written and implemented using Fortran on an AMDAHL V5, the modular nature of the software has allowed its installation on mini and microcomputer systems without a significant loss of analysis capability. The major difference between hardware configurations is in the data processing time required. All of the software ported to the micro based system was originally written in the Fortran 66 and 77. A pre-processor was written to allow the use of program control structures available in Fortran 77 to be used with standard Fortran 66. Since the software is disk access oriented, most of THEMAPS can be configured to run on as little as 64k bytes of memory.

DATA CAPTURE

The input section of THEMAPS is designed to provide a means of data capture which is rapid, accurate and easy to use. The input section allows the orientation, scaling and editing of map information. Once the information is input in its raw form and checked for errors, the data is prepared for use in the ANALYSIS section of THEMAPS.

ANALYSIS

The ANALYSIS section of THEMAPS allows the end user to easily access the information contained in the data base in several different manners. The types of access which are currently available include:

a) Interactive Decision: The interactive decision module of THEMAPS allows the user to use boolean operators such as AND, OR and TO as well as their negatives, to select information from the information base. Decisions such as '(deer and mature oak) not cedar' can be input to produce output in either map or tabular form to show areas with both deer and mature oaks present, not having cedars present.

b) Modular Decisions: The modular decison module enables the user to write small subroutines

to facilitate more complex inquiry of the information base. These modules allow analyses such as the application of the Universal Soil Loss Equation to areal features to be accomplished easily and quickly. The user modules can be written using any of BASIC, C, FORTRAN and PASCAL depending on the programming language available in the user system.

OUTPUT

The OUTPUT system of programs has been designed to enable all of the output files produced by the ANALYSIS routines to be routed to several different output devices by the use of device independent software calls to specific graphics hardware drivers. A few of the more important features of the OUTPUT section of the THEMAPS System are:

a) Plotting Devices: The OUTPUT section enables the use of several different types of plotting devices ranging from small desktop devices to large flatbed plotting devices for large plan scale drawings. Plot files can be generated to allow later transmission to a device used within a time-sharing facility. This allows a system with only minimal plotting abilities to produce large output products. The only investment is in a program interface to the plotting device and the expense of using the timesharing operation.

b) Display Devices: The use of a colour CRT (Cathode Ray Tube) device gives the THEMAPS system of programs a graphic feedback mechanism for use when previewing multiple decisions over a short period of time. The hardware chosen decides the limit of colours available to the user for displaying levels chosen in the ANALYSIS section of THEMAPS.

c) Tabular Output: The output from the ANALYSIS section of THEMAPS can be formatted to print out a user defined table of values resulting from the decision input by the user.

d) Graphic Commands: Graphical output has been designed to be device independent by using high level graphics calls. The calls currently supported are:

GOPEN () - OPEN THE GRAPHIC DEVICE READY FOR PLOTTING

SCALE (N,D) - SCALE BY FACTOR N/D

STATUS () - RETURN STATUS OF PLOT DEVICE AND PLOT BUFFER (IF PRESENT)

MOVETO (AX,AY) - ABSOLUTE MOVE TO COORDINATES AX,AY WITH PEN UP

MOVE (RX,RY) - RELATIVE MOVE BY COORDINATES RX,RY WITH PEN UP

LINETO (AX,AY) - DRAW FROM CURRENT X,Y LOCATION TO GIVEN ABSOLUTE AX, AY COORDINATE

LINE (RX,RY) - RELATIVE MOVE BY COORDINATES RX,RY PEN DOWN

COLOUR (I) - SELECT COLOUR I

WINDOW (X,Y,DX,DY) - CENTRE DISPLAY AT COORDINATES X,Y WITH SIZE OF DISPLAY 2DX,2DY

CHARS (STRING) - PLOT GIVEN CHARACTER STRING

GPOST () - CLOSE GRAPHIC DEVICE

THEMAPS SYSTEM EXPERIENCE

The THEMAPS System is currently operating on hardware configurations ranging from the AMDAHL V6 at the University of Guelph to microcomputer based systems costing less than $30,000.00. Several large projects have been completed using the THEMAPS software as an anlysis tool to aid in the planning and evaluation of spatially oriented projects. The microcomputer based system has successfully handled a data base which included eleven overlay levels of a 250,000 hectare study area, with a resolution of one hectare and an average of 1150 polygons per overlay. The overlays were analysed simultaneously using The Modular Decision package to apply various weighting factors to the available parameters in order to determine the reclamation potential of lands with viable coal deposits beneath them.

The THEMAPS System has been profitably used for site planning purposes on areas as small as 25 hectares. This allowed the consideration of multiple factors over time to attempt to determine the best practical development plan, with the lowest lifecycle cost, for a small private development.

Agencies for which we have used our Spatial Information System software include the Canadian Department of Energy, Mines and Resources, Department of National Defence, Ontario Ministry of Natural Resouces, United States Geological Survey, Universities and several private Engineering and Landscape Architecture firms.

The feedback which has been received from users is that the System is easy to access, simple to operate yet allows the incorporation of complex decisions if necessary. THEMAPS provides the type of interactive decision making capability which allows the various professionals involved in spatial planning to test out the many "what if" concepts their projects generate.

CONCLUSION

The THEMAPS Spatial Information System is providing a comprehensive set of software tools to deal with the problems of spatial planning. It allows the interactive manipulation of large sets of spatial data on various levels of computer hardware including very inexpensive microcomputers. The ability of the system to interface to a variety of graphics devices enables the system to generate the type and style of output material which the professional wants to use, rather than material which the manufacturer decided was the best alternative.

The THEMAPS system is currently operating on Amdahl, Digital, IBM, Perkin Elmer, and various Z80 Based microcomputers.

REFERENCES

Collins, S.H., Moon, G.C., Algorithms for Dense Digital Terrain Models, Photogrammetric Engineering and Remote Sensing, Vol.47, No.1, January 1981.

Collins, S.H., Moon, G.C., Creation and Implementation of Software for Terrain Analysis and Display, Final Report, DRES, DSS No 18ST.3280025, 1981.

Dueker, K.J., Land Resource Information Systems: a Review of Fifteen Years Experience, Geo-Processing, 1:105-128

Junket, M. Peter, Nuttal, Clifford, J., Haley, Peter W., The AMC '74 Mobility Model, Technical Report No. 11921 (LL-149), TACOM Mobility System Laboratory, U.S. Army Tank Automotive Command, Warren, Michigan.