Library space management: a GIS proposal

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Abstract

This paper identifies the importance of space management in support of the functions of academic libraries. It reviews current solutions on library space management by pinpointing their advantages and disadvantages, and it introduces GIS (geographic information systems) as a tool for library space management, because of its capacity for analyzing spatial data and interactive information. A proposal is outlined that attempts to highlight the process of developing, implementing, maintaining, and utilizing a GIS system for academic libraries.

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Introduction

Information about space and facilities is central to the operations of every organization. Libraries are no exception, especially academic libraries that are generally constructed on a large scale. A powerful space management tool can help libraries increase the efficiency and effectiveness of their daily operations. It is the goal of every library to "develop an efficient and harmonious balance of all the elements that make up a library" (Fuller and Post, 1991, p. 170).

By evaluating different space management tools, this paper proposes developing geographic information systems technology for libraries. GIS is considered to be better than other systems in incorporating spatial data analysis into visual presentation. It is also cheap and easy to develop. In this article, library floor plans are integrated with library feature data as an example of how GIS can be used as a practical library space management tool.

Library space management: a necessity

Space management has become a frequent activity in many libraries. In the early stages of architectural planning for any university library, stipulations for future development are commonly anticipated by designers. Their expectations, however, generally fail to keep up with dynamic changes in the real world. Accordingly, libraries have to schedule sporadic space re-arrangements in order to accommodate these changes, and the decisions about these re-arrangements rest primarily on information derived from daily operations. This makes it necessity to establish a space management system that is able to monitor and record data about how the libraries utilize space and facilities. Such a demand has been particularly popular in recent years when the development of modern technology as a resource and tool for library operations "has been exponential and significant" (Fraley and Anderson, 1990).

There are many situations in daily library operations that inspire consideration of space reorganization. Researchers have systematically explored the causes of space innovations. For example, Fraley and Anderson (1990), p.15 pinpointed four key conditions under which library space restructuring needs to be programmed:

(1) lack of collection growth space;
(2) lack of space for people;

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(3) change in direction or mission of the organization or community served by libraries; and
(4) introduction of new services.

Similar studies concentrated lately on balancing spaces of print materials and digital and online information owing to the increase of information technology in modern libraries (e.g. Bazillion and Braun, 2001; Miller, 2002; Potthoff *et al.*, 2000).

Collection growth has been a common topic in library research (Arfield, 1993; Lancaster, 1988; Montanelli, 1987). The infinite increase of collection numbers is unfortunately restricted by the space ability of libraries. A variety of strategies has been adopted by libraries to control the size of stocks, such as collection pruning, weeding and grafting. Many libraries have invested in compact shelving and microfilm/microfiche substitutes to save physical space. No matter what approach a library has taken, it is essential for libraries to manage the information of space usage for both collection and non-collection sectors. Space reorganization becomes inevitable.

Space reorganization is also caused by internal changes involving services for library users or restructuring library staff. Most of the changes involve repurposing space for library users, and were particularly common when online services developed since last decade (e.g. Thomas, 2000). At an early stage of the development, people witnessed the replacement of catalog cards by the OPAC systems. Then, CD-ROM stations appeared in many libraries. Most recently, the number of computers has been dramatically increased to provide users with access to the internet and networked resources, and internet hook-up facilities have been provided for users who want to bring their own laptops into the libraries. Librarians expect to allocate more space for computers and digital equipment in the future, in contrast to the reduction of library space for print collections (Bazillion and Braun, 2001; Thomas, 2000).

Another changing situation that could potentially trigger library space reorganization is the visible adjustment in the educational mission of many academic libraries. An obvious example is that the libraries have concentrated more on providing users with a learning and teaching environment (Bazillion and Braun, 2001, p. 38). Instructional activities for bibliographic control or online database searches have constituted an important part of library routines now. The development of information technology makes such efforts possible and easy.

