FROM TOOL TO MEDIUM: IMPLICATIONS OF THE CHANGING ROLE OF THE COMPUTER IN CARTOGRAPHY

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ABSTRACT

The role of the computer in cartography is changing. Once used exclusively as a tool to help the cartographer make maps on paper, the computer is now used as a medium of communication. Maps are being viewed directly on the screen of the computer. This new medium has fundamental implications for how we portray the world with maps.

Each medium embodies certain possibilities and limitations for communication. In the many thousands of years since the first map was created, and especially in the 500 or so years since the first map was printed, cartography has developed within the limitations and possibilities of the paper medium. The way that we have learned to depict the world is to a large degree a product of this medium. A 'paper thinking' still dominates our view of maps that controls the way maps are made and the way they are used.

Marshall McLuhan, whose famous motto - the medium is the message - has come to symbolize the effect that the medium can have on communication, observes that we initially approach a new medium by emulating the old. The

challenge of a new medium is to exploit its potential. The main advantage of the computer medium is interaction. Interaction with maps is the ability to choose what is displayed and how and can be either on a data or graphic level. The second major advantage of the computer medium is its ability to create and display animations that transcend the static nature of the paper map.

Keywords: cartography, interactive mapping, cartographic animation

Introduction

A medium is the carrier of information. It is used to transmit knowledge and ideas between people. Each medium has a certain potential for communication. For cartography, the computer medium presents the potential of interaction and animation.

For centuries, maps have been constructed on the medium of paper. These depictions of the world, created by the cartographer, represented the way we communicated about the world around us. The computer has been used for many years to assist the cartographer in making maps on paper. Now, the computer is being used directly for the display of maps and making it possible to 'rethink' how information is presented in the form of a map. Computers are facilitating more interactive and dynamic methods of map display. With the help of this technology, it is becoming possible to restructure the human relationship with maps - to change how maps are presented and how they are used.

I want to spend the next few minutes talking about how the computer can be used to create a more dynamic form of map use; how we can change the human interaction with maps and how we can ultimately improve people's conception of the world that surrounds them. I'll begin by looking more closely at the concept of the computer as medium.

I. Computer as Medium

High-tech visionary Alan Kay, who conceived of the Dynabook and whose design work led to the development of the graphical user interface, argues that the computer is not a tool or an instrument but a medium. He cites Marshall McLuhan's contention from the early 1960's that electronic technology is not merely another form of communication but is the medium of our time and is reshaping and restructuring all aspects of our life.

McLuhan's main concern is with the pervasive effect of the medium. He is particularly critical of the written word because it has forced us to attend to the recognition of text at the expense of all other sensory stimuli. This sensory impoverishment brought about by writing was further magnified by printing. McLuhan argues that the linear regularity of the printed page and our long-standing exposure to such a display has trained us to accept ideas only insofar as they conform to certain strict patterns. We have, thus, the creation of Gutenberg Man, a reference, of course, to the Gutenberg Bible and the invention of printing. Gutenberg Man, by McLuhan's account, is explicit, logical, and literal; by allowing himself to become overdisciplined by the closely ranked regiments of text, he has closed his mind to the wider possibilities of imaginative expression (Miller 1971, p.5).

McLuhan states that literate people are visually incompetent because they have been so conditioned by the recognition of printed text. Stroop Effect (Stroop 1935).

To demonstrate our lack of visual aptitude for things other than text, McLuhan cites studies of illiterate people that show a very high degree of visual competence within the area of prescribed social interests. The TEWA Native Americans of New Mexico, for example, have distinct names for a very large variety of coniferous trees. So many, in fact, that it is beyond the capability of literate people to see the differences. This visual

ineptness of western society may also be a reason that many avoid using maps.

According to McLuhan, some methods of communication are more pervasive than others depending upon the degree to which the medium employed reproduces the full sensory variety of the original experience. The capacity of any medium to perform in this way depends upon the environment it creates through the number of sensory channels that are called into play (Miller 1971, p.3). The larger the number of senses involved, the more conducive the environment to convey a truer message. McLuhan states that the ratio of the senses is altered by each technology. All media alter the sensory mix and result in forcing changes on the individual (McLuhan 1967, p. 30). "Media, by altering the environment, evoke in us unique ratios of sense perceptions. The extension of any one sense above the others alters the way we think and act - the way we perceive the world" (McLuhan 1967, p. 41).

Further, McLuhan argues that we live in a rear-view mirror society (Theall 1971). He states that all new forms of media take their initial content from what preceded them. Not only is the new medium based upon the old, but society dictates that the only acceptable way of approaching the new medium is by emulating the old - through the rear-view mirror.

McLuhan has forced us to recognize the way in which technical innovation like printing and the electronic media create psychological environments, environments to which we subordinate ourselves without clearly recognizing the price we pay in doing so (Miller 1971, p. 8). Thus, his famous motto - the medium is the message (McLuhan 1967). While it is an exaggeration, of course, to claim that the medium is the message, the medium does exert an effect over and above that which is carried in the message itself. According to McLuhan, we have subordinated ourselves to printed text. Electronic communication helps to free us from the constraints of this medium.

