DEMOGIS MARK 1: AN ERDAS-BASED GIS TUTOR

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ABSTRACT

There has recently been a number of calls by influential bodies for the development of computer-based GIS tutors. This paper reports on the progress in the continuing development of such a tutor called DEMOGIS. The tutor is based on the ERDAS Image Processing and GIS software package. It comprises a linear sequence of frames that deal with the principles of GIS and the application of GIS for locating land potentially suitable for mining and quarrying in the Charnwood Forest region, England. The limitations of DEMOGIS are discussed along with possible future developments.

INTRODUCTION

The relatively new field of Geographical Information Systems (GIS) is developing extremely rapidly at the present time and there is great interest in all aspects of it in governmental, commercial and academic spheres. The recent origin and rapid rate of development of the field have caused a number of problems, not least of which are the worldwide shortage of skilled staff and the lack of information outlining the fundamental principles and applications of GIS (Green 1987, Rhind 1988, Maguire 1989). This has led a number of influential bodies to call for initiatives in GIS education and training (DoE 1987, NERC 1988). The Committee of Enquiry into the 'Handling of Geographic Information', established by the British Government and chaired by Lord Chorley, for example, made nine recommendations concerning education and training (DoE 1987). Recommendation 50 stated "As part of the measures aimed at increasing awareness of Information, familiarization with geographic information technology should be encouraged throughout the education system" and 57 stated "The Department of Education and Science and the MSC [Manpower Services Commission] should encourage the development of computer-based interactive packages for teaching and home based learning in the handling of geographic information".

In addition to answering these calls for general initiatives in education and training, there were a number of significant practical reasons why we should develop a GIS tutor. The Department of Geography and the closely associated Midlands Regional Research Laboratory (MRRL), funded by the Economic and Social Research Council, are heavily involved in GIS education and training. In the Department's undergraduate programme there is a final year option in GIS taken by up to 20 students. The Department also runs a taught MSc in GIS which attracted 9 students in 1988/89. As well as this, the MRRL frequently arranges short courses in GIS, targetted at people in commercial and governmental organizations, and is frequently asked to arrange demonstrations of its activities at conferences and exhibitions and for potential clients. These activities all place a great burden on University and MRRL staff. The Department also has a long tradition of work in Computer Assisted Learning (CAL) and, given current interest in GIS, attention was naturally focused on this area.

This paper describes progress in the continuing development of a computer-based GIS tutor, called DEMOGIS, which was designed as a response to the calls for initiatives in GIS education and training, as a contribution to education and training programmes and as a test bed for applying CAL ideas to the GIS field. The remaining part of this paper consists of four main sections. The first section examines the design considerations for a GIS tutor, the second discusses why ERDAS was used for the development of DEMOGIS, the third presents an overview of the tutor and the fourth contains discussion and conclusions.

DESIGN CONSIDERATIONS

When designing the GIS tutor, DEMOGIS, a number of important requirements were identified. The tutor had to: be robust because it would be shown to potential clients and students; be capable of use by novices with little or no computer or GIS experience; require minimum user input because it would be used at conferences and exhibitions as a publicity device; run quickly and be entertaining in order to capture users' attention; illustrate something of both the principles and applications of GIS; incorporate both raster (e.g. satellite) and vector (e.g. thematic map) data, in contrast to the best known tutors, ARCDEMO and ECDEMO, developed by Green et al. (Green 1987), which only incorporate vector data; use examples relevant to the local (Midlands) area because of the regional dimension to the MRRL and the availability of relevant data in machine readable format; be produced quickly within a timescale of a few months because of impending commitments; be portable so that it could be transported to conferences and exhibitions.

THE ERDAS SOFTWARE

ERDAS (Earth Resources Data Analysis System) is a computer-based system for generating, managing, processing and displaying geographical data (ERDAS 1987) which is available for a wide range of micro- and mini- computers. The work described here was undertaken on a WYSE PC (an IBM PC/AT compatible) fitted with a No.9 framestore board. The ERDAS software is modular and has been under development since 1979. Briefly, there are modules for Image Processing (IP), Geographical Information Systems (GIS), Polygon Digitizing and Topographic Modelling. An interface to the dBASE data base management system is also available.

