USE OF GRID-BASED GIS -ANALYSIS AND PROCESSING IN LAND USE PLANNING

Kirsi Artimo
Helsinki University of Technology
Department of Surveying
Finland

Maria Erke
Helsinki University of Technology
Department of Landscape Architecture
Finland

Commission IV, Working Group 1

KEYWORDS: Land use, Planning, GIS, Analysis.

ABSTRACT:

Maps and map -like presentations are traditionally used in land use planning. Graphical maps are often digitized into vector format. However in data processing and analysis vector format is not always the best data model. Raster format seems to be the most suitable for combining data used in land use planning. Topographic maps can be scanned, air photos can be scanned as well as e.g. soil maps. Satellite data is primarily in raster format. In some attribute data registers information is collected also to regular grid. We can say that all planning information can be represented in raster format.

Raster based processing seems to be a powerful tool for land use planners. Compared to vector based systems several basic functions are more straightforward like: collecting and combining source information, computations which compare, overlay, sum etc. data of pixels on various layers. Grid -based software offer operations which perform analysis on one pixel location, on a defined neighbourhood, on certain zones or on the entire map area. GRID -modules of GIS-software packages include commands by which the user can implement analysis processes. If he or she is a professional GIS-analyst the analysis can be performed spontaneously. In most cases, however it is useful that analysis processes are aredy made and the planner can just use the new source material and by using an user-friendly user interface "run" the various analysis.

1. INTRODUCTION

In spite of the progress in geoinformatics during the recent years there are certain fields which still are lacking useful applications of GIS technology. One of those fields is land use planning. Architects designing buildings already use with great efficiency CAD-applications with 3d -modeling. However land use planners and architects involved with small scale planning seem to have great difficulties in utilizing computer assisted methods.

The reason for the slow development is not the lack of pioneers. The short history of geoinformatics shows that among those who “started” the development of GIS-technology were also land use planners at least landscape architects (Steinitz,1993).

In this paper we want to show that the biggest setback which was met by those who tried to develop computer assisted land use planning applications was the boom of vector-based data modeling. Land use planning in medium scales (1:10000 - 1:50000) covering general/master planning in municipalities and regional planning in counties do not need “object-oriented” models of the reality but rather can better utilize 2d -oriented cartographic model. 2d cartographic models of the reality are best implemented by utilizing raster-based data models.

We are not claiming that raster models are the best one for all applications, it is just suggested that for land use planning applications in the scales mentioned raster model could be a solution and a way for developing useful tools.

In this article land use planning as the field for GIS-applications is discussed in more detail and a case work is introduced.

2. GRID -BASED ANALYSIS AND PROCESSING OF GEOGRPHICAL INFORMATION

In this article we refer to the map algebra created by Dana Tomlin (Tomlin,1990) as the teory and GRID -modules of GIS -softwares (ArcINFO and Intergraph MGE) as implemented tools of raster based data processing and analysis.

Tomlin gives in his book the description of raster-based map processing functions and procedures. He divides processing into four groups of functions: local, focal, zonal and incremental. By local functions he means all functions which only touch one pixel location of the map matrix at a time. Focal functions calculate a new value for a pixel on the basis of a defined neighbourhood area (4-neihghbourhood, 8-neighbourhood etc.). Zonal functions deal with area divisions and a theme map layers. Incremental functions are for computing e.g. slopes and other characteristics based on the difference between the values of adjacent pixels.

Tomlin describes a set of functions and shows also examples of "programming" procedures by using these functions. Each analysis application is a combination of functions. This hierarchy of analysis functions has been discussed more in (Artimo, 1996 and 1995).

The most useful grid analysis functions are perhaps the most simple ones. With more complicated functions the understanding of the result of the analysis is more difficult.

When the question is about a land use planner the easyness of the planning tool is most important. A slight criticism against the implementations of Tomlins map algebra, the GRID-modules of ArcINFO and Intergraph MGE is perhaps well-founded: the implementations are not easy enough for a non-professional user.

