Spatial Analysis and Information Visualization: using Geographic Information System for Competitive Intelligence

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Abstract

Many have argued for the inclusion of geographic information system (GIS) into the IS/IT curriculum because of its on-going wide spread use. We present GIS as a strategic tools for the intelligent use of information. At least from one perspective, GIS is a database system with a specialized graphical user interface, along with a tool set for information processing dealing with spatial relationships. We discuss application cases of using GIS in visualization of spatial data and spatial analysis of information. The future trends of dynamic map rendering and provision of these functionalities on the web are then briefly introduced. Our emphasis is the generic usefulness of GIS and its significance in the current and future IS/IT curriculum development. We believe this is pertinent at such a time when the competitive advantage of IS/IT in business is changing from efficient data storage and effective data access to the intelligent use of information.

Keywords: geographic information system, information visualization, spatial analysis, business intelligence, competitive intelligence.

1. INTRODUCTION

We have seen the proliferation of the use of GIS. The reasons are simple. On the one hand, while it was once a costly undertaking, GIS is now reasonably inexpensive. With the simple use of interactive graphics, expensive hardware is no longer necessary, and the software systems that run on a PC are becoming cheaper. GIS is not just used exclusively in military and large businesses, but quite often very affordable in small companies and municipal governments (Gewin 2004). Installation of GIS is no longer an expensive undertaking for many schools, not just institutions of higher education (Sinton 2007), but also in K-12 schools (Wu 2005, Glover 2005), and in distance learning (Wen 2007). On the other hand, maps and data used to be difficult to acquire, but they are now quite readily available via the internet. We have access to vast collections of data, relevant to almost any areas of practice in industry and commerce (Wu 2007). GIS is now in use not just in land use and logistics planning, but also in marketing, politics, public health, crime prevention, and myriads of other areas (Gorr 2007, Clarke 2003, O'Looney 2000). Many have called for bringing GIS into the IS/IT curriculum because of this proliferation (Boasson 2004, Reames 2005), others also shared means and mechanism for this inclusion (Wu and Kohun 2005, Wu 2007). While this paper positions

along that same line, our focus, however, is on the core usefulness of GIS, particularly in view of the future changing trends of IS/IT in industry.

Computer information systems were once important in bringing to businesses a competitive advantage in efficiency, leading to effectiveness in business when we properly design and deploy these systems. IS/IT skills sought after by businesses therefore sufficiently defined the IS/IT curriculum in schools. This situation is however evidently changing. Use of computer information systems no longer brings a competitive edge, because every company is using them. Basic IS/IT skills are required for almost every professional employee. Granted the access to the plethora of data on the internet, and equipped with the processing power of today's cheap computers, companies must seek for the intelligence use of information to gain a competitive advantage in business. IS/IT curriculum is therefore shifting to focus on Business Intelligence, or Competitive Intelligence (Caputo et al 2004).

The following sections will present examples of application of GIS but highlight it as a tool for the intelligent use of information. The next section first discusses the information visualization on a map, which is a common use of mapping to show the spatial relationship and distribution. Then we move on to spatial analysis, to demonstrate how GIS tools can help us sort through spatial relationships to discover new information. More, we will discuss some of the further trends of GIS to make use of interactive graphics tools for dynamic visualization, and the new push to provide GIS functionalities on the web. These are important trends because they will make GIS functionalities more versatile and more accessible for use. There are quite a few different vendor GIS products available. We have maintained that the discussion of GIS functionalities in this paper to be generic.

2. INFORMATION VISUALIZATION

Consider the marketing proposition of determining the appropriate location for a new gourmet coffee shop. The simple understanding may be that the target customers should be the working professionals and members of households of income generally higher than average. For any city in the United States, relevant maps and average household income in census blocks are readily available from the US Census Bureau web site. Figure 1 illustrates the GIS map display of a study area in Washington, DC. Using 2000 Census information, we highlighted the blocks with average annual household income greater than $65,000.

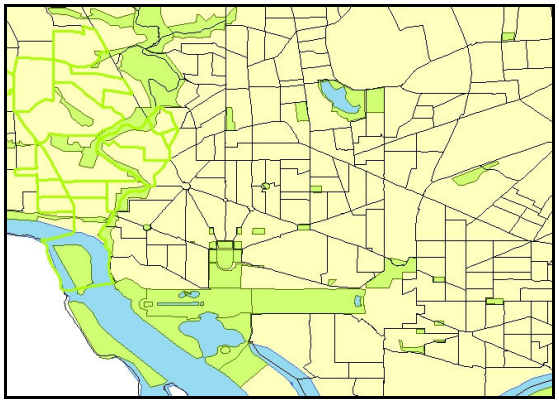

Fig.1 Census Blocks with average annual income >= $65,000

Since we may also assume that mostly only the adults drink coffee, figure 2 further shows the map with the adult population, age 21 or older, marked in each block. We now further label each of the selected blocks with the total adult population. If we may also assume that our target customers should reside within a one mile radius, and that those between 1 and 1.5 miles being less likely will count for, say, 50%, we can then come up with a measure of likely customer population for a proposed coffee shop location.