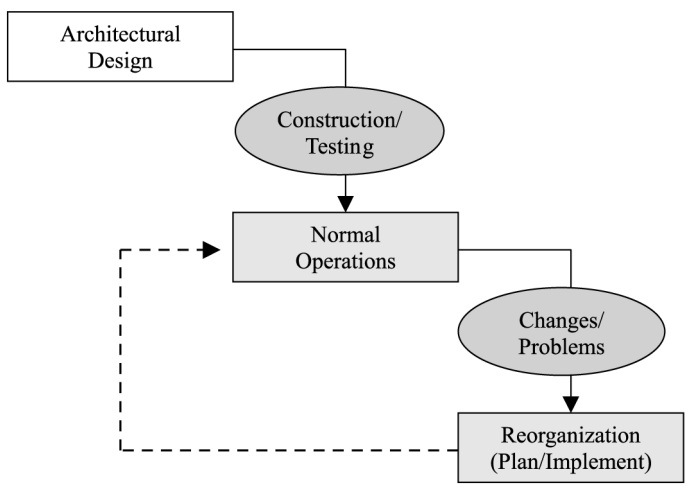
In addition to the situations discussed above, many other elements may also require a reconfiguration of library space, e.g. the introduction of new services and the change of team structures of library staff (e.g. Strain, 1979). The principle is clear that space changes are unavoidable after the construction of a library and during its normal operations. Figure 1 illustrates a space management cycle that many libraries may have already followed in their operations. Please note that the steps of library normal operations and space reorganization would itinerate indefinitely whenever and whatever changes become necessary.

Not only is the concept of space management fundamental for the implementation of space reorganization, but it is also important for maintaining the effectiveness and efficiency of everyday library functions. Considerations of routine management may include, and must not exclude, library furnishings or infrastructural supports, such as systems for water, temperature, ventilation, and electricity. The utilization of similar elements has been out of the reach of many librarians and is somewhat neglected in the rearrangement of physical library facilities. These elements are conventionally regarded as in the hands of maintenance personnel. However, librarians are better off controlling every piece of information pertaining to library operations. Such information is integral to library space management. A space management system becomes paramount for the maintenance of a flexible and functional academic library. The ideal system is one that allows automation and can be managed easily with great precision.

Space management system: practices in libraries

In practice, the majority of academic libraries lack an automated space management system in their

Figure 1 Work flow of library space management



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daily operations. In most cases, if space reorganization is planned, librarians launch investigations to get feedback via interviews and questionnaires from library users, or seek to discover user behavior via personal observation, in order to analyze the utilization of physical space and facilities (Hall, 1978; Neustadter, 1968; Potthoff and Montanelli, 1990; Potthoff *et al.*, 2000). This data, which may be summarized through statistical analysis, serves as the basis for librarians to make decisions about space reconsideration. The scientific reliability of data collection and analysis varies from project to project. Any carelessness in conducting the investigation could have a costly result in incorrect information.

Many researchers have made great efforts to develop a "good method" to enhance the creditability of their investigations. For example, among others, Potthoff and her colleagues followed the role repertory grid procedure, a method that was derived from psychological methodology for working with the settings of urban planning, to collect what they hoped to be scientific data on patron perceptions (Potthoff *et al.*, 2000). Hall (1978) and Neustadter (1968) tried to apply a spatial relationship approach to analyze the behavior of library users against the "bubble diagrams". Nevertheless, the question is: can any "good method" be better off generating accurate data for the utilization of library space and facilities than an automation system that is able to supervise everyday activities of a library does?

For the process of visualizing space management, several options have been relatively popular in library practices. The typical ones include sketches and small cut-to-scale paper models, both of which are based on printed building maps or constructional blueprints. In either way, designers have to create each individual element of the library with paper, such as a study room, desk, computer, bookshelves, or circulation area. By reassembling the elements on floor maps or building sketches, a space reorganization plan is expected to be worked out upon which structural implementation is undertaken. The disadvantages of exercising such methods are that they present a tedious and time-consuming task, whose product is ephemeral, and the paper models can be vulnerable to the slightest bump or breeze. Space design using these methods is inflexible and does not work for long-term management. Scientific measurements on the dynamic use of library space and facilities are hardly possible.

