GIS and Group Decision-Making: A Look at the Dark Side

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INTRODUCTION

Technology and technological change are important historical forces that shape how economies operate as well as how people conduct their daily lives. The changes induced by technology have often elicited strong reactions from different sectors of society, ranging from those who have sought to limit or destroy technological innovations to those who heralded technological change as the commencement of a brave new world. Currently, computer technology is bringing about changes in social and economic reproduction that are evoking these reactions. While many living in post-industrial countries have rushed headlong to embrace computer-mediated change, others have articulated a healthy skepticism about the value of such changes. Indeed, some critics maintain that new computing technologies are deforming social and economic interaction in ways that lead to increased personal isolation and, ultimately, to a collapse of community. Others express concern about the inequities that will occur as society is further refracted into technological haves and have-nots. Many of these overlapping concerns are brought into focus when we consider the ways that geographical computer technologies can and will be used by groups of people to organize, retrieve, display, and analyze information, especially when the results these activities are used to guide (or combat) the formulation of public policy. The purpose of this paper is to describe how emerging collaborative GIS-based tools can be used by different community members to support the deliberation of public policy issues. A specific emphasis is placed on the potential misuse of these tools. The discussion includes data selection and its effect on GIS results, GIS design and use, selective presentation of results, alternative solution evaluation mechanisms, and the role of visualization in group decision-making processes.

WHY GIS WILL MOVE TOWARD GROUP USE

Maps are often used to bring into public view the results of alternative planning analyses that may have broad-based community-level impacts. For example, when changes in zoning ordinances are proposed, citizens are often concerned about the overall geographical distribution of specific types and intensities of land uses, and they are often specifically concerned about the proximity of their dwelling to proposed changes. Maps depict these relationships. In other contexts, heated exchanges can occur when a school attendance area reorganization is proposed to reduce overcrowding in one or more schools. In such cases, maps that show the current situation and a proposed solution are often used to help the public understand how changes might affect them directly, and how proposed rearrangements of attendance area boundaries would affect levels of congestion in different parts of a school district. In these and other cases, when printing technology is used to produce and distribute maps, it is common to create wall-sized enlargements that serve as a visible mechanism for promoting discussion about the relative merits of a change during a public meeting. In addition, smaller maps are often printed in local newspapers. Note, however, that map creation has moved rapidly away from hand-drawn and printing technologies; we are now fully in the digital age. While it is possible and desirable to produce printed maps that can be used in the same way as they were previously, other opportunities and risks await those who are interested in innovative ways of using digital maps and map products. The capability to explore these options is now provided by many commercial GIS software products.

As GIS technology matures, it continues to move into specialized niches (e.g. epidemiology) as well as into widespread general-purpose use in "desktop applications". Increasingly, it is also being melded with other computer technologies, including GPS hardware and software, spreadsheets, and CAD software. Because developments in GIS roughly tend to parallel (sometimes leading, sometimes following) those in other areas of computing we can look to trends in these areas to see how GIS might evolve. When these hardware and software trends are examined, it becomes clear that there is a pronounced movement toward networked, distributed computing. This is reflected at several levels, from the improved network support provided by new generations of operating systems, to the explosive growth seen in use of the Internet and World Wide Web browsers. It is also clear that general purpose software, aimed at the business computing market, is developing "linked" tools that enable people to work together as members of project teams. These tools range from software options that support version management of written documents and graphics, to object linking among program modules and suites of applications, to software that is designed explicitly to handle group-based communication and scheduling; in some instances software environments now support the use of shared graphics, and promote electronically-supported and mediated meetings that take place when all members are present in specialized meeting rooms (Armstrong, 1993; 1994). With the increased availability of new high bandwidth communication technologies, digital video is being used to hold meetings in which the participants sit on different continents. The recent acquisition of the best known group-based software product by a company that was formerly synonymous with "big-iron" mainframe computing, is further testimony to the shifts that are well underway in the business computing world.