ERDAS was selected as the development tool for a number of reasons. The short time scale dictated that it was not possible to write the required software from scratch. In any case, ERDAS has good graphics and a number of useful facilities for creating demonstrations (see next section). ERDAS runs on a microcomputer and, therefore, any tutor developed using it would be easily portable. Although ERDAS is a raster-based system, with very good facilities for handling remotely-sensed data, it has the capability to input and integrate vector data using the Polygon Digitizing module. Far more important than any of these reasons, however, was the fact that the Department of Geography owned an ERDAS system and had some experience of its use.

OVERVIEW OF DEMOGIS MARK 1

The DEMOGIS (DEMonstartion Of a GIS) tutor was created by the author and Mr Trajco Mesev in 1988. It aims to introduce newcomers to some of the basic principles and applications of computing and GIS. Specific objectives include: an explanation of the term GIS; an outline of the basic elements of GIS; an overview of the fundamental principles of GIS, including a discussion of their functionality; presentation of an example using real data to illustrate some of the potential applications of GIS; and an introduction to the ERDAS GIS software.

DEMOGIS actually comprises a collection of 38 frames (Figure 1) which are automatically replayed in a linear sequence. It begins with a title frame (Figure 2), a short introduction to its scope and content and a brief explanation of what is meant by the term "Geographical Information Systems" (Frames 1-2). The main body of DEMOGIS is made up of two parts. The first is concerned with the principles of GIS (Frames 3-14) and the second (Frames 5-38) deals with an application.

1	Opening title
2	Contents, definition of a GIS
3-14	PRINCIPLES OF GIS

    4   Components of GIS
    5   Data collection
    6-8   Data storage
    9   Data manipulation
    10-14 Data display

15-37   AN APPLICATION OF GIS

    16-18 Location of study area
    19   Summary of data layers
    20-24 Maps of data layers
    25   Search criteria
    26-36 Data extraction and overlay
    37   Suitable land

38   Closing title, names and address of authors
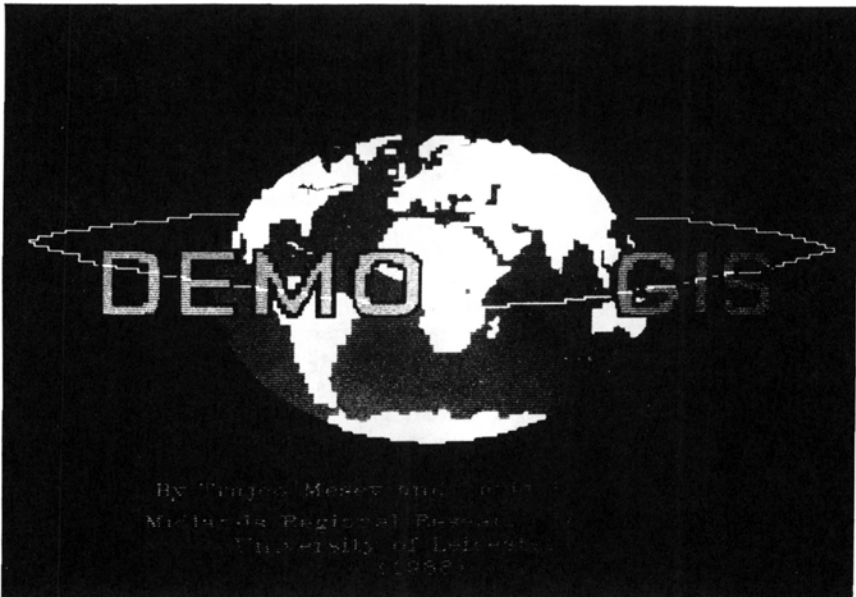
Figure 1.   Contents of DEMOGIS Mark 1

Figure 2. Opening title page.