An attempt to incorporate computer technology into space management has been made by some libraries. The endeavor immediately shows its great values and makes computers an effective tool for manipulating complex objects in library space design. The Meriam Library on the campus of California State University at Chico was among the pioneers. Through the development of a computerized model of the library using the drafting application program *MacDraft* (version 1.2b), a detailed floor plan of the Library was created to represent detailed visualizations of library facilities. This made an instant simulation of space change possible, and space planning turned out to be "a considerably less time-consuming and more precise proposition." (Fuller and Post, 1991, p. 172)

Alongside the development of information technologies and the recognition of computer power by libraries, some standardized planning tools have recently been introduced to the management of library facilities. Computer-aided design (CAD) has begun to become the choice of the automated space management tool for some libraries. Compared to early computer software in library space planning, CAD is superior for its ability to draw objects. It is also capable of creating three-dimensional views of library objects and structures, therefore dramatically enhancing planning visualization.

The Michigan State University (MSU) Main Library has implemented a CAD system in its space management and plans to update and review space changes on a regular basis (Haka and Hensley, 2003). Its administrators believe that the implementation will provide a possibility of measuring and calculating the utilization of library facilities, so that the impact of various space allocation decisions on library activity can be assessed. They also advocate a cross-library comparison in order to share valuable information and provide "benchmark measures".

In general, however, only a few university libraries have invested computerized systems in their space and facilities management. The concept of space management automation is relatively new in the library world. A couple of reasons may cause such negligence, such as financial constraints, lack of computer experts, and lack of recognition for the importance of an automated management system.

For those libraries that have already established a computerized space management system, the capability of most systems is constrained to the functions of manipulating space visualization. In practice, floor layouts and other library objects are drawn with automated devices and saved into computers. A three-dimensional presentation makes the computerized design and management tool more powerful and flexible in the organization of space objects (Greco and Dvorak, 2003).

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However, data of user perceptions and user behavior, as well as daily library activities, are generally not collected in and analyzed by the systems, even though such data are undoubtedly crucial to any space management decisions. In the past decades, space management outside the library world has developed widely-used systems that integrated CAD and database management technology to facilitate both the space visualization process and user data analysis, e.g. the computer-aided facilities management (CAFM). It seems that such practices are not well known to academic libraries according to published reports (e.g. Fuller and Post, 1991).

GIS as a space management tool

GIS have been used to assist in the management of building spaces and facilities in recent years. With powerful capabilities for presenting data in visual formats and analyzing spatial relationships, GIS has gained popularity in both research and practice. One example is the introduction of GIS software into the administration of hospital infrastructure. For example, the Downey Regional Medical Center in California has developed a tool that uses GIS to present both the floor plans and the supporting facilities of the hospital on detailed maps, and to store data associated with hospital activities in a database. These elements constitute an integrated part of the space management system[1]. Nurses find it efficient in refining bed selection and managing rooms, and doctors use it to group different patients based on their medical functions. Similar practices in the Loma Linda University Medical Center, California, proved that medical treatments have been greatly improved and business has been effectively enhanced with the investment of a GIS management tool[2].

In addition to hospital space management, some other applications of GIS have also shown their success. For example, the companies Bally Garning and Systems of Sparks in Nevada designed a suite of tools for displaying and analyzing casino floor data using GIS technology to meet the unique spatial data challenges of a casino environment[3]. The Jordani Consulting Group implemented an enterprise-wide GIS management system to supervise all facilities at the University of Minnesota[4].

Libraries share many similarities with hospitals and casinos in constructional scale and complexity. There is no reason that GIS cannot be used to work well with the concerns of library space management.

