

Stop Press

Visualization and virtual reality: prospects for GIS

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Introduction

The traditional problem for cartographers when compiling maps has been the lack of suitable information from which to derive the finished product. In the era of computer-based information collection the pendulum has swung to the point where it is no longer the lack of information that is a problem but the huge volumes of data being collected.

This raises fundamental issues of data and how to manage, sample and represent them. With the development of new computer technologies, there is the opportunity to establish new strategies for the handling of such data. These strategies should lead to a better understanding of spatial relationships and result in improved problem solving. They should also make spatial information available to a more broadly-based community of information users.

The emerging field of scientific visualisation is important in re-establishing the interaction between communication and cognition. This has always been part of the cartographic discipline but unfortunately many of the traditional cartographic principles have not been incorporated into GIS. There is a need to re-define models of information communication that will allow GIS to make fuller use of the emerging technologies like multimedia and virtual reality.

Map design

The importance of visual communication and interpretation has always been at the heart of the cartographic discipline. However, basic map design rules are poorly understood and rarely applied in a GIS environment where the typical user has little or no cartographic background. Badly designed maps produced as the end product of a GIS analysis can result in the incorrect interpretation of the information and lead to poor quality decision making.

Most GIS systems use, often by default, the map specifications designed for large format paper products. These are often inappropriate to small screen images that are transient in nature. It has been demonstrated that for certain types of information the digital representation is not as readily interpretable as the paper form of the same map.

Little work has been done to develop computer-based map specifications and to investigate the communication issues related to interactive map use in a GIS environment (Buttenfield and Mackness, 1991). The issues of visual search and recognition, the role of memory in interpretation and the user's own reality in comparison to the reality envisaged by the compiler of the map are all as relevant today as when they were discussed by Wood in the late 1960s (Wood, 1968; Wood, 1972). However, the way they are applied with computer-based images is different from the paper map.

Visualization

The emergence of scientific visualization is a recognition that the development of new computer graphic techniques will profoundly effect the way in which we are able to communicate information. Taylor (1991) defined visualization of spatial data in map form as an interaction between formalism, the new computer technologies; cognition, the analysis and applications of the information portrayed; and communication issues (Figure 1). Visualization is about exploring the analytical and communication power of visual interpretation.

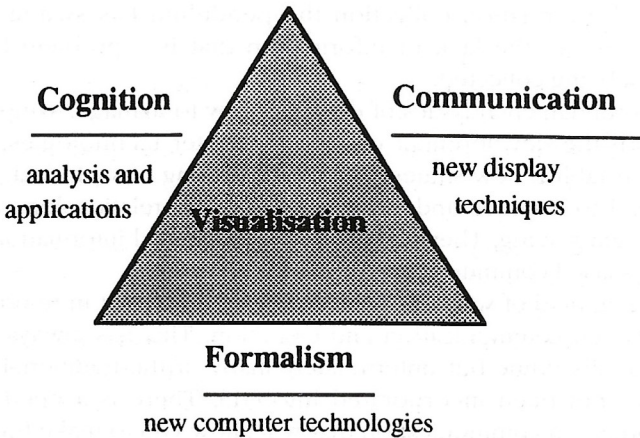


Figure 1. The components of visualization (after Taylor, 1991)

Visualization techniques are not just scientific tools, they also require elements of artistic input, imagination and intuition (Taylor, 1991). Cartographers have always introduced an artistic element into the design of maps with many products noted more because they are 'things of beauty' than scientific records of the landscape.

The growth of visualization has been closely linked to the development of new and more powerful computer graphics technology. But visualization is more than just the development of suitable computer technology. It is about the development of graphically-based decision support systems in which the user interacts with the graphics data. Thus visualization also has to address the issues related to the human use of graphical information and the strategies for improving the human/computer interface.

Visualization in GIS involves a consideration of data presented in many forms. These include the traditional 2-dimensional map, 2.5-dimensional surfaces,

3-dimensional objects and images, including vertical and oblique aerial photographs and satellite data.

3-Dimensional GIS

Many GIS packages manipulate and display 2.5-dimensional data as perspective views and block diagrams but few systems are designed to handle true 3-dimensional data. This involves complex data structures and data manipulation algorithms for the query and analysis of such data (Raper, 1989).

Visualization research has shown that the use of images that are similar to the natural 3-D world improves the ability to interpret information about the objects. To this end 3-D representations of spatial information are being used more extensively in such areas as geology, architecture and military studies.

The visualization of 3-D data allows the user to view spatial objects from any external position, move around objects and to look inside them. The user can also be positioned in the object and view the surrounding world just like someone looking through the windows of a house.