Part 1:   Principles

GIS deal with both geographical locational and statistical data. The locational data describe geographical features such as hospitals and soil pits (points), roads and rivers (lines) and postcode sectors and geological units (areas). These provide a spatial reference for statistical data such as hospital sizes, river flows and rock types.

Geographical locational data may be collected and stored in a number of different ways of which the most popular are the vector and raster systems. Each of these has its merits depending on the specific application.

The most commonly used data collection devices are, for vector data, the digitizer and, for raster data, the line scanner.

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Figure 3 Data collection frame.

Part 2:   Application

A: Solid geology – extract land suitable for mining and quarrying (coalfield, igneous, sandstone, limestone, syenite and dolerite).
B: Agricultural land classification – remove land unsuitable for mining and quarrying [grade 1 and 2 land]
C: General land use – remove land unsuitable for mining and quarrying (water bodies, urban areas and conservation woodland)
D: Transport network – only consider land which is easily accessible to mining vehicles (within 150m of an existing road or railway)
E: Past and present mining and quarrying – consider only land not previously mined or quarried

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Figure 4. Data layers and search criteria used in the example application.

Part 1 begins with a description of the key components of GIS and then considers data collection, storage, manipulation and display. The frame on data collection (Frame 5, Figure 3) identifies the fact that GIS deal with both geographical locational and statistical data. Some point, line and area examples of both of these are presented. The terms digitizer and scanner are introduced. The three frames which deal with data storage (6-8) outline the differences between the vector and raster structures, using two diagrams, and give some examples of GIS software packages which utilize these structures. Frame 9 lists the main types of data manipulation operations which GIS can perform, namely, cartographic operations, data integration, feature measurement, spatial searching and statistical analysis. The final five frames in Part 1 (10-14) show some examples of how ERDAS can display data in map form. The examples show data on population density (taken from the 1981 Population Census of England and Wales small area statistics), at local authority ward level, for the Charnwood Forest region, Leicestershire (the study area chosen for Part 2 of DEMOGIS).

In Part 2 an application is presented which shows how a GIS can be used to locate land potentially suitable for mining and quarrying in the Charnwood Forest region. The study area was chosen because it falls within the geographical area of responsibility of the MRRL, because of the varied nature of its human and physical geography, because of the problem of the local impact of mining and quarrying, and because of the availability of suitable data. The Charnwood Forest region is situated in North West Leicestershire in the Midlands of England and includes the towns of Loughborough, Coalville and Shepshed. It covers an area of approximately 180 square kilometres, the majority of which is rough grassland and heath, with a little woodland. The highest point is Beacon Hill at an altitude of 248 m. The Region has extremely diverse geology and there is a long history of coal mining and quarrying of igneous, sedimentary and metamorphic rocks. The Region is widely use for recreation, but there is considerable pressure to extend current mining and quarrying activities. The opening frames in Part 2 (15-24) introduce the study area and the data layers in the data base (these are listed in Figure 4). The data layers include both vector (e.g. Geology, Figure 5) and raster (e.g. General land use (derived from classification of a Landsat Thematic Mapper satellite image); Figure 6) data. Examples of point (e.g. Mining activity), line (e.g. Transport network, Figure 7) and area (e.g. Agricultural land) data are also included. The user is shown how each of these data layers can be searched using selection criteria (Figure 4) to extract the relevant categories of land use. The relevant categories of land use are then combined by overlay to give the land potentially suitable for mining and quarrying (Frame 37, Figure 8).