Given the increasing sales volume and development of "groupware", software that enables groups to work together to accomplish tasks, within the software industry, it is likely that networked desktop GIS software will be adapted to support group work. In fact, several prototype and functioning systems have been developed by linking existing software components (see, Faber *et al*., 1995; Shiffer, 1993). Sooner or later, GIS software vendors will use these concepts and develop tools to support group use. At present, however, shrink-wrapped software that is specifically designed to support group-based GIS analyses is not available. Moreover, little has been written about the implications of a shift in practice from what is largely individual use to group use of GIS. Though it remains unclear at present how these tools will be used in a practical sense and also what changes in social and political processes will occur because of the availability and use of these tools, some impacts can be foreseen.

First, more people could be involved in the creation of alternative solutions to problems. This could lead to broader participation in community issues with a greater number and diversity of opinions represented during the formulation of public policy. Schuler (1994) describes how computer networking can be used to address community needs by fostering a sense of community cohesion, by providing timely information to an informed citizenry, and by promoting and supporting participatory democratic activities. Fitchburg, MA, for example, is able to distribute GIS data using its cable TV network. The city has also established a WWW site (see, Fitchburg, 1995) in which interested parties can access and view three alternative sites for a new high school. Many other local communities have established similar policies or are contemplating them.

Secondly, evidence in the form of alternative mapped scenarios can be produced and more widely used to support and critique the positions of different stakeholders. Even though mapped alternatives are now widely used in many contexts, they are often produced by government agencies, who are already deeply involved in GIS, or well-funded private interest groups, to show a single (or limited number of) alternatives. Group-based GIS technology may support and spur new levels of community involvement and participation in which software is used to rebut strongly articulated "top down" positions that are advanced.

PROBLEMS WITH THE USE OF GROUP COMPUTING IN GIS

Too many cooks spoil the broth?

Although new groupware technologies could open up the process of public policy formulation, if everyone is able to voice an opinion, and if the opinions are unconstrained, then a chaotic jumble of alternatives could be advanced and decision-makers, such as elected officials, could be paralyzed in the face of a multiplicity of options with none clearly superior to others. Further research is needed to develop multi-criteria, multi-user decision-support tools, and methods must be developed that will help users to synthesize alternative solutions and distill from them their essential characteristics.

What goes in affects what comes out

GIS-supported analyses are only as good as their data. Many dimensions of data play critical roles in the quality, reliability and accuracy of results. For example, the spatial resolution of information has distinct impacts on results and these effects are well-known in the GIS user community. However, as GIS technology filters out and is applied by a broader set of users with no training in geographical and spatial data handling concepts, we cannot be confident that these individuals will be well-versed in the implications of spatial data error on their analyses. For example, when mathematical models, such as location-allocation models, are used as tools to help decision-makers understand the geographical expression of their preferences, care must be exercised when results are interpreted. Such results can vary as a function of the scale of the maps that are used as input because cartographic generalization practices, as employed by public and private sector map makers, tend to eliminate sinuosity and decrease feature density as map scales vary from small to large. These generalization practices cause network path distances to change and consequently, the assignment of demand to supply locations will be affected.

Several researchers have conducted experiments that demonstrate the impact of spatial aggregation on results of statistical analyses. These experiments suggest that results tend to behave in predictable ways. For example, correlations between variables often increase as data are aggregated. Debate about a problem could be guided in one particular direction if analyses were conducted at a single scale, one that supported a position, and if those results, and only those results, were selectively revealed to other participants.

Other factors also play a role in the kinds of information that can be obtained from GIS analyses. The variables that are encoded and made available for users place the results obtained in specific “data milieux”. And even when variables are made available, are used in analyses, and are labeled as such, subtle distinctions that might go unnoticed can also color results. For example, the degree to which data are categorically disaggregated can have a significant impact on resulting analyses. Who controls what is made available to a group or the public for its use? What is the “correct” scale of analysis? What is the “correct” level of aggregation?