The GIS technology is in many ways superior over existing space management tools such as CAFM. Its advantages can be summarized in the following:

- GIS has the ability of performing spatial analysis, a key that facilitates measurement on the utilization of library space and facilities. By treating each individual library object as a unit and collecting the data of library operations associated with the unit, GIS turns spatial analysis into a dynamic magic.
- GIS can treat objects differently by categorizing them and placing each type of objects into individual themes. By overlaying different themes on one another, the interactive spatial analysis becomes an easy task. Thereby, for example, analysis of study rooms can be conjunct with the analysis of pipelines going through ceilings of rooms.
- As part of a GIS package, the spatial database is able to store data related to each object and linked to the visual presentation of the object. Spatial data analysis and visual presentation have become an integrated system.
- GIS can perform infrastructure management at very detailed level, e.g. a study room, a desk, or a chair. The ability to navigate geographically over floor plans and building sketches is easy in a GIS platform.
- It is possible to implement the system online so that operating it can be easy and be controlled remotely. This makes maintenance of the system less expensive.
- Developing such a system costs almost nothing. Since many academic libraries already have popular GIS software, no further investment on computer hardware and software is required. Any GIS tool that is available can be a good candidate, such as *ArcView*, *ArcInfo*, *ArcGIS*, *MapInfo*, or *IDRISI*. The cost of developing the system is relatively low because of the simplicity of the development process. The cost of system maintenance will vary from library to library.

Library space management: a GIS proposal

Development

There are two major tasks in the development of a GIS library space management system: drawing the floor plans and building maps, and designing the database schemes. In doing the first task, AutoCAD has proven to be a good tool, and a regular digitizer linked to the GIS product also works well. Converting an accurate architectural layout of a library building into GIS themes may save a lot of drawing work for developers, while other library objects such as building supports and furnishings will need to be drawn into the files.

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The MSU Library's experience shows that "the creation of the CAD drawings was the most complex and time-consuming portion" of such project (Haka and Hensley, 2003, p. 25). Nonetheless, as soon as the initial drawing is completed, updates and modifications will be minor and occasional, and then the efficiency of the automation tool becomes obvious.

AutoCAD drawings directly determine the quality of data visualization and the applicability of simulating space reorganization over the system. Basic requirement for drawing is precision and accuracy of the objects in every dimension. It is evident that objects drawn in proper scale will work perfectly when they are moved onto GIS maps for reorganization simulation. Fancy visual presentations may include the design of encoding colors to reflect various types of objects or various values in databases, the attempt to distinguish minor differences by not only object shape but also color and material (for example, a wooden bookshelf can be differently visualized from a metal one), or the presentation of annotation with meaningful values.

Database design is the most challenging part of the development, because a well-designed database will ensure precise yet flexible data analyses in future system maintenance and utilization. According to relational database design principles, objects are entities that will be transferred into database tables. Hence, major database tables may include bookshelves (regular, compact, oversize, etc.), study rooms, study tables, chairs, offices, computers, printers, couches, reference desks, stairs, elevators, maintenance rooms, restrooms, map cabinets, microfiche machines, and the like. Activities, which may represent relationships during the stage of conceptual database design, may also be converted to database tables, such as schedules. Architectural and decorative units such as windows, doors, carpets, electric wires, network wire, pipelines (water, heating, etc.), vent tunnels, gates, and so on, will also have their own tables. Individual records can be queried by joining relational keys from different tables to return related information, e.g. study-table 1 being related to chair 1, 2, 3, 4, study-room 2, floor 5, . . .

Each database table has a couple of fields that represent features of the object. For example, the table of lecture rooms may contain such fields that tell their size, capacity, equipment, occupancy schedules, use purpose, as well as other information, in addition to relational keys linking each object instance (e.g. lecture room 1, 2, 3) to furnishings inside the room, constructional supports around the room, or the floor location of the room. By associating the graph of each object instance on GIS maps with its feature data in the database, operators of the system are able to work on both visualization and database to perform spatial analysis.