Each of the thirty-eight frames in DEMOGIS had to be compiled separately using the ERDAS software and then stored on the hard disk in ERDAS dump screen format. When the tutor is run, the frames

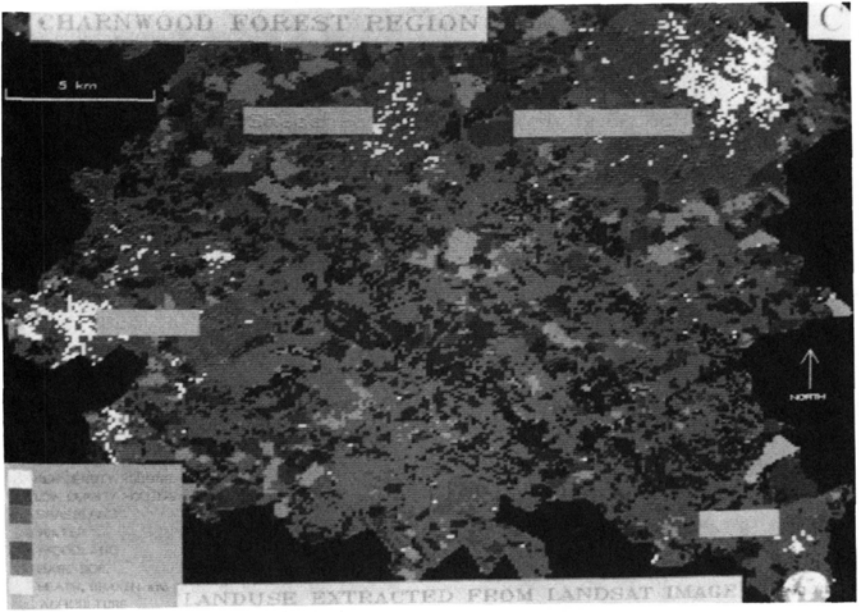Figure 5 Geology data layer used in the application.

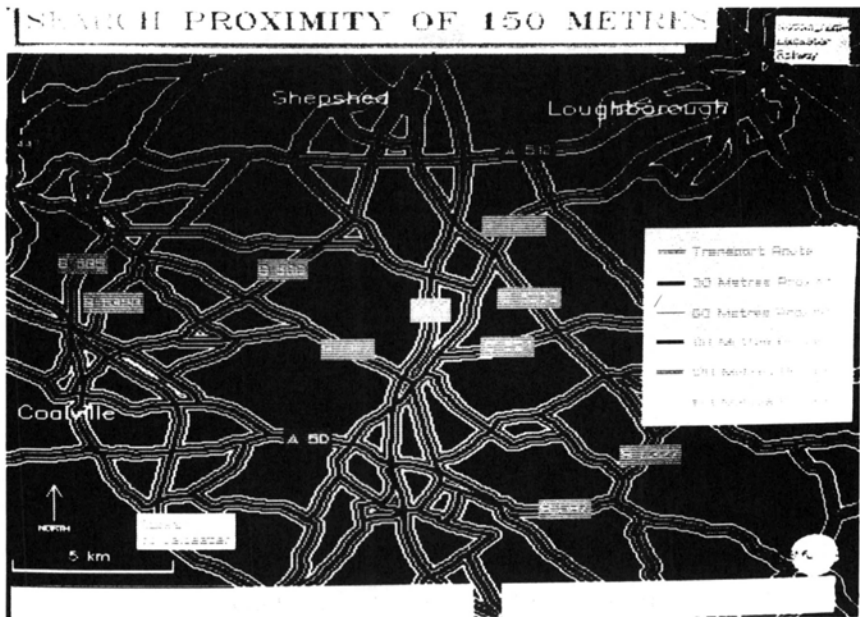Figure 6. General land use data used in the application.

Figure 7. Transport data layer used in the example after creating a 150 m buffer around routeways.

