A UNIVERSITY CHALLENGE: INTEGRATING CARTOGRAPHY AND GIS CURRICULUM

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Abstract

Although many theoretical concepts of GIS have strong historical relationships with cartography, the development of GIS and cartography curriculum in some Universities has evolved quite separately. Advancements in the areas of web-enabled cartography and GIS, rule-based cartography and database-driven cartography continue to 'blur the boundaries' raising new challenges. An important question for Universities offering courses in both cartography and GIS is the relevant emphasis placed on both discipline areas and the integration of multimedia and new-media technology into the curriculum.

This paper describes the integration of Multimedia Cartography and GIS education across the Land Surveying, Geomatics and Multimedia Cartography programs at RMIT University and highlights the benefits through a renewed focus on the close relationship between GIS and cartography. Examples of interactive teaching techniques using ArcGIS, Maplex and ArcIMS are presented along with an outline of future projects to enhance the education of tomorrow's GIS and cartographic professionals.

Introduction

Geographic Information Systems (GIS), also referred to as Geographic Information Science have a strong historical connection to Cartography. Many of the concepts found in GIS have a theoretical basis derived from cartography. Early GIS were criticised for their lack of cartographic quality and map production capability and were regarded within some mapping organisations as merely tools for data preparation and analysis. Today most GIS vendors have products that contain a suite of high quality cartographic and map production tools and many National Mapping Agencies, atlas publishers and other cartographic organisations base their map production around GIS. In addition, the emergence of rule based cartography tools such as Maplex and the explosion of GIS based map server technology for publishing maps on the web further confirms the closer integration of GIS and cartography.

This paper describes the integration of aspects of GIS curriculum such as rule based cartography, 3D visualisation and Web GIS across the Cartography and Geomatics programmes (degrees) at RMIT University. After providing a short overview of the history of GIS and cartography and the importance of the 'map' as an interface to GIS, the paper outlines several emerging areas of GIS related to cartography and geo-visualisation. A brief overview of GIS and Cartography programs at RMIT University is provided followed by a description of several areas where GIS and cartography curriculum is being integrated.

Geographic Information Systems (GIS) & Cartography

Historical Reflection

The earliest maps date back thousands of years and cartography, the *"making and study of maps"* [Robinson *et al*., 1995] has evolved as a discipline over the last 500 years. In comparison, Geographic Information Systems (GIS), and the associated science, referred to as Geographic Information Science has evolved far more recently. The computer revolution transformed cartography replacing the traditional map with a digital spatial database and a set of visualization tools [Robinson *et al*., 1995] of which perhaps the most common are GIS.

The discipline of Geographic Information Science (and GIS products themselves) has partly evolved from the discipline of cartography, in addition to many other disciplines such as geodesy and geography [Kraak & Ormeling, 2003]. GIS and 'computer' cartography have shared elements of a common history [Jones, 1997] over the last 20 to 30 years in terms of the emergence of firstly 'workstation systems', followed by desktop systems, increasing levels of functionality and overall integration with core IT technologies. When compared with commercial GIS products available today, early systems lacked a full suite of cartographic production functionality and were typically focussed on data storage and analytical capacity. In spite of this, map based display within GIS has always played an important role and the use of geographic display as part of analysis processes within GIS was traditionally the capability which differentiated this technology from computer aided mapping [Clarke, 1995].

Fast Forward to 2005

Despite claims that *"GIS images are not maps"* [Van Der Merwe, 2003], the reality today is that most GIS products contain a range of functionality for the creation of high quality maps and cartographic products and are widely used for cartographic focussed applications. GIS are now commonly used in national mapping agencies such as the United Kingdom Ordnance Survey, military mapping organisations [ESRI Australia, 2003], atlas publishing organisations [ESRI, 1998] and travel and street directory publishers [Duarte & Camarano, 2001].

Map based display is a key interface to GIS in the context of visualizing data, visualizing analysis processes and presenting results [Kraak & Ormeling, 2003] and this is demonstrated by the range of visualisation tools available in GIS products such as ArcGIS. Such products contain, in addition to quality 2D map display capabilities, 3D visualisation tools, animation tools and tools for exploratory data analysis. Furthermore, products such as Maplex and Production Line Tool Set (PLTS) further confirm the incorporation of cartography theory and practice within GIS products. In addition to soft and hard copy map production, the web and mobile mediums are further increasing the use of GIS for map production (map serving). GIS often playas central role in the overall technology platform required to publish dynamic maps via both the web and mobile environments.