Figure 2 presents an example of the association between visual object instances on a floor map and feature data of these instances stored in database, both of which are highlighted. It is modified from the floor plan of the Information Commons in the University of Calgary MacKimmie Library[5]. Since the library is intensively used, an automated space management tool is particularly helpful there. With available functions of GIS software, operators of the tool can click on any of the objects on the floor maps and expect automatically to bring up a database window with feature data of the object also being highlighted. This represents one of the numerous handy and useful features that GIS can provide to users.

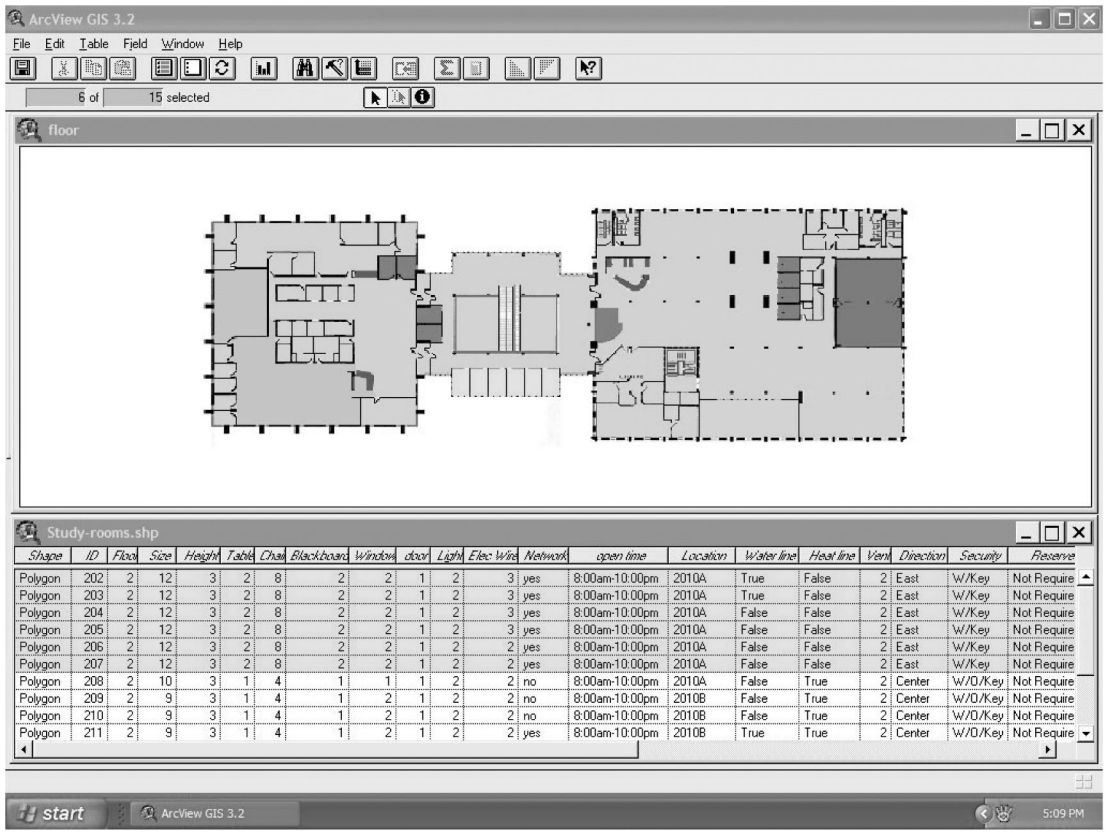
Needless to say, designing a good database requires the developers thoroughly to understand library space norms in general, and specific situations of an individual library in particular. They must bear in mind future library developments, including its collections and services. It is best to have librarians and GIS specialists sitting together to work out a good development plan.

