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The potential of computer animation has been realized in many different disciplines. Animation is also a powerful visualization tool for cartography; however, it has been neglected until recently. This paper portrays the need for animation in cartography in the light of the new approaches and methods in the sciences as well as in society. It discusses two main reasons for the lack of animation in cartography: the fixation on the printed map and the absence of a comprehensive approach to cartographic animation. Finally, a variety of issues for further research are proposed.

Computer animation has become an important visualization tool in recent years. Improvements in computer hardware and software have made the widespread use of computer animation possible. The potential of computer animation has already been realized by different disciplines, for example the film industry, architecture, fashion design and the sciences.

Computer animation also has many potential uses in cartography. It allows the creation of map sequences that can show spatial information dynamically. Animated map sequences can depict time directly as a cartographic variable, they can depict information mapped in different ways; and they can present the map objects in a particular sequence. But do we really need this sort of information display? Can animation really show more than the presentation forms we already have, or is animation only a toy for cartographers? To answer this, we need to examine the modern approaches and methods in the sciences as well as in society.

Spatial science has changed from the analysis of static states to the study of processes. Researchers are no longer interested in studying only static situations; they are more concerned with changes and forces that induce or cause different states. Maps are an important tool for spatial scientists. The static map, however, is not able to show processes directly. Of course, cartographers have developed different methods for depicting changes, but all of these methods reduce the dynamic aspects of reality to static states that can hardly show the changes that take place. Cartographic animation can do more by making the dynamic aspect of spatial changes visible to the map user. Processes become more transparent using animation for their visualization.

Spatial science has also been influenced by system theory. Scientific investigations are no longer concerned only with isolated phenomena; they examine particularly the relationships and correlations of different phenomena. Scientists need a representation form that can show all the correlations. Static maps are not the best presentation form for displaying these relationships. Often, maps are overloaded with information layers to show the many correlations. In an animated map sequence, map elements can be presented in different orders and combinations to make the spatial relationships more apparent. The map user can be directed through the presented subject, and the correlations can be brought to the user's attention.

In the late 1980s, the sciences discovered scientific visualization. It is used for data analysis to see patterns that either answer questions or that pose new and unexpected questions. Scientific visualization requires computer animation, especially interactive animation, that can show the

## Cartographic Animation: Potential and Research Issues

*Doris Karl*

THE NEED FOR ANIMATION  
IN CARTOGRAPHY

*Doris Karl is a student at the  
Freie Universität Berlin,  
Fachrichtung Kartographie  
Arno-Holz-Str.12, D-1000  
Berlin 41*

data set in many different ways. The static map does not have this flexibility in information display; it can show information only in one way, so it is not a suitable instrument.

Finally, one should look at the map users of the future — the children of today. This young generation is often called “the video generation” because it has grown up with video and computer games. These children are more accustomed to the computer than most adults; the interactivity and dynamic aspects of computer games are a matter of course for them. At some schools computers with interactive and dynamic programs are used as a didactic device to rouse the students’ interest. In this respect, cartographers have to ask if the traditional static map will be a good communication medium for these future map users or whether we should look for alternative forms. Animated map sequences that can be controlled interactively are an alternative.

It seems that cartographic animation is more than a nice toy and should be viewed as a powerful visualization tool for cartography that transcends the potential of the printed map. In spite of this potential, computer animation has been neglected in cartography until recently. Two main reasons for the absence of animation in cartography will be discussed in the following two sections. The first and most important reason is the fixation on the paper map; the second, resulting from the first, is the absence of a complete and systematic approach to cartographic animation.

#### THE EMPHASIS ON THE TRADITIONAL PRINTED MAP-- AN OBSTACLE TO CARTO- GRAPHIC ANIMATION

The traditional printed map is regarded by cartographers as an excellent form of presentation. It is considered to be a product that has attained near perfection in a long evolutionary process. Many representational methods and techniques have been developed for topographic and thematic maps which, in general, enable the creation of good maps. Also, the map user is accustomed to the printed map and presumably he wants to have a “real” map, a paper map. Thus, one can say that the traditional printed map is a standard for both the mapmaker and the map user. New techniques and methods, such as the use of computers in cartography, are always compared with and measured against the printed map and evaluated accordingly. This is perhaps especially true in Europe as Gillessen (1986, p.53), a German cartographer, states:

“The excellence of maps produced in Central Europe places high quality demands on alternative mapping solutions and is therewith a standard of quality for all new developments in cartography. [...] One would go so far as to say that the high standard of cartography in Central Europe has hampered the development and the willingness to accept the products of any new technology [...] in cartography.”