The Medium in the Map

To what extent do maps suffer from the same limitations as text? Have printed maps closed our minds to the wider possibilities of imaginative expression and communication about the spatial world?

In the many thousands of years since the first map was created and especially in the 500 or so years since the first map was printed, cartography has developed within the limitations and possibilities of the paper medium. The way that we have learned to depict the world is to a large degree a product of this medium. Different methods of symbolization were introduced to improve the representational qualities of maps on paper. General map-design principles were incorporated to improve the user interface of maps to the maximum extent possible with this static medium. An implicit goal of map design was to improve the aesthetic or graphic quality of maps to maintain the interest of the map user.

Each map embodies paper in the sense that the cartographer has been controlled by centuries of experience with this medium. The influence of paper upon cartography is so pervasive that it is difficult to conceive of a map form that is not influenced by this medium, even those displayed on the computer. We might speak of a 'paper thinking' that still dominates our view of maps - influencing how they are created and how they are used. It will take many years to transform cartography to the new medium before this 'paper thinking' can be overcome.

The transition to the interactive map is made possible by the computer. Computers can be used to improve the general human interface with maps. With an appropriate user interface, the interactive map can provide a more effective and more meaningful access to information. One of the major problems in increasing map use with computers is access to computers. The concept of the Superboard can be used to envision a possible future medium for cartography.

Envisioning a New Medium

An obvious trend in the development of computers since the early 1950's has been an increase in performance and a reduction in size. Initially filling entire rooms, computers with greater speed and capacity now fit in the palm of a hand.

These computers are based on a stylus interface and are designed to interpret handwriting. For the processing of commands, the operating system incorporates the recognition of meaningful gestures such as caret for insert, cross-out for delete, square-bracket for block-marking and a question mark for help.

The stylus interface represents a major advance in the interface with computers. In many ways, the stylus interface differs more from the popular mouse interface than the mouse differs from the keyboard. As advanced as these new computers are, they are only the precursors of a whole new generation of computers. What might a future stylus computer look like?

As the size of the display area is increased to the size of an atlas, a truly portable computer of this type will take on greater significance in cartography. For purposes of discussion, let us refer to such an atlas-sized computer as the Superboard.

It would be flat and portable with a screen area of 42 cm by 30 cm (16.5 inches x 11.8 inches). The initial implementations may have only a black and white display because of video memory considerations. It is impossible to forecast when such a computer will be available. The initial stylus computers will be designed primarily for text applications and have a relatively small screen. The Superboard version described here might require another two to three years of development after the initial text-entry versions become successful. It may be that stylus computers will not become successful until they can

support more sophisticated computer graphics applications.

To cartography, the Superboard represents the medium beyond the microcomputer. The challenge cartographers will face is to use this new medium to its potential and not merely emulate paper methods, or even microcomputer methods, of map presentation. An example of it's potential would be the implementation of a 'cartographic zoom.' Here, the information content of the map would change as the scale is changed. With the type of zoom, more features are added and the lines become more detailed on the zoomed-in, larger scale map. Icons of a magnifying glass with plus and minus symbols could be selected to control the zoom-in and zoom-out functions.

The Superboard could also be used to interactively select the features that are displayed on a map. For example, a series of buttons could be used to control which features are visible. Clicking on a button would display the indicated features. This method of map display would greatly affect map design. It would reduce the amount of generalization of individual features since not all categories would be displayed at once, as is necessary with maps on paper.

The stylus computer presents cartographers with a special challenge. The computers will require a high degree of user interaction with the map. As Muehrcke (1990, p. 13) states: "We must be willing to challenge all design assumptions associated with printed maps if we are to optimize the design of the new interactive map form." This will be especially true if stylus computers are to be effectively incorporated for map use.

II. The Interactive / Animated Map

Consider for a moment how you answer the following questions: Do the states of New Hampshire and Vermont have similar shapes? What is the location of Atlanta within the

state of Georgia? Which states border the Mississippi river? For people familiar with the United States, the mere mention of these places leads to the formation of a mental map. The human mind seems to be extremely active in acquiring, manipulating and displaying mental images in the form of maps. Research in cognitive psychology has shown that these mental images are a functional part of human thought.

A zooming process may also accompany the experience of mental mapping. The mention of a city such as Los Angeles, for example, might result first in a mental map that locates Los Angeles within the United States, then within the state of California and ultimately within the southern part of the state. This mental zooming indicates that the human mind can visualize not only static mental maps but also dynamic mental map *animations*.

Limited to the static medium of paper, cartographers have been unable to properly engage the mental imaging abilities of the human mind. A map form is needed that more closely approximates the dynamic nature of mental maps. Combined with an appropriate user interface, the computer represents such a dynamic medium.