Figure 8. The resultant land identified by extraction and overlay of the data layers.

are displayed in a linear sequence, with the capability to cycle round to the beginning after the last frame. The creation of these frames required completion of a number of separate tasks. The mining and quarrying example application uses real world data and attempts to portray a realistic application of a GIS. Each of the thematic data layers (A,B,D and E - see Figure 4) had to be digitized from appropriate paper maps. Digitizing was undertaken using a Calcomp 9100 semiautomatic digitizer. Because of the limitations of the ERDAS digitizing software (only entity by entity digitizing is available), special software was used for topological digitizing and the digital data were converted into ERDAS format using a FORTRAN program. The maps used for digitizing varied in scale from the 1:25,000 Ordnance Survey topographic maps, from which the transport and mining and quarrying data were collected, to the 1:63,360 British Geological Survey map, from which the solid geology data were collected. The satellite data pertaining to the study area had to be extracted from an appropriate image of the area (collected on 8 July 1984) and then geometrically corrected to the National Grid and classified to give a representation of the general land use of the area. Programs within the very good ERDAS Image Processing software module were used for these operations. Once the basic data had been prepared, spatial processing was undertaken using the programs within the ERDAS GIS software module. This involved extraction of the appropriate land use types from each data layer and then overlay, as described above. In the tutor itself, each of the frames showing the data layers and spatial processing operations were embellished with titles, explanatory text, legends etc., using the good annotation facilities in ERDAS.

The annotation programs were also used to create all the text and graphic frames which make up the remainder of DEMOGIS. In creating these, extensive use was made of the ERDAS symbol library facility. This allows symbols, such as the DEMOGIS logo (Figure 2) to be placed anywhere. at any size, on any frame.

DISCUSSION AND CONCLUSIONS

Throughout the development of DEMOGIS, educational issues have always been given priority. In order to maintain the users interest, DEMOGIS uses a mixture of 15 frames of text, 6 frames with graphics and 17 with maps. The text only frames were kept to a minimum and were limited to a maximum of 150 words and used bright colours. To emphasize the integrated layout and organization of the tutor, where possible, a standard screen layout was adopted (compare, for example, Figures 3 and 4) and each part has been colour coded with a separate background colour: the Introduction is mid-blue, Part 1 is light-blue and Part 2 is green. The spatial processing operations of extraction and overlay are shown step by step with intervening text to explain each step.

DEMOGIS is still under development and so far we have only progressed to a Mark 1 version which has a number of limitations. DEMOGIS relies heavily on the ERDAS software for the displaying the tutor. The frames are stored in ERDAS dump screen format which, although it allows rapid display of files, utilizes a relatively inefficient storage structure. Most of the frames in DEMOGIS are about 0.7 mb in size and this leads to problems of data storage and transfer. This problem has been partially solved by using a shareware data archiving routine called PKARC (PKWARE 1987) which compresses the whole of DEMOGIS into an archive of only 0.8 mb. Probably the biggest limitation of DEMOGIS Mark 1 is the lack of any animation or user interaction. As it stands, at present DEMOGIS Mark 1 is basically a computer book. It does not make use of the full potential of CAL for user learning by experiment and feedback (Shepherd 1985). It is the intention that future versions should incorporate a higher degree of user interaction. This might include experiments into, say, the effects of different size buffers around the transport network, question and answer sections, optional sections with varying levels of explanation and animated sequences. All these require considerable development and whilst there are some facilities available in ERDAS it may well be that some are beyond its capabilities. It is intended that future versions of DEMOGIS will incorporate other aspects of GIS not covered in Mark 1, for example, the use of data base management systems for handling geographical statistical data, map projections, scale change in spatial data bases and digitizing.

In spite of its obvious limitations DEMOGIS Mark 1 has proved to be very useful and it does meet some of the demands for initiatives in GIS education and training. Already it has been used by undergraduates and postgraduates at the Universities of Leicester and Aberdeen and Chester College, and has been shown to a number of potential clients of the MRRL, both in Leicester and elsewhere at conferences and exhibitions. It satisfies the modest design requirements outlined earlier in this paper. In developing DEMOGIS we have learned a great deal about the

educational issues involved in teaching GIS, about ERDAS and about mining and quarrying in Charnwood Forest region. Hopefully, there will be future editions of DEMOGIS which will alleviate some of its current limitations.

ACKNOWLEDGEMENTS

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