This quote illustrates the extent of the fixation on the printed map. As a result of this thinking, other and perhaps better information displays are overlooked and the standard map is not placed in question.

If one asks why the traditional map is used as the standard, many arguments are listed in its favor:

- traditional maps are thought to be more attractive than computer generated maps;
- text, line and other symbols are thought to be more “alive” on a traditional map and not as artificial or synthetic in appearance;
- it attracts the eye and keeps the map user’s attention.

All these arguments are based on the aesthetic impression of a map. The exterior appearance is a very important criterion in its evaluation. The importance of beauty in a map can also be found in a common definition of cartography as the art and science of map making. But, can the aesthetic value of a map continue to be one of the most important

criteria for judging the quality of a map? Maps are the carriers of information in the process of communication and should they not be evaluated in this light as well? So the question to ask is whether the traditional map is really the best presentation form.

The use of computers in cartography offers new forms of information display. However, because we are still fixated on the traditional map, we overlook this potential and use the computers predominantly to mimic manual methods.

If one looks more closely at the application of computers in cartography, one sees that they have been extensively used to shorten time and work intensive tasks. Data processing and drafting have been automated and interactive computer systems now facilitate the map design process. Languages like Postscript allow the direct transfer of maps between the display and the image setter. The main efforts have been directed in making computer-created maps as good as the traditional map.

The fixation on the printed map within computer cartography can be further demonstrated with regard to the German ATKIS project (Authorized Topographic Cartographic Information System) that will contain the data of the topographic maps of Germany in digital form. The purpose of ATKIS is to make possible the digital production of topographic maps that can be updated quickly and easily, and the creation of special purpose maps of single topics. The maps that are generated from ATKIS are the traditional paper maps. New forms of information display are not a goal of ATKIS. Harbeck (1989, p.98), one of the designers of ATKIS, states in this context:

"Without doubt at the end of the digital topographic information system there is the cartographic output — the map. Whether this product is on the computer display or a printed map depends on the user. But surely it can be stated that the color printed map will continue to have its importance — perhaps even gain in importance as a commodity."

The fixation on the traditional map and on paper as the primary output medium is strongly present within cartography. If we do not overcome this fixation, we may ignore new forms of information display and we may not realize their potential.

As a result of the fixation on the printed map, other forms of information display have been overlooked and too little research has been done in this area. This is true for cartographic animation.

The potential of animation for cartography was initially described by Thrower (1961) and by Cornwell and Robinson (1966). Nevertheless, only a small amount of work has been done in this field. In the 1970s, when computer animation became available, individual cartographers used animation predominantly to show spatial changes over time. The efforts were focused on producing animated map sequences for special issues like the growth of a city (Tobler 1970), traffic accidents (Moellering 1976), population growth in urban regions (Rase 1974) and animation of three dimensional objects (Moellering 1980). Most of the 1980s saw no further work in cartographic animation. Not until the end of the 1980s was cartographic animation rediscovered when cartographers realized the potential of animation for the depiction and exploration of spatial and statistical relationships and patterns. Some authors again called attention to the potential of cartographic animation (Campbell and Egbert 1990), and a few new animation techniques were suggested for the analysis of spatio-temporal data (Monmonier 1989 and 1990) and the study of geoscientific processes (DiBiase et. al. 1991). In

THE ABSENCE OF A COMPREHENSIVE APPROACH IN CARTOGRAPHIC ANIMATION— ANOTHER OBSTACLE

addition, a program for animating choropleth maps was created (MacChoro II 1989).

All these works employed the application of cartographic animation. Most of them exclusively deal with the realization of an animated map sequence for one special issue. Only the later works pick up a more common and extensive attempt at the cartographic application of animation.

These are important contributions, but they are individual solutions to individual problems. A comprehensive and systematic approach to the use of animation in cartography does not exist. Many essential issues have not been examined. Therefore, basic knowledge about design, perception and production of animated map sequences is not available. There are no principles that tell cartographers how to make and design animated maps. Without extensive knowledge of the creation of animated maps, cartographic animation cannot be applied widely and efficiently; it can be used only sporadically because too many design issues will need to be worked out for each single application. If the influence of animation in cartography is to increase, we must expand our knowledge about cartographic animation and develop a comprehensive and systematic approach to it. This will require intensive research in different areas.

## REQUIRED RESEARCH

Future research in cartographic animation has to deal with a variety of questions. The following issues must be examined:

### **Definition of cartographic animation**

The absence of a systematic approach to cartographic animation becomes particularly evident when we arrive at the question: What is cartographic animation? There does not seem to be a consensus. Can animation be used only for map sequences that depict changes over time, or can it also be used for map sequences without a time element that show changes in the presentation form or create a map in a sequential form? Can animation be used only for complex map sequences created by a special animation technique, or is a simple "slide show" also an animation? What are the characteristics of animation and how can it be defined? This should be the first question to be examined.

