Appears in C*artographic Perspectives*, Issue 44 (Winter 2003): 63-65.

Tips for Designing Effective Animated Maps

Mark Harrower
Department of Geography
University of Wisconsin–Madison
550 North Park Street
Madison, WI 53706
e-mail: maharrower@wisc.edu
web: www.geography.wisc.edu/~harrower/

Introduction

For mapmakers, animating maps presents an amplified cartographic challenge. Because animated maps are difficult and expensive to make—even with today's powerful software and computers—a designer will want to be reasonably confident that their efforts will pay off with a map that is both attractive and informative. There is no shortage of poorly conceived and clumsily executed maps with animated content to be found these days, and many such examples seem made for no other reason than "they look cool" (Campbell and Egbert 1990). In the spirit of Edward Tufte, it is always worth asking *why do I need to animate these data?* Does the animation lend something to the representation that would be difficult or impossible to convey in static form? If the answer is yes, than the added expense and time of creating an animated map may well be justified. Cartographers who want to use animation to make a better map must know the strengths and limitations of animation as a tool, and how map-readers are likely to be impacted by animation.

This article presents suggestions for creating effective animated maps derived from my experiences both as a user and as a creator of animated maps, as well as insights from formal user-testing over the past few years. Below, I offer some solutions to the four major challenges identified by Morrison (2000) with watching and learning from animated graphics: *disappearance, attention, confidence*, and *complexity*.

Challenge #1: Disappearance

By their very nature animated maps change, often quite dramatically from moment to moment. As a result, there is always the potential that the map-reader will miss important information or cues. Because of *disappearance* (i.e., blink and you miss it), many basic map reading tasks can be very difficult, such as: estimating the size of symbols or areas, matching colors to a legend, comparing one symbol to another, or reading text labels. As MacEachren (1995) notes, due to perceptual power of motion we should expect a decrease in the ability of map-readers to notice differences in non-dynamic visual variables on animated maps. As a result, the individual frames of the animation should be relatively simple since small details are unlikely to be noticed. This is true of both the base map and the thematic data. In many cases, a simple base map with a few data classes or features can be highly effective and dramatic. Extra information only competes for the readers' attention and may increase the chances of missing important cues or events.

Solutions to the problem of *disappearance* include letting the viewer (1) watch the animation multiple times (looping), (2) stop the animation and proceed frame-by-frame, and (3) adjust the frame-rate or speed of the animation (see Figure 1). Testing has shown that map-readers become frustrated with maps they cannot control (Monmonier and Gluck 1994, Koussoulakou and Kraak 1992). More complex solutions include the use of "decay" images where important features linger in the image. For example, a proportional symbol map showing earthquake events over the last 100 years may need to exaggerate the length of each earthquake event (let the symbol fade slowly). In other words, the event is not drawn to its correct temporal scale because a 2-minute event in a 100-year animation would be missed if not exaggerated in time. Temporal exaggeration is analogous to spatial exaggeration on static maps (e.g., exaggerated highway widths on road maps).