The Interactive Map

The interactive map is a computer-assisted form of map presentation that attempts to imitate the display of mental maps in the mind. It goes beyond the mental display of maps by presenting a more vivid and accurate display. The maps include more features and do not exhibit the distortions and biases of mental maps. The interactive map is characterized by an intuitive user interface consisting of graphical icons and a pointing device, and the near instantaneous display of maps. The interactive map includes 'tools' to further zoom-in on the map or 'open-up' different areas and may include 'video-clips' of places with pictures

Types of Interaction

The Animated Map

Animation is a "graphic art that occurs in time" (see Baecker & Small 1990). It is a dynamic visual statement that evolves through movement or change in the display. The most important aspect of animation is that it depicts something that would not be evident if the frames were viewed individually. In a sense, what happens between each frame is more important than what exists on each frame.

Animation as an Exploratory Tool

What is Animation?

In practical terms, animation is creating the illusion of change by rapidly displaying a series of single frames, as with film or video (Roncarelli 1988). A common example would be the movement of a cartoon character. Movement can also be interpreted as the change in the perspective of the observer as the figure remains still.

Temporal vs. Non-Temporal

Non-Temporal Types

III. Cartography's Frontier

Maps have served an important role in the opening of frontiers. Early explorers charted new territory on maps. Settlers relied on maps for the division of land. The role of maps in the exploration of the unknown is still evident in the search for resources. Maps are created to determine the possible locations of needed resources such as oil. The map will always be an important tool of science and exploration.

Cartography now faces its own frontier. The frontier is a new medium; a medium that goes beyond paper and the individual, static map to one that presents a more dynamic view of the world. A medium that changes how space and place is conceived. This new medium compels us to approach maps differently. They exist for user interaction. It should be possible to 'go into a map,' to change what is presented and how it is depicted. Map use should be an active process that helps to visualize the world around us.

Animation helps to demonstrate that individual maps are only a snap-shot in time. One should ask: What was before? What will come after? What trends would be evident if the time element could be viewed as an animation? The individual map is a snap-shot not only in time but also in terms of the data. What non-temporal trends would be evident if a map were viewed along with other related data sets (e.g., age distribution in a city)? Finally, the individual map is a snap-shot in the choice of the representational forms that were used to depict the world. The use of different symbols or data classifications can also constitute an animation.

MEDIUM:

Each medium has its own sets of biases that alter and control the form of information it transmits. One of McLuhan's arguments was that anyone who wishes to receive a message embedded in a medium must first internalize the medium so it can be 'subtracted out' to leave the message behind (Kay 1990). Literate people have internalized the medium of print. How do we internalize the medium of the computer?

One answer may lie in the use of metaphors. The word metaphor is used here to

describe a correspondence between what the computer does and how we should think about what it is doing. A metaphor relates our understanding of the computer to something with which we are already familiar. The 'desk-top metaphor', for example, has become the standard way or interacting with the computer. This metaphor is actually composed of multiple metaphors including windows, folders, menus and the trash can. These metaphors help us to work with the computer.

What metaphors can we use in cartography? The implicit metaphor for interaction is a conversation. The metaphor for animation is film. How do we extend these metaphors? How can we make the creation of maps more like a conversation? If we approach the computer with the use of metaphors; an emulation of a non-computer activity, then the role of the computer is to refine and improve this activity, to extend it beyond what is possible without the computer. The way we refine and improve an activity performed by the computer and thereby internalize the medium is a function of the user interface.

The User Interface

Creating an interface to the map user has always been a central concern of the cartographer. This concern is based on the need for communication. The computer medium simply presents another element in the map-user interface.

The computer user interface is often simply thought of in terms of windows, pull-down menus and dialogs. Of course, these are only the surface elements. Viewed in these terms, the user interface is static. However, the user interface should be dynamic. It should adapt to the user and stimulate their interests.

In user interface design, much can be learned from computer games. The computer game market is highly competitive. If the interface to a game is confusing, the player simply abandons it. The user interface of a computer game must not only be functional and

easy to use, it must also be fun. The lessons to be learned from computer games are to (after Crawford 1990):

1) avoid the keyboard as the primary input device. Many games and some programs operate entirely without the use of a keyboard. There are, of course, some applications where the input of text is required. Even here, however, the keyboard is often overused. Generally, its use can be limited to the naming of files.

2) place greater reliance on graphics and sound. It is regrettable that programs for computer mapping rely so heavily on text. As with maps, graphics can express ideas directly. With text, communication is always indirect.

3) emphasize intensity of interaction. The user needs fast responses from the computer. A delay of even a second is enough to break the user's concentration. Game designers speak of an "interaction circuit" in which the user and computer are in continuous communication. The user may opt to break the circuit but the computer cannot.

4) increase the level of complexity seamlessly. The central problem in computer games is to smoothly move to increasing levels of complexity. Complexity is introduced by expanding the "vocabulary" of interaction. The "vocabulary" refers to the possible forms of interaction with the program. Expanding the possible forms of interaction clearly demonstates that the user interface can be dynamic. It also shows that the user interface can constitute a learning environment.

Map as Abstraction

Creativity

Creativity is usually associated with the arts, not the sciences. However, it has a role in both. Creativity is needed when something is approached for the first time and there are few guidelines to follow. This is certainly the case with cartography and the new medium.