3. LAND USE PLANNING AS AN APPLICATION FIELD FOR GIS

3.1 Land use planning process

As mentioned earlier in this article we deal with "medium-scale" land use planning, it means general/master planning in municipalities and regional planning in smaller scales. This means scales which vary from 1:10000 to 1:50000.

The description of the planning process is here given in a very general form. The definition of the following stages is made on the basis of practical experience and is not a result of deep analysis on planning process.

In land use planning the following stages can be identified:

-source data collection, inventory,
-definition of the planning goals and restrictions,
-analysis of the existing situation,
-creation of the alternative planning ideas and making sketches about alternative plans,
-evaluation of the alternative plans,
-making presentation documents for the decision makers,
-decison of the best draft and finalizing the plan,
-making documents and illustrations for both professionals and inhabitants,
-updating the plan.

In the following we deal with the possibilities of applying raster-based data processing, especially analysis methods in some of the previous stages of the planning process.

3.1.1 Source data collection, inventory

Perhaps the biggest development from the point of view of land use planning among GIS-technology is the progress in scanning techniques. Source data available is no more limited to manually digitized vector format maps and data bases but any graphical map can be scanned, converted into right coordinate system and thus utilized in digital form. Manually drafted maps in field inventories, historical maps, plans etc, all graphical documents are available in digital raster format.

On the other hand lots of existing maps - topographical and soil maps for example - have been scanned and are delivered in CD-ROMs, in raster format.

If we compare the easyness of digitizing into raster format with the manual vector digitizing or vectorizing of scanned maps the advantages are obvious.

In addition to the traditional source material digital satellite images and aerial photographs are available and can be used as source data when 2d raster format is used. In "traditional" planning GIS-environment where all active data were in vector format both digital aerial photographs as well as satellite images could only be used as passive background maps. When processing and analysis is in raster format also these data sets can be used more effectively.

3.1.2 Analysis of the existing situation

When source data have been collected and the planning goals and resrictions are defined the planner can concentrate in analysis of the existing situation. Analysis means that source data are processed into more understandable form. In this stage the map algebra based GRID -tools of GIS -software are most useful. Simple map overlay analysis can be made for searching suitable areas for building. Digital elevation models can be used for analysing for example suitable slope and sight conditions. In landscape analysis important areas which should be protected can be identified. - All these procedures would be most difficult and complicated if data were in vector format.

3.1.3 Creation of alternative plans, evaluation of plans

Planning is always a human activity. No computer assisted application can replace human planner. Knowledge based and intelligent systems can take part in planning process by storing human knowledge and applying it in planning situations. Certain limited problems can be solved also by optimizing.

Raster processing is also available in this kind of problem solving. Shortest paths along or outside networks can be solved by GRID -analyst modules as well as proximal areas. However planning itself is mainly ruled by human planners. Tomlin makes a distinction between descriptive (answering questions) and prescriptive (solving problems) analysis methods. In practise descriptive methods are perhaps more simple and thus more useful than the prescriptive methods.

3.1.4 Making presentation documents for the decision makers

It was previously mentioned that scanning technology is one of the greatest advantages in developing planning applications. Raster colour output technology is the second great development. There is not very much use of advanced processing of data if the results are not presented in an attractive way for the decision makers. In the days of pen plotters the presentation of results was the worst bottle-neck. High quality colour outputs produced by ink jet, electrostatic or laser plotters give the full benefit of computer assisted processing for the users.

4. CASE: LANDSCAPE ANALYSIS BY USING GRID-ANALYST

In this article a case project is briefly described. The case is about landscape analysis in Palojoki area (Nurmijärvi, Finland). Landscape analysis is made for the purposes of general/master planning. This project was made by a landscape architect student and documented in her diploma thesis (Erke, 1995). Intergraph MGE GRID Analyst was used as the software tool.