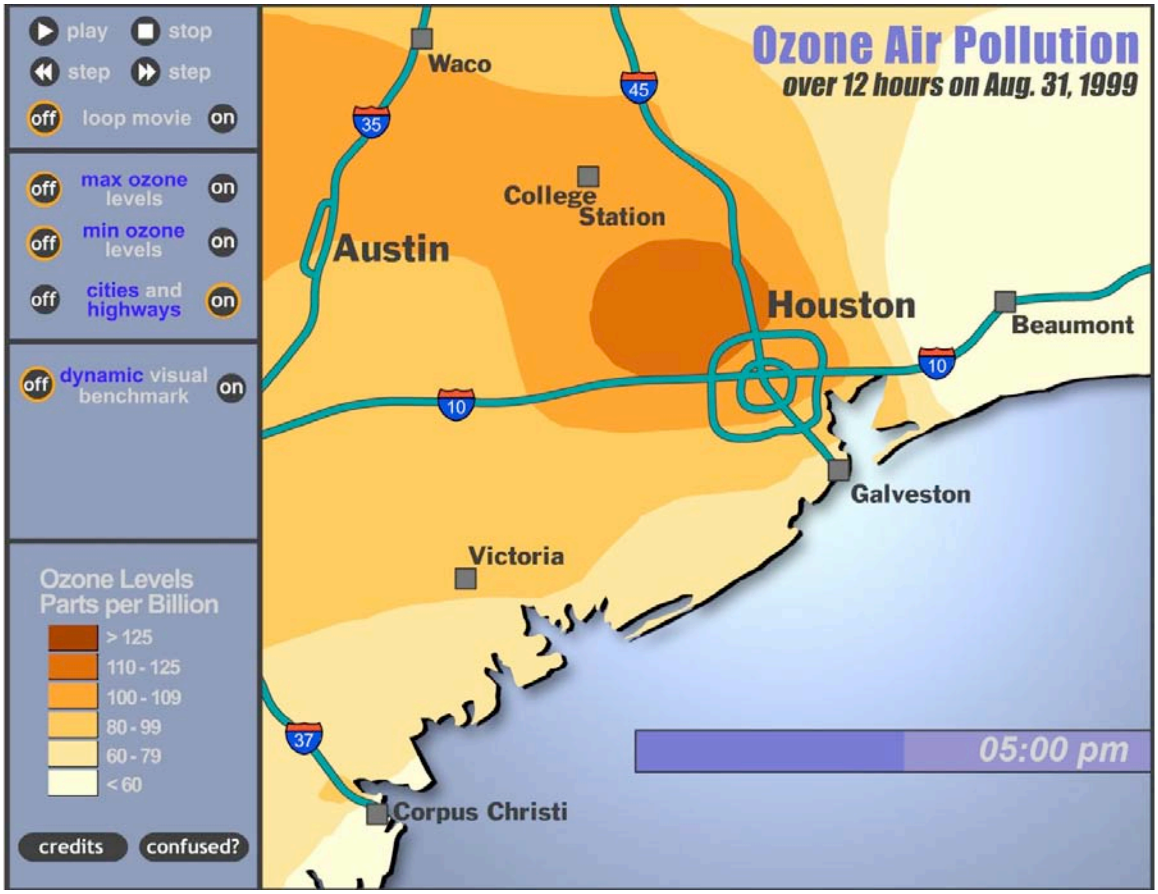

Figure 1: Minimize the footprint of the interface and devote as much of your limited screen real estate to the map itself. Do not hide important interface controls (a common mistake) as most people will not try to find them, thinking, what they see is what they get. Standard VCR-style controls (stop, start, etc) are widely understood, and should normally be included since testing has shown users are frustrated by, and perform poorly with, maps they cannot control.

Challenge #2: Attention

The problem of where to look as the animation plays (i.e., attention) is a related to disappearance. I have seen that many map-readers who have limited experience with animated maps do not know *where to look* (a problem with the map) or *what to do* (a problem with the interface). All other things being equal, the less intrusive and demanding the interface, the more time the user can spend looking at the content.

"Sequencing" is one strategy that has proven successful with learning from animated maps (Slocum et al. 1990, Patton and Cammack 1996). By depicting the information in a logic and pre-defined sequence, the cartographer can increase the likelihood that the reader will notice important features or events in the animation. Voice-overs and sound prompts can also be effective in directing the readers' attention. Another strategy is to employ dynamic map symbols at critical moments. For example, flashing or moving symbols are more obvious and ascend the visual hierarchy. Monmonier (1992) was one of the early proponents this strategy. For example, in his Atlas Touring maps individual enumeration units and their corresponding bar chart graphic would blink for a few seconds to focus the users' attention (Figure 2). Testing has shown, however, that excessive use of such "attention grabbing" symbols can be annoying and virtually impossible to ignore —hence the abundance of blinking symbols on Web advertisements! (Monmonier and Gluck 1994, Harrower et al. 2000).