In a book entitled *A Kick in the Seat of the Pants*, von Oech (1986) describes a method of thought provocation through role playing. He points out that we are often blinded by our own short-sighted view and tend to defend this view at all costs. He argues that role playing can be both creative and liberating. von Oech describes four characters that are a part of each of us to varying degrees and can be used on a problem to different degrees:

1) the Explorer - this person gathers information. Activities include reading, asking others about their views and deciding which issues need additional work or definition.

2) the Artist - this character generates new ideas. The most energetic and active; potential solutions and new problems are defined.

3) the Judge - this character evaluates and filters the ideas that have been

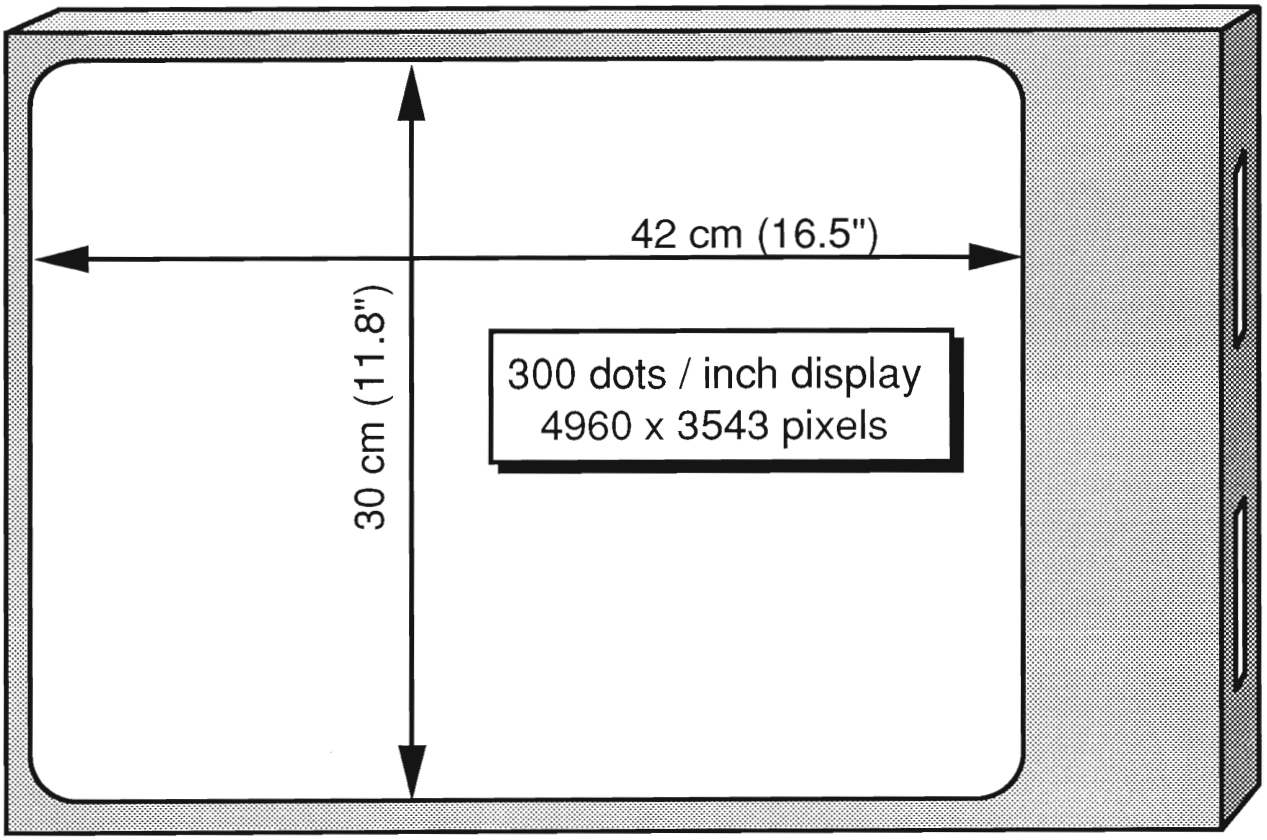
generated. Some ideas are discarded. If the Judge has control in the beginning of the brainstorming process, creativity is short-circuited and new ideas do not emerge.