Technology Developments

During the last decade there have been significant developments in the technology used for hard and soft copy map design and production. Although a number of different types of software are used for mapping such as Computer Aided Design (CAD), Computer Aided Mapping (CAM) and graphics packages, there has been an increase in the use of GIS for cartographic applications. This is due in part to both improvements in the cartographic capabilities of GIS and the proliferation of source mapping data in GIS formats. In addition, the integration of GIS with other core IT systems leading to 'enterprise GIS' often linked to workflow and resourcing systems has further enhanced the use of GIS for mapping, especially in national mapping agencies and military mapping organisations.

Automated Map Production

GIS technology developments have reached a level of maturity that facilitates the automated production of some types of mapping products. Automated map production is characterised by a map production process with little or no human interaction in terms of the content, once the general design and symbology of the map product has been determined and recorded in a template or rule-based system. As outlined in Figure 1, the process of automated map production typically involves the use of a map design template and a set of map parameters (scale, symbology etc) linked with a spatial database containing well maintained and attributed spatial data. The 'cartographic rules' required to produce a specific map product are generally implemented in the application software, however, they are also implicit in well structured and maintained spatial data.

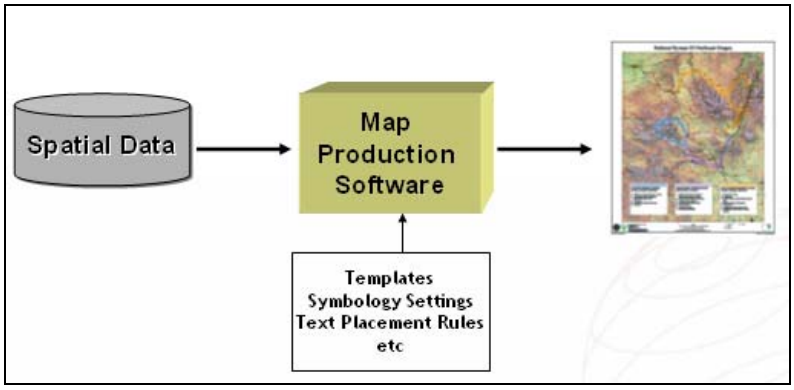

Figure1: Automated Map Production Process

Automated map production is typically well suited to map products such as topographic maps [Kraak & Ormeling, 2003] that have a high turnover and demand, a standard layout and content, defined symbology and a well understood quality requirement.

Text Placement

Traditionally the placement of labels (text) on maps has been a time consuming part of the overall map production process [Robinson *et al*., 1995] and has constituted one of the significant barriers to increased automation of the map production process. There is a long history of research into automated label placement and this has led to the emergence firstly of stand alone GIS labelling products such as the ESRI® Maplex product and more recently, the inclusion of complex automated labelling routines within desktop GIS products [ESRI, 2004]. Such developments now mean that it is feasible to complete some types of high quality cartographic map products using automated labelling techniques. This can significantly reduce the production time for standard mapping products such as topographic and atlas style maps. Well structured and managed spatial data is a key element of an efficient and effective map production toolset. Many of the key productivity tools available in GIS can only be fully utilised when used in conjunction with well structured spatial data. In particular, labelling engines can have significant performance issues when dealing with excessively segmented data and complex symbology tools require spatial data that contains explicit relationships between layers. This places renewed importance on the integration of spatial data management as part of the overall map production process. The use of annotation related to underlying spatial features places further importance on the cartographer having an appreciation for spatial data management.

3D Visualisation & Imagery

Visualisation, also referred to as geo-visualisation is another significant trend in cartography and a thorough review of this area can be found in Dykes *at al* [2005]. Two areas of particular relevance to GIS are the development of 3D visualisation tools and the incorporation of high resolution imagery. GIS products used for map production allow the integration of high resolution remote sensing imagery and digital aerial photography to create new highly 'visual' products. The use of DEM's and other terrain layers such as hillshades together with imagery facilitates the production of map products that can have a high level of visual reality. When integrated with 3D capabilities, the use of imagery allows new 'photo-realistic' map products to be produced in hard and software copy. In particular, when such products are linked with interactive map interfaces, a range of visualisation opportunities are possible such as those provided by ArcScene and ArcGlobe. The ability to integrate 'models' from 3D GIS into formats such as VRML further enhances the capability to provide wider access to such visualisations via the web and this potential has been outlined by a number of authors [Fairbairn & Parsley, 1997; Moore, 1999; Ottoson, 2003].