Implementation

Implementation of a GIS library space management system requires the selection of several software components. The selection criteria are relatively flexible because such a project could be generally small and simple. Any library that has a GIS software can eventually adopt the system. *ArcView*, a software patented by the Environment Systems Research Institute (ESRI), is the most popular one and can be found in many libraries that have paid the (reduced) educational license fees. It has powerful functions for graphical presentation and navigation. *ArcGIS*, an improved version of *ArcView*, can also be used. Please be aware that *ArcView* has many extensions, dramatically expanding the power of the software, which should be included.

ArcView possesses a built-in database that can hold data to interact with visual presentations and engage in data analysis. This database, however, does not handle big chunks of data. A practical solution is to use it to store aggregated information that has been summarized from data in another behind-the-scene database. Microsoft Access works well to serve as the database and can be costless because of the popularity of Microsoft Office Suite in many library computer systems, if data stored in it are not huge. Otherwise, enterprise-level database management systems

Figure 2 Floor layout of the Information Commons in the University of Calgary MacKimmie Library



Shape	ID	Floor	Size	Height	Table	Chair	Blackboard	Window	door	Light	Elec Wire	Network	open time	Location	Water line	Heat line	Vent	Direction	Security	Reserve
Polygon	202	2	12	3	2	8	2	2	1	2	3	yes	8:00am-10:00pm	2010A	True	False	2	East	W/Key	Not Require
Polygon	203	2	12	3	2	8	2	2	1	2	3	yes	8:00am-10:00pm	2010A	True	False	2	East	W/Key	Not Require
Polygon	204	2	12	3	2	8	2	2	1	2	3	yes	8:00am-10:00pm	2010A	False	False	2	East	W/Key	Not Require
Polygon	205	2	12	3	2	8	2	2	1	2	3	yes	8:00am-10:00pm	2010A	False	False	2	East	W/Key	Not Require
Polygon	206	2	12	3	2	8	2	2	1	2	2	yes	8:00am-10:00pm	2010A	False	False	2	East	W/Key	Not Require
Polygon	207	2	12	3	2	8	2	2	1	2	2	yes	8:00am-10:00pm	2010A	False	False	2	East	W/Key	Not Require
Polygon	208	2	10	3	1	4	1	1	1	2	2	no	8:00am-10:00pm	2010A	False	True	2	Center	W/O/Key	Not Require
Polygon	209	2	9	3	1	4	1	2	1	2	2	no	8:00am-10:00pm	2010B	False	True	2	Center	W/O/Key	Not Require
Polygon	210	2	9	3	1	4	1	2	1	2	2	no	8:00am-10:00pm	2010B	False	True	2	Center	W/O/Key	Not Require
Polygon	211	2	9	3	1	4	1	2	1	2	2	yes	8:00am-10:00pm	2010B	True	True	2	Center	W/O/Key	Not Require

Note: When six study rooms are highlighted over the layout, data records in database related to these rooms are automatically highlighted

such as Oracle or SQL Server should be considered. But generally, Access is big enough to accommodate the data of space and facility management for libraries (not including individual books).

Some customization of the GIS and database systems may become necessary in order to produce user-friendly interfaces and enhance the usability of the tool. Visual Basic is a standard computer language incorporated into GIS software, and can be used for customizations. Customized interfaces can allow people to input or query data, as well as to present analyzed information in the form of reports, graphical statistics, or other outputs.

Web applications are a wonderful alternative to software customization. Online applications have many advantages over some standalone products, and are relatively easy to develop and utilize. What is needed for implementing such an online GIS library space management system is to have web server user privileges. For security, an intranet or firewalls on the web server are a good idea. Happily all these requirements are basic to the systems that modern libraries have.

Finally, the drawing tools have been mentioned earlier: AutoCAD or a regular digitizer device. In the implementation of a GIS management system, data conversions may be a big task in order to convert existing graphical files into new formats. This requirement varies from situation to situation. In terms of computer hardware requirements, current library computer capacities should have no problem with the implementation.