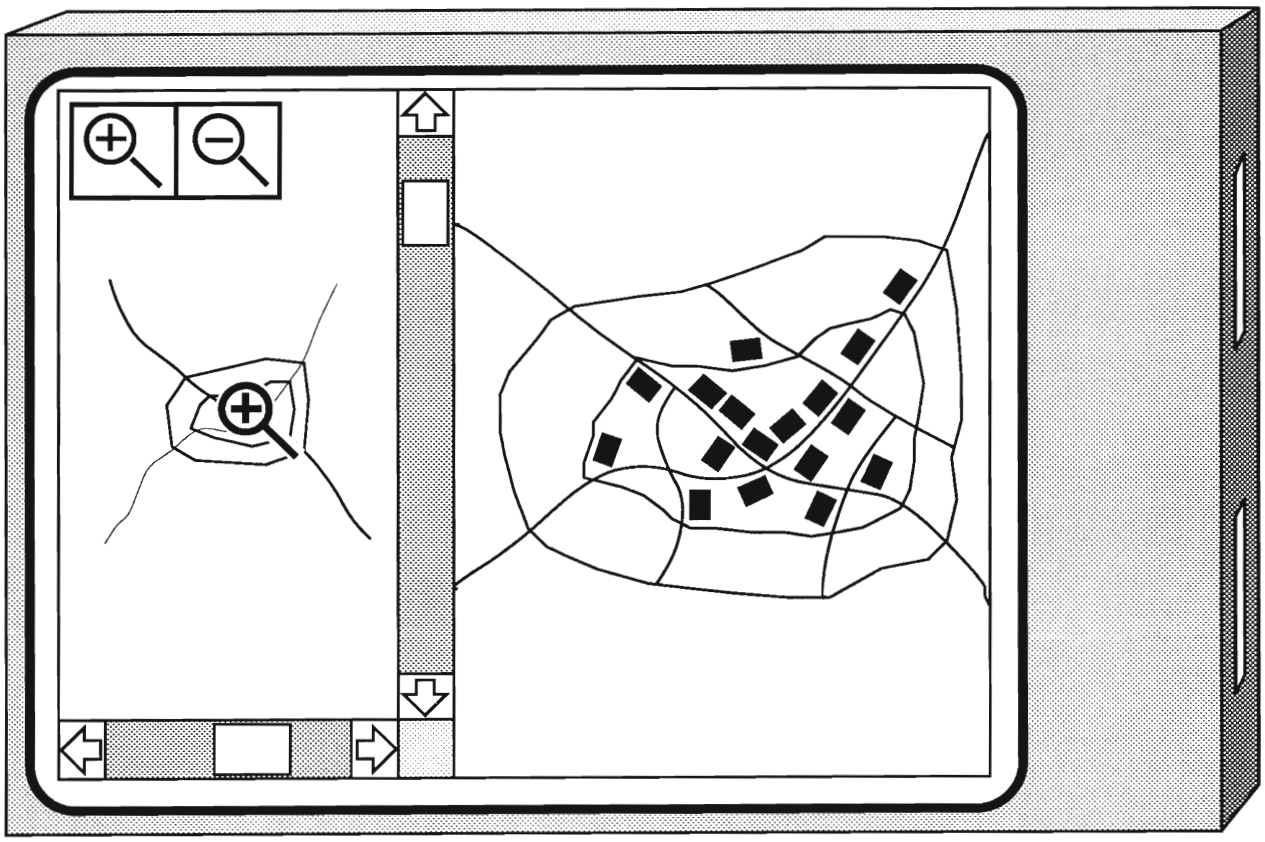
4) the Warrior - this character champions a particular idea and sets the course for the next round of problem-solving. This includes planning how the idea will be tested, evaluated and developed.