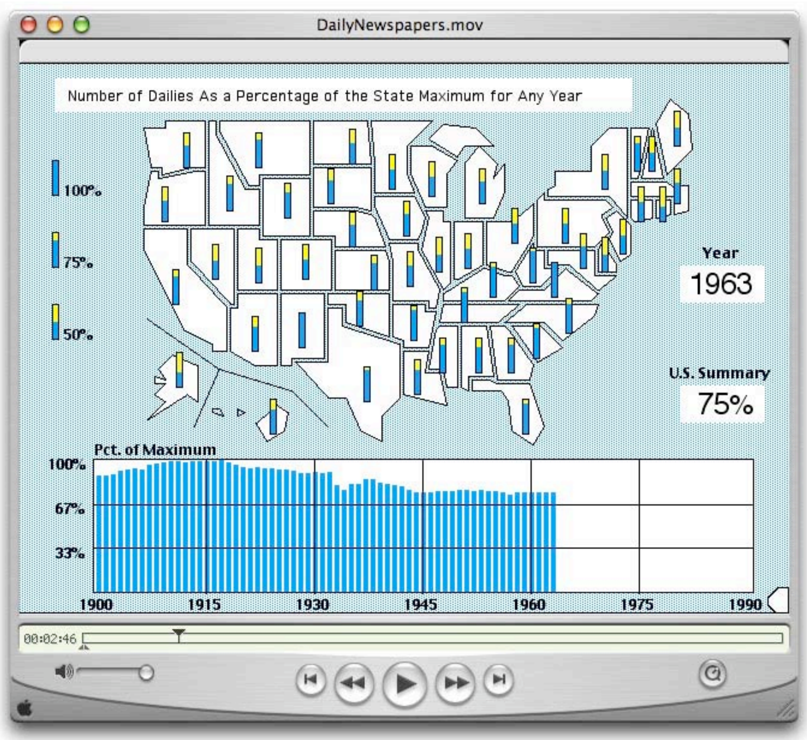

Figure 2: Pioneering work in map animation by Monmonier over a decade ago showed how the user's attention can be directed through complex data presentations with the use of flashing and sequencing.

Challenge #3: Complexity

Many animated maps try to do too much and end up saying very little. Burdening the user with more information than they can process in real-time undermines the map's design and may confuse or mislead the reader. Effective animated maps are often highly generalized so that only the most important trends or feature emerge. This may take the form of *data filtering* (e.g., presenting only a subset of the data), *data smoothing* (e.g., running average to reduce the variability), or *aggregating the data* into two or three classes. For example, consider using categorical data legends. A legend that depicts "High", "Medium", and "Low" is very easy to understand and colors for those classes should be easy to remember so that the user does not have to divide their attention between the map and the legend. The numerical details of those classes can be given later once the larger patterns have been noticed (e.g., by directly clicking on a symbol/color to retrieve specific rates).

Acevedo and Masuoka (1997) employed a highly simplified and highly interpolated representation of urban growth in Washington, DC (Figure 3). Although this growth process is complex, their map is successful because the data are generalized, they used hundreds of individual frames so that the amount of change between frames is small, and the maps have been greatly smoothed. Their animated map consisted of only two classes—urban and non-urban—in order to more clearly show the rapid (and non-linear) urban growth rates of the last 200 years. No attempt is made to characterize differences within the urban class (e.g., retail, residential, industrial). By not depicting changes *within* the city, the reader is free to focus on the relationship *between* the city and the surrounding county and the shape of the urban expansion.

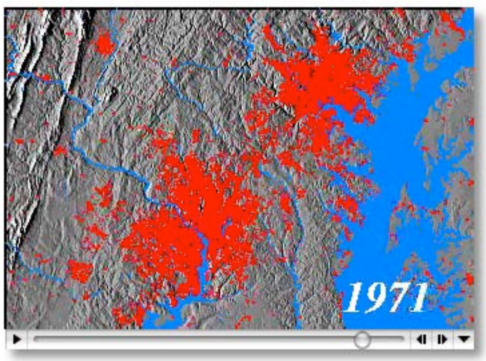

Figure 3: A highly smoothed and generalized image of urban growth, from a popular animation by Acevedo and Masuoka.

Letting users turn data on and off can help reduce information overload. Changing the tempo of the animation can also help by allowing users to slow down the map during complex periods of change, or speed it up to “blur-out” noise and insignificant events. Giving users the ability to change the tempo of an animation (i.e., change the temporal scale of the map) is analogous to zooming and panning on static maps (i.e., change the spatial scale of the map).

It is my contention that animated maps are better suited to depicting geographic *patterns* (and changes in those patterns) rather than specific *rates*. If retrieval of exact rates is important, provide the numbers (i.e., data) in some other form such as a spreadsheet. With interactive maps, there is no need to burden the reader with trying to rapidly extract specific rates from generalized symbols (a weakness of most thematic maps): have that information appear on demand, when it is needed. One of the cornerstones of today's geographic visualization systems is the use of multiple linked representations—such as a planmetric map, parallel coordinate plot, and 3D block diagram—that each cater to different knowledge construction tasks. Similarly, by using complementary data portrayals, such as histograms or charts that are labeled with the specific rates/values, we may be able to increase either the amount or kinds of information the user can process compared to a solo animated map.