Maintenance

As soon as the implementation process is done and necessary testing is completed, the system becomes ready for use. Technical maintenance is only occasional, while normal utilization will be carried out by designated staff who periodically updates the database and/or graphics. Information to be updated may fall into two major categories: the activities of people (users and staff), and the utilization of collections.

The updates can be performed through a combination of different techniques. For example, circulation data may be loaded into the system in order to examine material check-outs; and

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in-library book use may be recorded by reshelvers regularly in order to analyze the behavior of library users pulling out books for reading or reference. An alternative solution for efficiently monitoring the move of library collections is to incorporate an innovative technology – radio frequency identification (RFID) – into the system.

RFID is a technology that uses radio waves to uniquely identify items in a library. With the components of a tag, a reader and an antenna, the RFID system is able to trace library items without requiring direct contact or visual scanning. In addition to improving books check-out process, inventory can be taken simply by walking through the shelves and passing a wireless reader wand over the books. Some academic libraries have started using RFID in their collection management to streamline check-in, check-out, and inventory tracking, as well as to help minimize theft. The technology can assist in information collection, and upon connecting to the GIS database it can automatically make updates for library collection utilization.

Yet, the majority of academic libraries still do not have a plan to invest in a RFID system due primarily to its high cost. The GIS management system will have to rely on human efforts to maintain the data on collection movement for some time.

Analysis

Data analysis is one of the ultimate purposes for operating a GIS library space management tool. Analytical units will change based upon different designs for data analysis, but the conduct of data analysis will remain on a case-by-case basis.

The means of data presentation by the system can take multiple forms, such as graphical or textual reporting. The presentation of analysis results in graphical form can provide an easy way of understanding, and this is simple for GIS tools. However, in many cases, analysis can be complex and requires advanced statistical representations. Fortunately, most GIS products have also provided dynamic reporting mechanisms to fulfill the task. It is worth spending time to explore such analytical and reporting utilities of the GIS.

One of the utilities is *ModelBuilder*, a tool in the ArcView Spatial Analyst extension (as well as other GIS packages) that helps analysts create a spatial model of a geographic area. With *ModelBuilder*, mathematical expressions and statistical formulas can be applied against data in the database to perform spatial analysis for specific purposes and designs. Personalized formulas can also be easily incorporated into models to solve particular problems. This is one of the important reasons why GIS products are powerful and flexible for spatial analysis. As soon as the analysis is finished, results can be sent to a report that is customizable, or be presented to graphical interfaces for better visualization. At the same time, a diagram will be generated to illustrate the analysis process, on which there are nodes representing input data, spatial functions that do the processing, as well as output data. Models built are reusable and modifiable, and can be shared with each other.

GIS tools are known as an excellent means for spatial analysis and graphical navigation, and they have great flexibility for solving problems concerned with library space management. The issue is how to exploit all aspects of their great functionality. Fortunately, only some basic functions will be required in support of library activities.

Conclusion

GIS technology is new to library space management. This paper argues that it is a very efficient and effective tool. The simplicity of developing GIS interfaces and spatial databases, and the low cost of implementing them, make the technology applicable to nearly every library. This paper offers only a general proposal that aims to call the attention of librarians to this wonderful tool. Actual implementation can only become possible when the advantages of GIS technology have been more widely recognized. This day is not far off.

Notes

1 www.esri.com/news/arcnews/fall02articles/downey-regional.html and http://gis.esri.com/library/userconf/proc03/p0112.pdf
2 www.esri.com/library/newsletters/healthygis/healthygisfall99.pdf
3 www.esri.com/library/fliers/pdfs/bally_gaming.pdf
4 http://gis.esri.com/library/userconf/proc99/proceed/papers/pap532/p532.htm
5 www.ucalgary.ca/informationcommons/floorplan.html

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