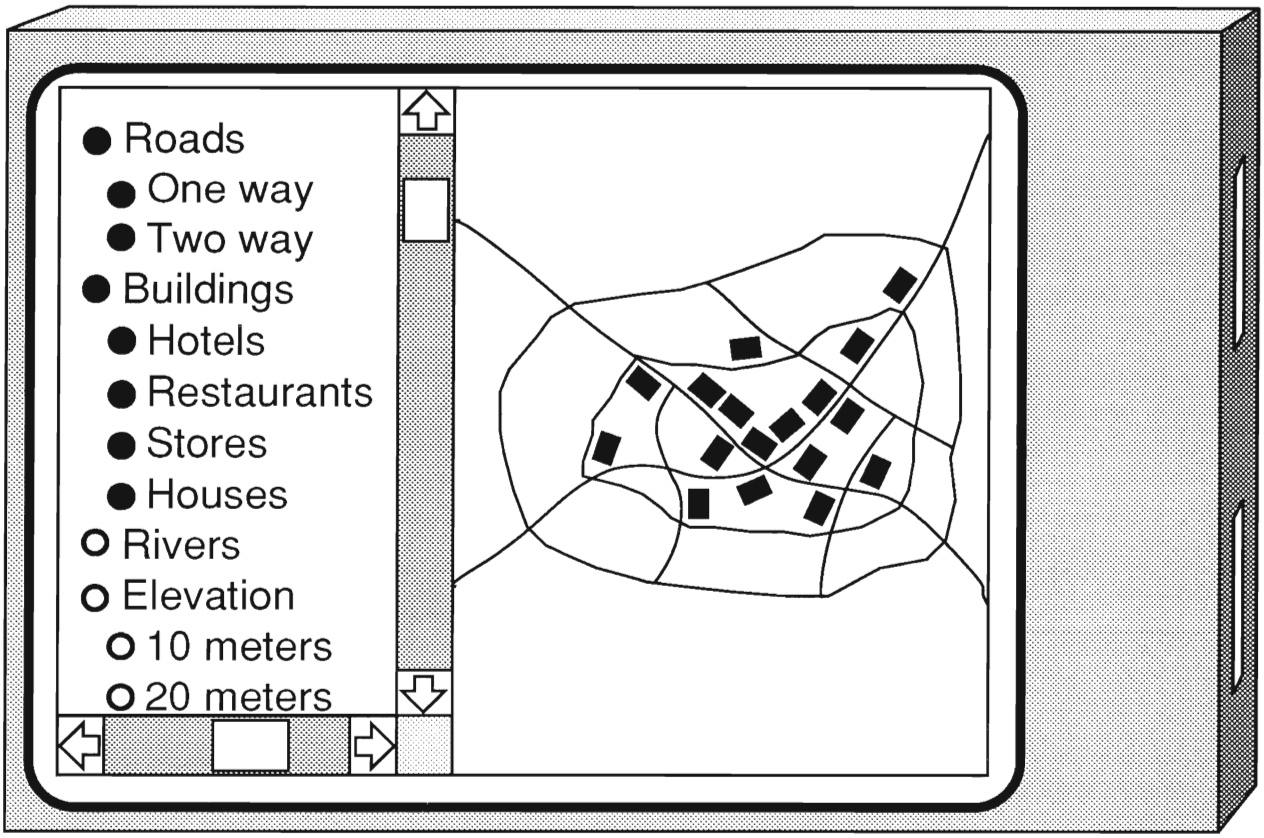
The Personal Frontier

The frontier is the boundary between the known and the unknown. As each of us comes to know the spatial world we live in, we push back the boundary of our own personal frontier. We do so by learning the streets of a city or the hills and valleys of a surrounding countryside. So it is too with the world beyond our own personal experience. Here, we use maps to push back the frontier – to find out where things are and how things are related to each other. While we succeed in pushing back the frontier, it is always out there. There is always a point in our understanding of the world where the known ends and the unknown begins.

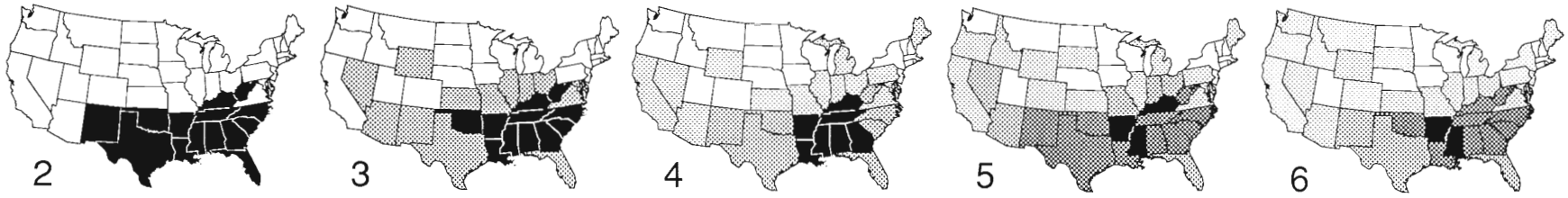
Every one of us is faced with our personal frontier. The movements we make in our immediate surroundings and the thoughts we have about the larger world are limited by this boundary. We all exist up to the boundaries of own frontier. Maps can help us move beyond these boundaries. They can provide information expand the boundaries of our own personal frontier. This is both the purpose and the promise of an interactive and animated cartography.


42 cm (16.5")
30 cm (11.8")
300 dots / inch display
4960 x 3543 pixels

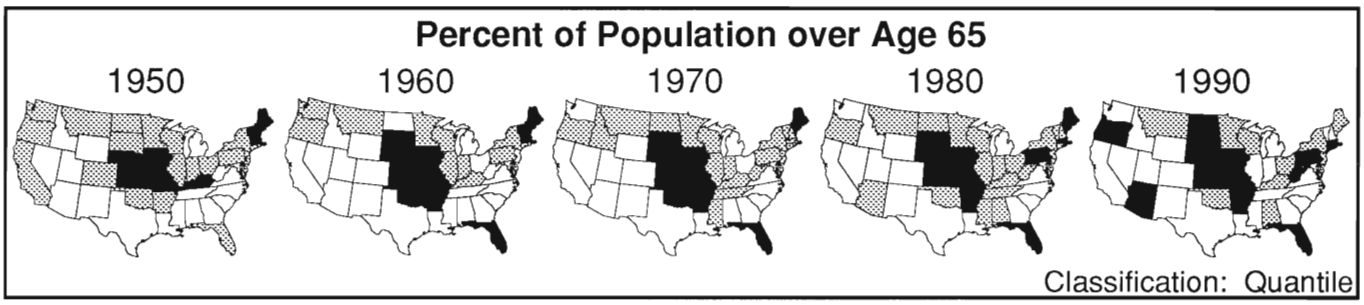



● Roads
● One way
● Two way
● Buildings
● Hotels
● Restaurants
● Stores
● Houses
○ Rivers
○ Elevation
○ 10 meters
○ 20 meters

