Architectural GIS: Interoperable and Integrated Information Environments

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Abstract

This paper investigates ways of bringing together the existing GIS techniques of spatial analysis with emerging object-based computer modelling and presentation methods. The end product is Architectural GIS: computer systems that can be applied to the analysis and evaluation of both rural and urban environments. The paper will focus on the various ways in which information is represented, and the spatial analysis techniques that form the basis of mainstream GIS.

Databases of digital spatial data are constructed as a consequence of the relationships between users’ understandings of geographical phenomena on the one hand, and computer modelling techniques on the other. A comprehensive GIS data capture programme often includes the scanning of background OS maps, the digitisation of property maps and other environmental data. Once constructed, data can be retrieved and analysed, and spatial analysis methods can derive new information from existing data. The application of spatial analysis techniques to geographical data extends beyond the information of conventional maps and images. This paper describes computational ways of expressing and exploring design concepts with the use of spatial models of information. The role and function of the model in the design process is explained, and the paper investigates the ways in which models become reflections and representations of design thinking. The paper compares and contrasts the spatial properties of GIS models with those of three-dimensional computer models, and the corresponding processes of model creation, model development, and model modification. The data types used in existing available GIS tools such as MapInfo, ArcInfo and ArcView, will be assessed in relation to common CAD model formats such as DXF, DWG and VRML.

A central argument of this paper, is that in order to fully exploit computer representations of both rural and urban design concepts, computer models in virtual environments will in future depend more upon their dynamic qualities. These qualities will have the potential to allow designers to escape from the restrictions and constraints of static data and fixed images. These new forms of expression of design thoughts and ideas go beyond mere model making, and move more towards scenemaking and storytelling. The latter represent new methods of expression within computational environments for both designers and planners.

Over the last few years, object-oriented technologies such as JAVA and XML have had an increasing impact on the ways in which web-based information is delivered and exchanged between professionals using GIS. The fast evolution of these technologies is being driven primarily by their usefulness in the development of web applications. Whilst
Introduction

Architects and architectural design students increasingly want to be able to refer to both CAD and GIS data during the course of design development. The consequences of such demands are capabilities for exchanging data to and from either of these environments [Clayden & Szalapaj, 1997]. It is now becoming increasingly possible to access digital GIS data which can then be exported into CAD data formats such as DXF and VRML, for example. Designers need access to such data in intuitive ways without having to worry about data exchange transformations and protocols.

An important argument presented here is that GIS functionalities for CAD-based design should not be limited to the range of currently available techniques of spatial analysis in urban and rural planning applications. Integrated computer environments for the progressive analysis and evaluation of both rural and urban environments need to represent users’ understandings of topographical phenomena on the one hand, and computer modelling techniques on the other [Burrough and McDonnell, 1998; Goodchild et al 1999]. User queries for GIS information should be expressible in terms of natural language-like constructions that refer to well-understood data types e.g. Ordnance Survey grid references associated with various datasets such as Sites of Special Scientific Interest (SSIs), Special Protection Areas, Woodland Data, etc. How this data is actually stored and retrieved can be different from how users perceive it. Users do, on the other hand, need to know about the attributes of GIS objects in order to be able to interact with them.

GIS to Building Modelling – A Seamless Process?

Figures 1-3 illustrate a progression of levels of detail currently available to users for preliminary GIS-based site studies. Figures 4-5 show an initial application of XML in co-ordinating map data of different types and levels of detail for purposes of superimpositions of data in response to user
queries for GIS information. Figures 6-8 show some additional functionalities currently under development that the author believes have great potential, particularly for supporting the analysis and development of urban form.

Ordnance Survey data using the National Grid coordinate system for the Peak District is first downloaded from the Edina Digimap website. Land-Line Plus data can be derived from three scales of mapping:

Urban (1:1,250) - major towns and cities;
Rural (1:2,500) - smaller towns, villages and developed rural areas; Moorland (1:10,000) - mountain and moorland areas.