New technologies

Current computer technologies incorporate major advances in graphics display technology and huge increases in processing speeds with the ability to handle millions of calculations for the interactive manipulation of graphic images. As a result complex graphic images can be created in which different elements of a scene are changing, apparently independently of each other. For example in aircraft simulators the view of the buildings from the cockpit changes as the aircraft comes into land. To make the scene more realistic vehicles are driving around on adjacent areas of tarmac, independent of the aircraft's approach but within the pilot's view.

Current computer games have highly developed background images and foreground computer animations which respond to user inputs. The sophistication of these images and the quality of the computer response to the user input has increased enormously in recent years.

At the same time there has been a great increase in data storage capabilities. The introduction of CD-ROMs or optical discs has made large volumes of data available on low cost media. The next generation of blue light CD's promise to increase the data storage capability of the media by an order of magnitude.

Multimedia

One result of the increased technological capabilities is the emergence of interactive multimedia systems. These include the ability to play digital video, incorporate sound, create animations and to construct virtual views from still photographs. This latter is a technique that allows still images to be joined to form a continuous hemispherical image around a point. The viewer may scan the image to get an overall impression of the area, much like someone standing in the middle of a cathedral will do to get an overall impression of the architecture.

Multimedia techniques are gradually being applied to spatial data and some very successful integrated solutions have been developed which use maps, images, sound and digital video to give an impression of an area (Lewis and Rhind, 1991; Parsons, 1992).

The use of such a wide range of data types involves careful consideration of the ways in which users might interrogate and interpret such data. The issues related to visual communication become more important and there are concerns that multimedia systems can lead to information overload for certain groups of users. Successful multimedia solutions are as much to do with entertainment and the appropriate production skills as with database technology and computer graphics.

Computer animation

Animations are increasingly being used to convey information. Computer animation techniques are becoming very sophisticated, so that inanimate objects can be given life and be moved around in a parody of human behaviour. Light and shadow effects are carefully calculated and the break-up of objects are accurately portrayed. The effects of hitting an object and the deformation caused by objects colliding can all be simulated.

One particular technique is that of computer puppeteering in which computer animations of people, animals or cartoon creatures are interactively manipulated using a hand control device which moves the animation in much the same way that a puppeteer controls a puppet. From this sequences of animations may be used to evaluate designs of buildings or furniture or to show the effects on people of car or aircraft crashes.

Computer animations are used extensively in advertising and increasingly integrated with 'real world' video images. A film sequence of a car driving through the country can have a cartoon character placed at the wheels and all the movements of the car can be reflected in the animation.

These techniques allow spatial data in the form of aerial photographs or satellite images to be integrated with animations to portray information about the environment. The animated flight of a spacecraft across the surface of Mars produced by the Jet Propulsion Laboratory, California, is a particularly good demonstration of what can be done with appropriately powerful computers and the time and resources.

What such techniques provide is an opportunity for developing closer links between animated images and geographical investigation. An example of how this can be applied was demonstrated for a proposed building development in Vienna (Ertl *et al.*, 1992). A CAD drawing of the proposed building was placed in its true perspective position on each frame of a video sequence taken from a moving vehicle. Replaying the video showed what the visual impact of the structure would be on the local area.

Virtual reality

With the development of new computer technologies for interactive manipulation of graphics data has come a series of new concepts and techniques which are

broadly grouped under the term virtual reality. They include such ideas as cyberspace, virtuality and three dimensional artificial reality.

Virtual reality involves the projection of computer images into a headset and the wearing of gloves and other devices to record body movement and to provide other stimuli. The wearer is projected into the computer environment and body movements or interactions with the computer environment are recorded. In this way the individual may walk about a room, pass through a door out into a courtyard, touch an object and so on. It is possible to increase the user's perception of the environment by providing not only visual stimuli but also touch and sound stimuli.

Such techniques while they are exciting for games also have very practical applications. They have been used in the design of cars and buildings and used to model human interactions with particular objects or environments.

The increased ability to portray the real world in an animated form or using images taken from video or oblique aerial photography, is likely to offer opportunities for using virtual reality techniques for the evaluation of real spatial information.

Again the link between animation and real images will be very important. The ability already exists to create a 3-dimensional model of the world in which buildings are not just boxes but are true images of each building face superimposed on a solid box. Virtual reality will then let people walk through the environment. This will allow planners to assess the reaction to proposed developments, including the apparent ability to touch the buildings or to peer through windows.

Spatial Decision Support Systems

A key to the development of computer-generated environments based on real spatial information will be how the user interaction is monitored and the results used to understand and solve geographically-based problems. To be successful, the use of animation, multimedia and virtual reality techniques will need to consider issues of visual interpretation and models of evaluating user reaction.

There will also need to be the development of tools that allow the results from such systems to be fed into the decision making process. This requires the use of spatial decision support systems that can evaluate human responses to visual information systems.

To date little has been done to consider the visualisation and interpretation issues resulting from a combination of image-based spatial information systems and new technological developments. Even less has been done to evaluate the problems of integrating such techniques into a formalised decision making structure.

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