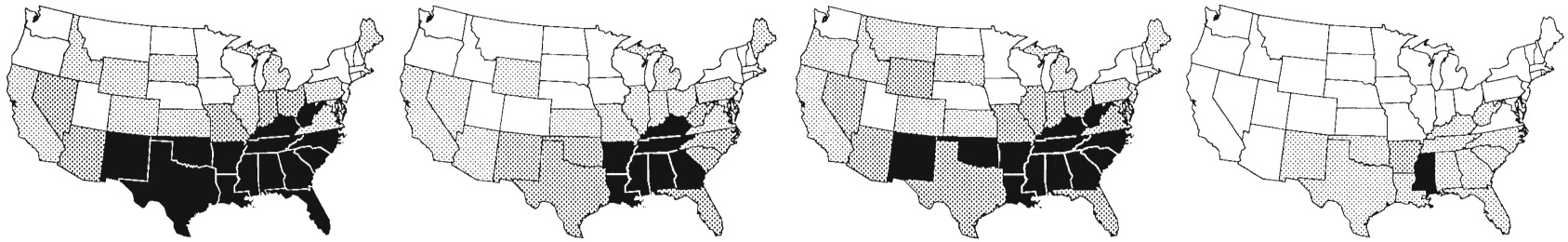
Births to Mothers under Age 20



Classification: Equal Interval

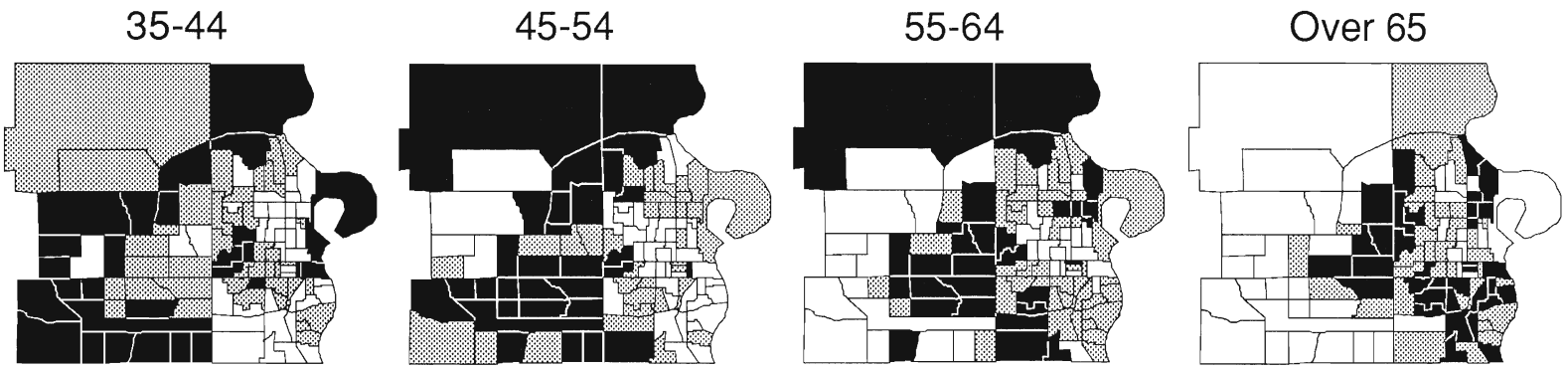

Percent of Population over Age 65
1950
1960
1970
1980
1990
Classification: Quantile