4.1 The goal of the project

The goal of the project was to test the GRID-analyst software tool in landscape analysis. We wanted to identify the most useful raster analysis functions in GRID and in Tomlins map algebra. Later on the purpose is to develop a more specified application for landuse planner. This case was to be as an prestudy showing the requirements of landscape analyst and land use planner which should be known in developing an application.

4.2 Source data

The basic source materials which were used in this case project were partly received in digital raster form (scanned maps, classified satellite images, digital aerial photographs) and partly they were scanned by using a colour scanner. The source data which were used are listed below:
-digital elevation model (pixel size 25m x 25m),
-base map 1:20 000 in raster form
-topographic map 1:50 000 in raster form
-soil map (scanned)
-classified land use data from satellite image (pixel 25m x 25)
-digital air photo
-copies of historical maps (scanned)
-plan maps and drawings (scanned)
-data from building register (converted to raster format)
-photographs of the area.

Raster maps, satellite images and aerial photographs were delivered by the National Land Survey.

The first stage in the project was the conversion of different data sets into the same coordinate system.

4.3 Analysis procedures

The analysis procedures which were made are documented in the poster. In the following a brief description of the analyses:

4.3.1 Map overlays

Different maps were overlayed in order to see "what there is in different locations". In this analysis almost all 2d material was used.

4.3.2 Digital elevation model -based analyses

On the basis of digital elevation model the southern slopes were ientified. These areas were combined with the "warm soil types" classified from the soil map.

The drainage analysis was also made on the basis of the DEM.

4.3.3 The use of classified satellite images

The classified satellite images show different forest types as well as open areas. The edge areas where for example old forest or leaf-tree forest meet an open area are important in landscape analysis and they were calculated in this case study. In the same way the surroundings of water areas and damp places were identified.

4.3.4 The use of historical maps

Colour copies of historical maps of the planning area were available, they were scanned and rectified as well as the data was classified. They were used to study the change in the open areas as well as the built areas.

4.3.5 3d visual analysis

The digital elevation model was also used in constructing a 3d view about the historical situation: the height of the historical forest are was calculated on the top of the digital elevation model and a perspective view was then computed. This view was visually compared with normal perspective photographs which were taken in the area.

4.4 Conclusions of the case project

By using the grid analyst the planner can make inventories. Best analysis procedures are typically the simple ones which can be easily ruled by the planner, it means that the planner knows what happens and how to interpret the results.

Computational analysis is not always required. A lot of things can be seen visually (Artimo,1996,1995). Use of colours in visualization of computations as well as in pure visual analysis is very important. The use of colours was one of the challenges in the case project.

5. FUTURE PLANS

Raster analysis seems to be a strong tool. The main advantages are the easyness of getting source data by scanning, aerial photography and remote sensing as well as visualizing both source data and analysis results.

The use of attribute data from registers as well as the linkage between 2d and 3d data are the future topics of study.

At the moment we are implementing a prototype of land use planners GIS which is based on raster data analysis and processing. The goal is to design an easy-to-use user interface as well as make prototypes of analysis and design procedures required in land use planning.

6. REFERENCES

Artimo,K.,Spatial analysis in geographical information systems - a data model oriented approach. The 5th Scandinavian Research Conference on GIS, 12.-14.7.1995. ScanGIS 95. Trondheim. Norway.

Artimo,K., Spatial analysis in GIS - a data model oriented approach, International Journal for Geomatics, Geomatics Info Magazine, vol. 10., March 1996.

Erke,M., GIS and landscape architecture, The implementation of GIS technology in landscape planning, diploma thesis, Helsinki University of Technology, Department of Landscape Architecture, (not published, in Finnish), 1995.

Steinitz, C., GIS: a personal historical perspective, GIS Europe, vol 2, nr 5, June 1993.

Tomlin,D., Geographic information systems and cartographic modeling. Prentice Hall. 1990.