Some of the features included in the Land-Line Plus specification are:
Buildings (with selected building names and house numbers);
Roads (with road names and/or Department of Transport road numbers);
Extent of vegetated areas;

Vegetation type such as reeds or scrub.
Exploiting the digital dataset supplied by Ordnance Survey provides more functionality than previous large-scale data. This data is seamless (but a bit shallow) i.e. one map for the whole country and is also structured to include point, line and area features within a given area of inter-
Users can specify this. Each feature has a unique ID called a Topographic Identifier (TOID) as well as a version number, which are essential for change-only updates.
This is a level of detail at which architectural GIS systems should allow architectural designers to analyse the particular contexts of any given urban site. Analysis begins with the user-definition of urban elements and patterns thereof. This can be supported by means of tracing functions which allow the identification of salient elements with the exclusion of irrelevant detail. Once this has been achieved, more formal operations can be applied to these newly derived abstract representations.

Abstract plans with details eliminated allow the analysis of essential features of urban form. These include fields or zones that define urban structures, and often their edges or boundaries. New urban interventions typically either conform to or extend such fields. Fields can be defined either by solids or by voids, and some possible internal structures of fields include rectilinear, radial, and freeform patterns.

Figures are perceived as existing spatially above ground level and consisting of enclosed surfaces. Enclosing surfaces are ground. Figure and ground are conceptually reversible, and therefore interdependent. Urban developments can also be seen to have some form of hierarchical definition. A hierarchy can be based upon principles of domination/subordination, or upon gradation. Hierarchical analysis can determine both the scale and the location of urban elements [Copper, 1982].

**Linking GIS with Conventional CAD techniques**

An important contemporary example of the seamless linking of GIS data in the form of a series of aerial site surveys with digital ground models was provided by the Eden Project [Jones et. al., 2001; Szalapaj, 2004].

The Eden Project [Jones et. al., 2001; Szalapaj, 2004] made extensive use of 3-D digital ground models with cut and fill analysis, structural analysis, together with environmental loading calculations.
Sectional cuts through 3-D CAD models were used to show the positioning of the structural forms prior to further structural analysis.

Electronic distance measuring equipment was used to set out important structural co-ordinates, particularly those associated with the foundations.

Implementation

This paper has attempted to visually illustrate some of the possibilities and limitations for the integration of GIS with mainstream CAD techniques. Many of the existing problems revolve around the multitude of data formats for GIS information that often need to be converted prior to their use in response to user queries in the context of site studies. Additional new problems emerge through the need to implement functions that support the intelligent analysis of urban form.

Over the last few years, object-oriented technologies such as JAVA and XML (Extensible Markup Language) have had an increasing impact on the ways in which web-based information is delivered and exchanged between professionals using GIS. The fast evolution of these technologies is being driven primarily by their usefulness in the development of web applications. Whilst HTML allows only one way of describing information, XML allows groups of people to create their own customised markup applications for exchanging information. Environments such as XSLT support easier transformation of information between one description and another. JSP technology supports the generation of dynamic or constantly changing content [Rockwell, 2000].

Through its XML Schema Repository, the UK Digital National Framework (DNF) has released a number of draft XML schemas supporting the Ordnance Survey’s geographical database. The schemas are based upon extensions to the GML version 2.0 specification. The draft DNF Release 1 product data specification includes XML schema documents, a specification overview, classification and attributes of DNF features, DNF themes, lifecycles of DNF features, DNF geometry and topology, DNF data in GML, and a DNF glossary. The DNF application schemas define four main types of properties that are present inside a feature element: simple, complex, geometric, and topological.

Conclusion

Since these object-oriented technologies are already being incorporated into GIS systems in the form of languages such as GML, this paper is proposing that it should also be possible for the academic community to become involved in extending the range of functionalities needed for intelligent urban and rural design applications by adopting the same representational systems.
These languages are the most user-friendly we have had access to for some time now. The consequence of this is that Architectural GIS applications will be capable of demonstrating design and planning concepts and principles during the design process in responsive ways which give users control and rapid feedback. This paper has attempted to address some of the issues involved in the development of an Architectural GIS that can be used for both urban design and rural planning applications. Of particular importance within such applications will be issues of multiple viewing at a variety of different levels. These will include: generic support for collaboration between different members of a design/planning team; information exchange between designers and planners; the ability of designers and planners to look at any given object in a variety of different ways.

References