Births to Mothers under Age 20

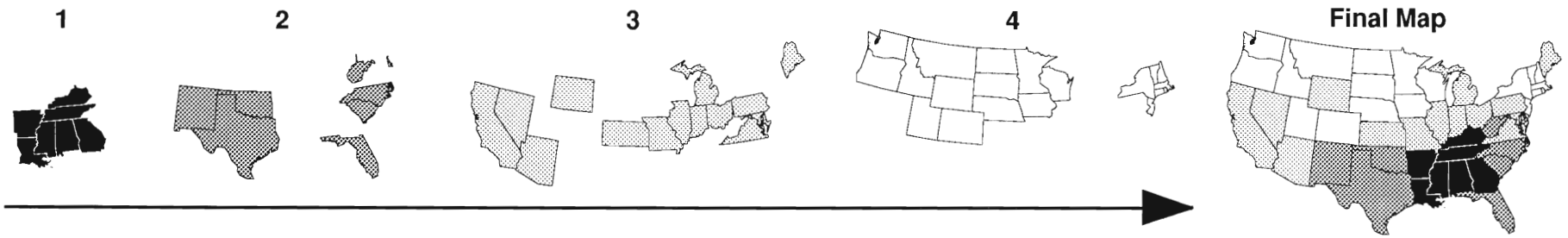


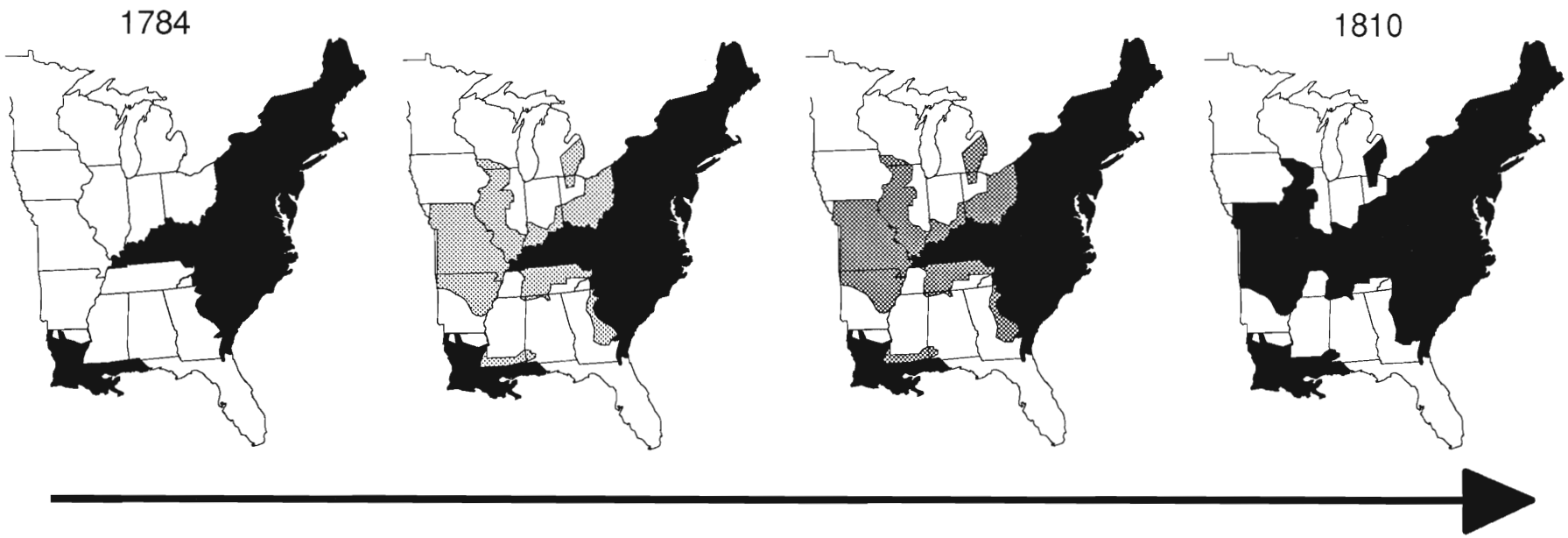
Standard Deviation | Equal Interval | Quantile | Natural Breaks

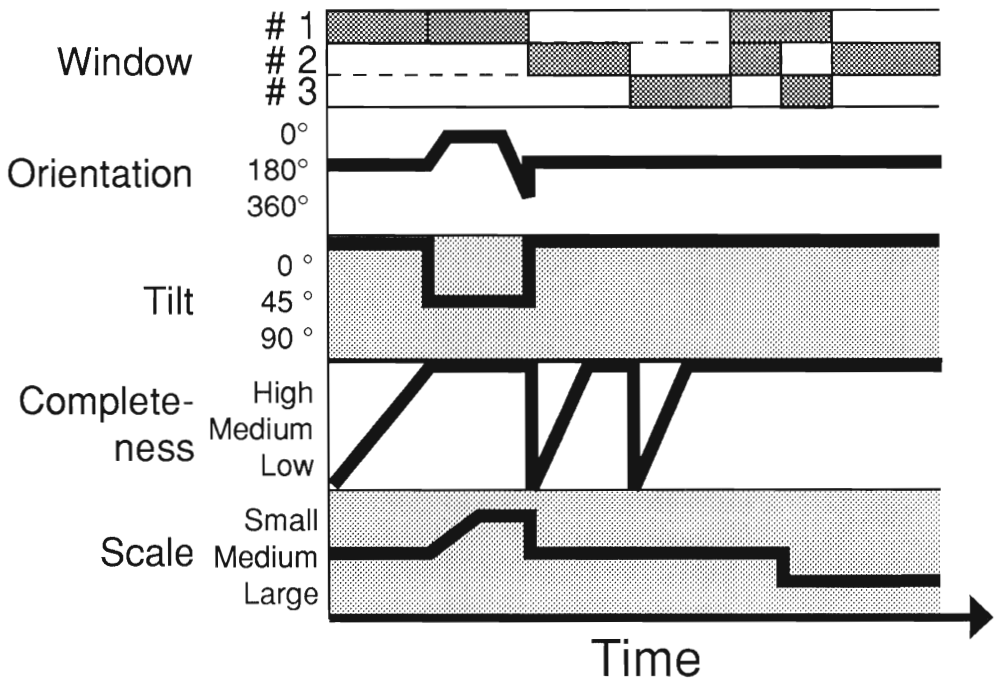
Omaha, Nebraska: Percent of Population by Age Groups



Classification: Standard Deviation


1
2
3
4
Final Map


1784
1810


Window
1
2
3
Orientation
0°
180°
360°
Tilt
0 °
45 °
90 °
Complete-
ness
High
Medium
Low
Scale
Small
Medium
Large
Time