Computers are not universally available

Although computers are increasing rapidly in price/performance, they are still expensive items of electronic equipment, and when they are configured to be well-suited for use by GIS software, they normally cost several thousands of dollars (US). Because of this cost barrier, many individuals are unable to purchase a computer and as a consequence gaining physical access to one is difficult. In some instances, computer systems have been located in public places. Access to these computers may be “first-come, first-served” or they may be reserved for blocks of time. Nevertheless, using publicly accessible computers is not an ideal way to gain experience with the use of complex software. In addition, the software and data that are needed to support GIS-based analyses often cannot be easily transported among PCs because of both licensing restrictions and disk space requirements. Consequently, data and software that are needed to conduct analyses, to replicate operations that have been used to generate a proposed alternative, or to create a new one, may not be available on any given publicly-accessible machine, improvements in networking notwithstanding. The net result is that GIS-supported knowledge production activities will remain constrained. Some attempts have been made to overcome these constraints through the use of local computer bulletin boards and cable television access (Schuler, 1994), but to date these efforts have been limited in scope. But even fairly inexpensive and commonplace delivery systems such as cable television do not dissolve all economic barriers that preclude free and open access to information. Who will represent the poor and the disadvantaged? Will they have advocates or will technology further isolate the underclass from the elite who already have access to it and the inclination to participate in public policy debates.

All computers are not created equal

New operating systems requirements are continuously "raising the bar" of the minimum configuration that is required to implement the latest versions of software. In many instances, specific programs have their own unique requirements that exceed that of the operating system. These requirements are especially important in GIS applications since large amounts of disk space and RAM are needed to support geographical analyses. Because maps are a common medium of information exchange, screen resolution and printing capabilities also often assume an important role in the effective use of GIS-based analyses.

Computers can be difficult to use

In addition to the physical access restrictions described above, the casual user who wishes to use GIS software to address a problem is confronted with an additional barrier to use. We will call this a *conceptual access* barrier. At the outset of use, GIS software presents a bewildering array of choices to the uninitiated. Navigating through hierarchies of software menus requires training or hours of exploration and self-paced learning. Many GIS operations, such as those performed when map algebra-like manipulations are used to analyze data layers, require the user to complete several steps in a correct sequence. Such concatenated sequences can introduce further uncertainty into an analysis.

There are several ways that this complexity can be partially overcome. So-called "GIS-wizards" can be programmed in macro-languages to automate some operations. This comes at the cost of decreasing flexibility and introducing a high degree of determinism into solution processes, however. Other tools, such as lineage tracers (Lanter, 1994) can improve the ability of users to keep track of, and if required, replicate, their activities and thus speed the recreation of scenarios. In some instances, however, special-purpose routines may need to be used outside of a specific GIS software environment. Moving back-and-forth between GIS software and, say, a special-purpose spatial analysis routine (e.g. Rushton *et al*., 1995) that is not provided in the set of available GIS functions, can be difficult for some users.

It should be evident that the user interface plays a very important role in the usefulness of software by both inexperienced as well as expert users. If an interface is designed for casual use, it is important that it be simple to use at the outset. But simplicity can lull the user and it can be invoked for a variety of reasons, not all of them beneficial. Much can go on beneath the surface of a program that is invisible to the user. By restricting the range of parameters which a model accepts, for example, the sector of the solution space available to the user can be controlled. This is especially easy to do in a graphical user interface with controls that are directly manipulated by users (e.g. sliders) to set values. If they are labeled 0 - 100%, for example, users may assume that they have access to the full range of feasible values, but it may not mean that at all! Rather, values can be mapped to a restricted range and the model results would reflect those unintentional (by the user) choices.