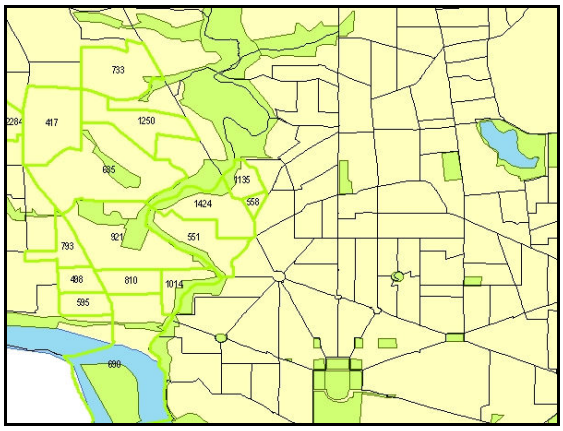

Fig.2 Selected blocks are labeled with adult population from 2000 Census.

Figure 3 shows the use of ring buffers around a prospective location of 1 to 1.5 miles, using the geometric intersection with the census block information to calculate an estimate of potential customer population.

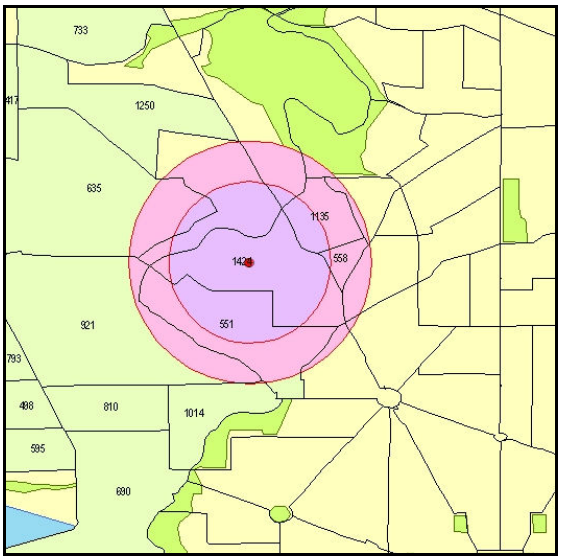

Fig.3 Using ring buffers to estimate the population of potential customers

3. SPATIAL ANALYSIS

Spatial analysis refers to the processing of data while dealing with the spatial relationships between them, such as proximity or intersection, in search of relevant information (Mitchell 1999). The GIS usually comes with these tools.

Consider again the project to locate our new gourmet coffee shop. It also requires us to analyze the situation of our competitors. Are there also other coffee shops in the area? How well can we compete for the business at that prospective new location?

If we have the addresses of the shops of our competitors, we can locate them on our map. The process of converting a street address to a geographical location on a map is called geocoding. This can be manually done since a street centerline is a polyline feature with attribute information for the street address numbers at both ends. GIS may also come with variety of tools for geocoding. These tools are quite necessary when we have hundreds or thousands of street addresses that need to be located on our maps.

Assume that we have located a competitor's coffee shop on the map. We can then apply the same ring buffers analysis technique to estimate the potential customer population. If our new coffee shop is located less than 3 miles away from the competitor's coffee shop, the two sets of buffer rings will overlap. The situation of this overlap gives us an estimate of the level of competition between the two shops. Even with the competition, there may still be business sufficient for both shops to survive and make profit. For the potential customers in the overlapped areas, assume that the likelihood for them to prefer a specific coffee shop to the other is proportional to the ratio of the respective distances to the two coffee shops. We can then re-evaluate the estimate of potential customer population for both shops in the competitive situation. Figure 4 illustrates the two ring buffers at the two coffee shop locations.

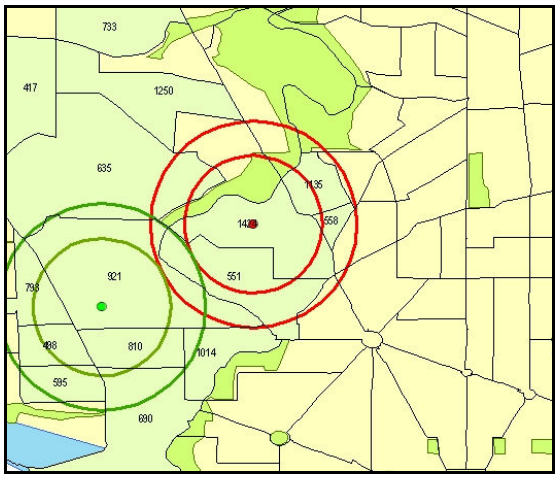

Fig.4 Intersection with competitor's ring buffers to re-assess the population of potential customers

4. DYNAMIC MAP RENDERING

Traditionally we make maps for reference. Given the versatility of GIS, we can also make maps for the purpose of analysis, as the two previous sections showed. When our purpose is to reason about what is happening, we process the data for investigation to make maps which illustrate the evidence to support our argument for our decision.