Challenge #4: Confidence

Evidence exists that users, especially children, are less confident of the knowledge they acquire from animation than from static graphics (see Rieber and Parmley 1995, and Morrison 2000). Since people have far more experience visually interpreting static graphics than animated graphics, it is not surprising that without equivalent experience and training, people are less confident with animation.

A strategy that can increase user confidence is to provide a short (e.g., less than 30 seconds) guided introduction to the interface before showing the data, thus breaking the learning curve in two: first learn what the map can do (the tool), then apply that knowledge to learn about the map (the data). Since most animated maps are not meant to be full-fledged GIS viewers, they need significantly simpler interfaces that become transparent to the user as quickly as possible. Otherwise, the user may abandon the map because they become intimidated by the interface not because they were incapable of understanding the map.

In order to make it possible to add animation to a map and make it possible for a broad audience to successfully interpret the map, the basic cartography must become highly focused and quickly readable. While this is the same general guidance that would be given to mapmakers who want to convert a map that was originally intended for paper to be used on a computer screen, the degree that guidance must be followed is considerably higher for animated maps since both the computer medium (at 72-96 dpi) and the ever-changing images limit your design choices. For example, use larger text than you would on paper maps (at least 10 pt), brighter colors, thicker line weights, and less detailed base maps. What you loose due to the display limitations of the medium, you can make-up through interactivity, linked displays, live data delivery, and multimedia possibilities. Digital and Web cartography fail when we try to reproduce paper maps on-screen. New media demand new graphic techniques.

Thinking of the User: "Effort-to-Reward Ratio"

As a rule of thumb, strive to have the time it takes to learn how to use the map be less time than it takes to play the map. This is the *effort-to-reward ratio*: the designer's job is to maximize it. Tapping into existing popular interface metaphors (e.g., pull-down menus) and cartographic techniques (e.g., dark-equals-more color schemes) can accelerate the learning process. One of the best methods for improving your map is to formally test it with potential users (e.g., not other programmers, but members of your target audience). Watch them as they use your maps—often a humbling experience—and ask them questions about both the interface and the map. Discover what is causing them trouble, and never hesitate to incorporate their suggestions. I have come to appreciate how important testing is in the development cycle of dynamic maps.

Acknowledgements

I would like to thank Charlie Frye at ESRI and the director of the NACIS Student Web Mapping Contest for encouraging me to write this, for his skillful eye as an editor, and for helping to generate many of the ideas presented here.

References

Acevedo, W. and P. Masuoka (1997). Time-series animation techniques for visualizing urban growth. *Computers & Geosciences* 23(4): 423-436.

Campbell, C. S. and S. L. Egbert (1990). Animated cartography: Thirty years of scratching the surface. *Cartographica* 27(2): 24-46.

Harrower, M., A. M. MacEachren, and A. Griffin (2000). Developing a Geographic Visualization Tool to Support Earth Science Learning. *Cartography and Geographic Information Science* 27(4): 279-293.

Koussoulakou, A. and M.-J. Kraak (1992). Spatiotemporal maps and cartographic communication. *Cartographic Journal* 29(2): 101-108.

MacEachren, A. M. (1995). *How Maps Work: Representation, Visualization and Design*. New York: Guilford Press.

Monmonier, M. (1992). Authoring Graphics Scripts: Experiences and Principles. *Cartography and Geographic Information Systems* 19(4): 247-260.

Monmonier, M. and M. Gluck (1994). Focus groups for design improvement in dynamic cartography. *Cartography and Geographic Information Systems* 21(1): 37-47.

Morrison, J. B. (2000). *Does animation facilitate learning? An evaluation of the congruence and equivalence hypotheses*. Doctoral Dissertation, Department of Psychology, Stanford University. 161 pp.

Patton, D. K. and R. G. Cammack (1996). An examination of the effects of task type and map complexity on sequenced and static choropleth maps. In Wood and Keller (Eds.) *Cartographic Design: Theoretical and Practical Perspectives*. New York: John Wiley and Sons. p. 237-252.

Rieber, L. P. and M. W. Parmley (1995). To teach of not to teach? Comparing the use of computer-based simulations in deductive versus inductive approaches to learning with adults in science. *Journal of Educational Computing Research* 13: 359-374.

Slocum, T. A., S. H. Robeson, and S. L. Egbert (1990). Traditional versus sequenced choropleth maps: An experimental investigation. *Cartographica* 27(1): 67-88.