Visual manipulation and representation of the "truth"

During the past several years, cartographers have begun to develop a literature that explores the roles of maps and map-making institutions in the process of communicating (and obfuscating) geographical "facts" (Harley, 1990). Monmonier also has written extensively about the role of maps in public discourse. His work is designed not only to alert the casual map user about the pitfalls of different aspects of map design (such as class interval selection for choropleth maps) but also to guide users in the preparation of maps that are intended to persuade public officials to a particular viewpoint. For example, in *How to Lie with Maps* (1991) he has written a chapter with the subtle subtitle: (or, How to Seduce the Town Board). In this chapter, Monmonier demonstrates how an astute and "map aware" individual might use a map to coax a discussion in a direction that would be to the liking of the map designer. It should be noted that in some instances what *doesn't* get shown may be more important than what is. More recently, Couclelis and Monmonier (1995) have begun to explore how technology can be applied to NIMBY (not in my back yard) problems. When such problems are addressed, a key issue is the elicitation, in whatever form, of the different interests that are held by a diverse set of actors. They conclude that geographical technologies in the form of a SUSS (spatial understanding support system) can build upon the fact that contentious problems are likely to have many reasonable solutions given the different interests of the actors who participate in the process of searching for its solution. Negotiation and communication among different stakeholders can be facilitated using dynamic cartographic scripts that are used to bring out their different interests and perspectives on a problem.

Armstrong and Densham (1995) have begun to explore issues that arise when users wish to create maps that synthesize the results of several analyses. This need might arise, for example, when several individuals wish to assess the degree to which they are creating similar solutions to a problem, or when a single individual wishes to assess the consistency of a set of scenarios that they may have created during the process of problem exploration. Their approach decomposes maps that geographically represent solutions into a set of basic geometrical and topological primitives. These primitive objects are then operated on using a set of simple algebraic operations, summaries are calculated and then displayed. In this way, individuals can place the results that they have created into a broader group context. Since the results are mapped, it is also possible to determine if there are particular areas in which group members are in collective agreement of disagreement.

Mode of operation of groupware

When groupware is implemented, several modes of operation can be chosen. The mode selected, or imposed, can influence the degree of autonomy experienced by users, and influence the paths chosen during different stages of the decision-making process. The most loosely structured format is a type of anarchy, in which all users have equal control over the direction and content of the discussion. When such anarchic structures are adopted, however, it is sometimes difficult to arrive at a consensus during different stages of decision-making. A variant of this approach is an episodic anarchy; free exchange is punctuated by pre-arranged periods of discussion, voting, and consensus building. Finally, a chauffeured model is one in which an individual is appointed as a nominal leader. This individual can initiate votes, divert focus to a set of issues that must be considered, and make suggestions for ways to overcome impediments. Important characteristics of the chauffeur are their identity, personality, and perspective on the problem. The degree to which they exert control over the decision process is also important.

Achieving dominance

When technology is used to foster discussion and support various decision-making activities, it is inevitable that some individuals will be better suited to its use than others. These individuals, either because of past experiences, or because they are technically adept, will be able to dive immediately into a problem, exercise a wide range of available options and generally exploit the capabilities that the technology provides to them. These users may have superior knowledge about system use, data resources available and its limitations, how models are used and results interpreted and with decision-making processes that are supported by the software. Other users will be less experienced with computing technology and will exhibit a certain level of timidity when confronted with GIS technology. While they may hold strong views on a particular aspect of a decision, they may, in fact, become inhibited when faced with the prospect of confronting technologically-supported and well-orchestrated opposition to their position.

CONCLUSIONS

As GIS computing technology continues to evolve, the emergence of group-based software environments will become more commonplace. When these new environments are applied to problems in which various interest groups have very different, but valid positions and when the outcome of a decision has substantial social, economic or environmental impacts, questions will be raised about many of the issues discussed in this paper. These issues must be anticipated and faced openly.

Acknowledgments

This research represents part of Research Initiative 17, "Collaborative Spatial Decision Making", of the National Center for Geographic Information and Analysis, supported by a grant from the National Science Foundation (SBR 88-10917); support by NSF is gratefully acknowledged. Thanks also to Claire E. Pavlik for comments on an earlier version of this paper.

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