Web Mapping and Web-enabled GIS

Maps have been published on the World Wide Web since its earliest days [Cartwright, 1999] and today many hundreds of millions of maps (if not more) are accessed and viewed by users via the Web [Peterson, 2003]. Although early web based GIS products lacked a complete set of cartographic capabilities, the presentation functionality within such systems has significantly increased over recent years and reviews of such functionality can be found in MacGillavry [2000] and Neumann & Winter [2003]. The integration of web-enabled GIS products such as ArcIMS with powerful fully functional server side GIS applications such as ArcServer opens up the potential for highly interactive and high quality web based mapping applications. In addition, data formats such as Scalable Vector Graphics (SVG) provides further opportunities to link GIS data and GIS products with high quality web based mapping.

Web-enabled GIS applications are becoming more widespread and important to the public [Peng & Tsou, 2003] and the analysis capability provided by such systems often reflects functionality which until recently was only found in desktop GIS products. A small, but growing number of web-enabled GIS applications are providing functionality once the domain of desktop GIS products, particularly in the area of shortest path and route planning [Jiang, 2003], basic data entry and editing and exploratory data analysis. Many of these applications are found within the Intranets of various organizations which are using web-enabled GIS as an alternative to large seat deployments of desktop GIS products. Use of the World Wide Web as a medium for delivering GIS applications (maps and functionality) has been growing in popularity due to the cost–effectiveness and widespread acceptance of web standards for interfacing and integrating information [Longley *et al*., 2005].

Applications such as the Montgomery County 'Route Mapper Application' (figure 2a) and the Vermont Agency of Transportation (VTrans) 'Web-based Route Logs System' (figure 2b) are two examples of web based systems incorporating GIS based route analysis and such applications place renewed importance on the cartographic presentation of dynamic information.

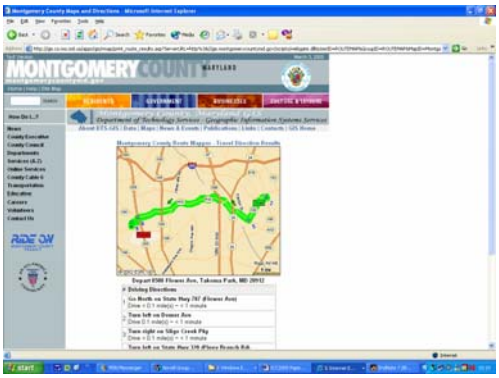

Figure 2a: Montgomery County Route Mapper Application (http://gis.co.mo.md.us/gistmpl.asp?url=/content/gis/rmap.asp)

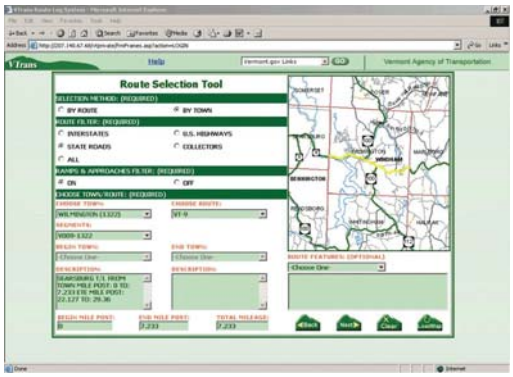

Figure 2b: The VTrans Web-based Route Logs System route selection screen (http://www.esri.com/news/arcuser/0704/vtrans.html)

Geographic Information Science and Cartography at RMIT University

Geospatial related courses have been taught at RMIT University (formally the Royal Melbourne Institute of Technology) since the 1950's with degree level courses covering Surveying (1971) and Cartography (1978) emerging in the following decades. Four year degrees in Surveying and Cartography were introduced in 1989 and a third degree programme, Geomatics, was added in 1995. Amongst other changes since the early 1990's, the Cartography program has been reorganised into a 3 year program (with an additional honours year) and combines significant Geovisualisation and Multimedia components.

The School of Mathematics & Geospatial Sciences (formally the Department of Geospatial Sciences) at RMIT currently offers 3 core undergraduate degrees in Surveying (Land Surveying), Cartography and Geomatics in addition to postgraduate (graduate diploma), masters and doctorate programs. Within the 3 undergraduate programs, Cartography and GIS subjects are delivered through years one to four as a series of core and elective subjects.