When GIS does map rendering on the computer, we can further take advantage of the interactive use of computer graphics. The user may directly interact with the GIS by

adjusting rendering parameters through the use of interactive gadgets. Figure 5 in the appendix illustrates a map to highlight the census blocks with average annual income higher than a certain amount. The GIS refreshes the map as needed while the user makes adjustment of the dollar amount on a slider. The approach allows the user to gain a visual perception of how the parametric value under control relates to the spatial distribution, such as the range of income level in the neighborhood. It would be very valuable in political campaigning to comprehend the range of party membership, or in public health administration to understand the spread of an epidemic in a community (Scotch et al 2006). Dynamic map rendering as described above is still new and is not yet readily available in most GIS's unless the system is extended by programming support (Gervais 2005).

5. WEB-BASED GIS

Even when GIS is becoming less and less inexpensive, latest research in system design is increasingly trying to provide GIS functionality on the web. This means that the users of GIS do not need to have the GIS software installed on a local computer, but as long as there is reasonable internet connectivity, GIS functions are available on the web through the use of a web browser. It is called the web-based GIS (Peng and Tsou 2003).

As a web-based application, GIS will become even more accessible. Quite often government agencies use a web-based GIS to provide GIS functions to the public for access to their maps and data. Vender software systems for web-based GIS are available: prevailing ones, for example, include ArcGIS Server from Environmental Science Research Institute (ESRI 2006) and Manifold Internet Mapping System (CDAI 2008), following from behind. More specialized GIS functions are often not available in these systems via the web. Research in system design and development of web-based GIS functions is on-going (Calder 2008), and GIS will be even more commonly available to the public.

6. CONCLUSION

Basic IS/IT skills are required for all IS professionals, and the use of IS/IT no longer gives businesses a competitive advantage. When it is necessary for IS professional to possess problem solving skills, the IS/IT education needs to move on to focus on the intelligent use of information. We present GIS as a significant tool for that purpose.

We described the main functions of GIS as a tool for the intelligent use of information. The predominant GIS functions described in the paper include information visualization and spatial data analysis. They were illustrated with examples, and we focused on the generic GIS capabilities for business intelligence. We also briefly discussed two ongoing trends of development in GIS. Dynamic map rendering will further enhance the usefulness of GIS as a tool for business intelligence. On the other hand, web-based GIS will make these functions even more widely accessible to the public.

GIS is becoming widely used in many areas of application. We have shown that it is a significant tool for the intelligent use of information. That will be a skill sought after in the next generation of IS professionals.

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APPENDIX

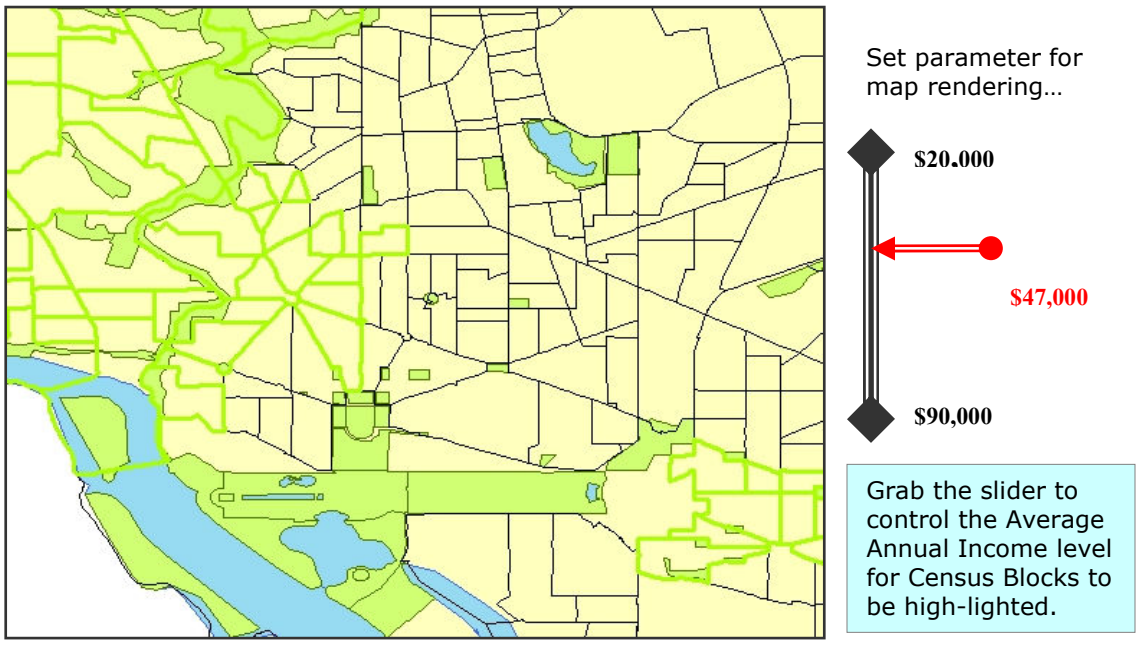

Fig.5 Dynamic map rendering with parameter value controlled by interactive device. Census blocks with Average Annual Income higher than the selected value are high-lighted.