ESRI GIS @ RMIT

The use of ESRI® software at RMIT University has a long history beginning with PC ArcInfo in the early 1990's and ArcInfo version 5. Throughout the 1990's, the use of ESRI® software at RMIT University increased, firstly through the creation of a dedicated UNIX based computer lab running ArcInfo version 7 followed by the implementation of ArcInfo (Windows NT) and ArcView (2.x/3.x) across a number of PC computer labs. In 2000, RMIT University signed a University Site Licence agreement with ESRI® and has since expanded the use of ESRI® products as part of its teaching and research programs. In addition to Geospatial Sciences, ESRI® software is used within a number of Schools within the University including Social Science & Planning and Geological & Environmental Engineering.

Despite both the historical use of GIS at RMIT and the presence of both dedicated Cartography and Geomatics degrees, the integration of aspects of the GIS and cartography curriculum has presented challenges in the past. As outlined earlier, the lack of cartographic functionality in early GIS in addition to the perceived analysis bias of early systems towards analysis and away from presentation meant that GIS curriculum became firmly entrenched within 'GIS subjects' with little relationship to cartographic theory and analysis subjects. The emergence of products such as ArcIMS, Maplex and improved map production and 3D visualisation functionality in ArcGIS provides an opportunity to 'bridge the gap' between GIS and cartography curriculum at RMIT.

Web Mapping & ArcIMS

Web mapping is a major curriculum theme within the Cartography degree at RMIT University. Recently, attention has turned to improving the capacity of students in both the Cartography and Geomatics degrees in the area of web-enabled GIS, with specific focus on the presentation aspects of this technology. Ares of the curriculum that have been recently updated in response to the increasing impact of this technology include Open Standards, technology developments and interactive presentation approaches. Students are introduced to Open Standards and in particular, initiatives sponsored via the Open GIS Consortium (OGC™) and the impact of such standards on web mapping applications. Standards relating to communication (WMS/WFS) are introduced in addition to mark-up related standards such as GML, SVG and ArcXML. Finally, students undertake a number of practical exercises utilising ArcXML, ArcIMS and SVG to develop skills in defining cartographic rules and properties for web based display and the benefits and limitations of the various presentation options available. Figure 3 provides an example of a student exercise evaluating ArcXML display capabilities via ArcExplorer. Such initiatives are hopefully better equipping students for roles within organisations implementing web-enabled mapping and GIS technology.

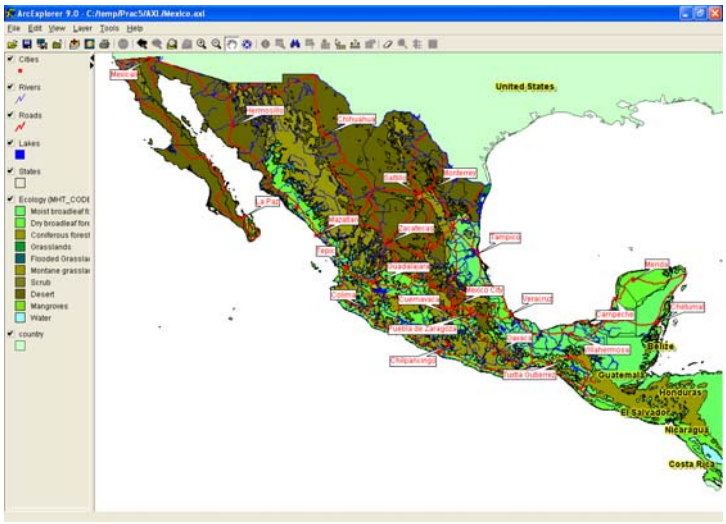

Figure 3: Student project – setting cartographic properties for the web via ArcXML

Rule Based Cartography, Text Placement & Maplex for ArcGIS

Although the theory and practice of text placement on maps is taught as part of cartographic subjects delivered to Surveying, Cartography and Geomatics students, the link between this theory and the use of GIS as a mapping tool has been difficult to establish. The emergence of rule based cartography places renewed emphasis on the relationship between cartography and GIS as the effectiveness of such technology is dependent on well structured spatial data and well defined cartographic rules. In response to this, rule based cartography is now taught in the final year of the Cartography programme and the third year of the Geomatics programme (as an elective). Students are provided with a series of lectures on the theory of rule-based cartography covering the major areas such as label placement strategies, label and feature conflict detection, rule based engines and database driven labelling. In addition, emphasis is placed on the relationship between automated labelling technology and effective spatial data management and database design topics covered in other GIS subjects throughout years 2 and 3. A number of practical exercises using Maplex for ArcGIS (figure 4) are completed by the students to re-enforce the theory presented in lectures.

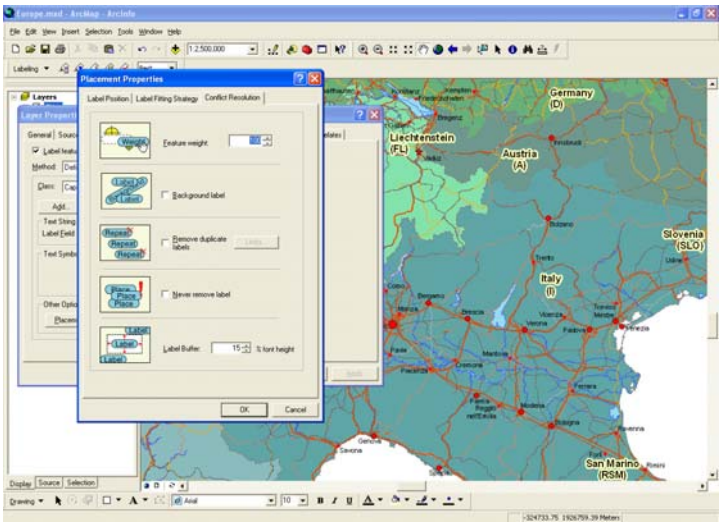

Figure 4: Evaluating the impact of label priorities and conflict detection rules in ArcMap

3D Visualisation & Presentation

A major theme of the multimedia cartography program at RMIT is geo-visualisation both in terms of theory and practical application. In particular, 3D geo-visualisation is of particular interest with a number of research projects undertaken at the postgraduate level [Basic & Nuantawee, 2004; Germanchis, 2004]. Recently, attention has turned to the integration of the theory, techniques and tools used in geo-visualisation and 3D GIS. As part of this initiative a number of final year projects in both the cartography and geomatics programs are investigating the use of both GIS and multimedia as tools for 3D visualisation. Students are utilising ArcGIS as a data management and data manipulation tool and ArcScene as a presentation and visualisation tool. Furthermore, students are experimenting with exporting data from ArcScene into Virtual Reality Modelling Language (VRML) format, subsequent editing ad manipulation within VRML editing packages and eventual publication via the Web (figure 5). The early results of these projects suggest that students benefit from a greater understanding of the data processing and preparation capabilities offered by GIS and a better appreciation for 'selecting the right tool for the job' in the context of creating geo-visualisation models and the presentation of these models in the Web environment.

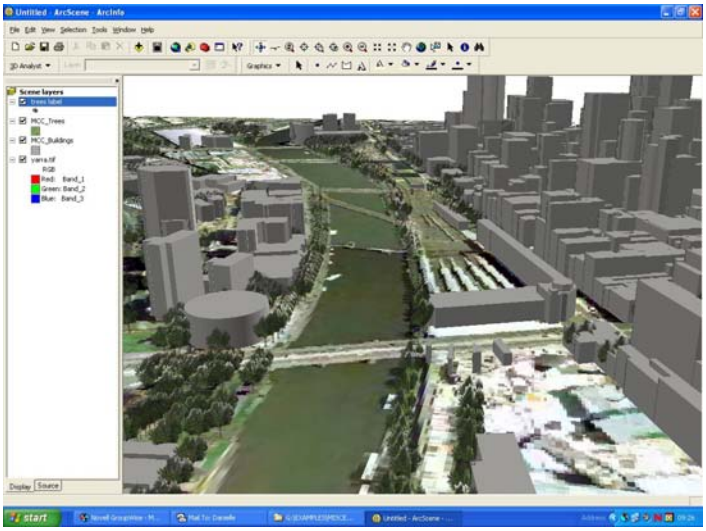

Figure 5: 3D Model of the Yarra Precinct (Melbourne) created in ArcScene

Conclusions

This paper has described some of technology developments that are influencing the closer integration of GIS and Cartography and the impact of these developments on University curriculum. A number of initiatives at RMIT University focussed on integrating GIS and Cartography in the areas of map production 3D visualisation and web mapping have been outlined.

Ongoing developments in both the theory and practical aspects of Geographic Information Science and Cartography will continue to present opportunities and challenges for universities, particularly in the area of Geo-visualisation and rule based cartography. The challenge for universities is to adapt programmes to respond to the ongoing theoretical and practical developments to enhance the education of tomorrow's GIS and Cartographic professionals.

Acknowledgements

The author would like to acknowledge the support of the School of Mathematics and Geospatial Sciences at RMIT University in the preparation of this paper and the associated research. However, the views expressed in the paper are those of the author and do not necessarily reflect the views of these individuals or groups.

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