### **Cartographic applications**

Most of the work in cartographic animation has been done in this area. However, the issue has not been handled in its entirety. Further work must investigate which other or new forms of animation are possible and whether they are useful. For this we have to examine different map types and their possibilities for cartographic animation. Perhaps we will find new forms of animated maps. A great deal of experimentation must be done within this issue.

### **Graphic design of animated maps**

Animated map sequences are different from the maps we ordinarily use. They are predominantly displayed on a CRT, are not static but dynamic, and are often shown very quickly. We must examine how such maps must be designed. Some research on the design of maps on the computer display already exists and we can also look to television to find some ideas about the layout of pictures and the use of color. The next question is: Must we consider the dynamic aspect of map sequences when we symbolize single maps? For example, how do we select different densities in an animated choropleth map sequence, or what about labeling isolines in an animated map? And finally, there is the aspect of map complexity. In an animated map sequence the user

will see a single map for only a short time, so the map cannot be too complex. But how complex can the map be? These issues must be tested.

### **Legend design**

Animated map sequences are different than static maps, therefore, the legend, the explanation of a map, should be different in an animated map. How must it be designed? Multimedia offer the possibility to combine animation with sound. Therefore, the legend can be an audio explanation. But is an audio explanation sufficient for the complete understanding of the animation, or must it be completed by a visual legend? If we need a graphical legend, we have to think about the design. Surely, it would have to be a dynamic legend; however, it also must be readable for the user.

### **Speed of animated sequences**

We know that in computer animation 20-25 pictures per second are required for the perception of a continuous movement or change. But we do not know how fast an animated sequence created for the depiction of relationships must be, so that the user can recognize the objects and relationships of the map sequence. This is a problem especially for animation on video because the sequences cannot be controlled by the user and the speed cannot be changed.

### **Creation and control of an animated map sequence**

Cartographic animation will become a widespread visualization tool only if the creation of animated map sequences is not too difficult. A user interface that allows the user to produce animations easily has to be designed. For this, useful cartographic animation functions such as changing the view-point or moving an object must be defined and arranged in menus. With these various animation operations, the user has the potential to compose complex animation sequences. Ideas for this have been suggested by Monmonier (1989). A second and very important point is the interactivity of an animation. If animation is to be more than just a film, it must have the possibility of interaction. Animation systems should have the minimum ability to stop and restart the sequence and to change the speed. The animation for graphical exploration of a data set must have a variety of controlling functions. We have to think about the whole range of interactions that cartographic animation requires.

### **Animation techniques**

We also need more knowledge of the different animation techniques and for what types of animation they work best. Our experience in this area is limited because only a few cartographic animations have been realized. Gersmehl (1990) has examined this issue and describes nine animation metaphors and their use. Further work should expand this subject.

Cartographic animation requires a variety of research on design, creation, and use of animated map sequences. Because of the potential of animation for cartography, more attention to research is required in this field.

The potential of computer animation has already been realized by different disciplines. It can also be used for cartography as a powerful visualization tool that transcends the potential of the printed map. With animation, dynamic and interactive map sequences can be created that show changes over time or can be used to depict or explore spatial and statistical relationships.

## **CONCLUSION**

New approaches and methods in spatial sciences such as the strong emphasis on examining processes and correlations and the use of scientific visualization require a more dynamic and user-oriented form of information display that is not possible with the printed map. Also, the map users of the future, the children of today, who are more accustomed to interactive computers, will probably ask for more dynamic and interactive forms of information display.

In spite of the need for computer animation in cartography, it has been neglected until recently. There are two main reasons for this. The first is the fixation on the traditional printed map that is strongly present within cartography. As a result of this thinking, other and perhaps better forms of information display such as computer animation have been overlooked. The second reason is the absence of a comprehensive approach to cartographic animation. Because of the fixation on the traditional map, too little research has been done on cartographic animation. Only some research has dealt with the application of animation in cartography, and many essential issues have not been examined. Therefore, basic knowledge about design, perception and creation of animated map sequences is not available. If the potential for animation in cartography is to be realized, we need a comprehensive and systematic approach to cartographic animation. This will require intensive research focusing on the definition, application, design, creation and control of animated map sequences as well as on animation techniques and their uses.

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El potencial de animación por computadoras ha sido descubierto en muchas disciplinas diferentes. La animación es también un instrumento de visualización poderoso para la cartografía; sin embargo, hasta hace poco ésta ha sido descuidada. Este artículo describe la necesidad de la animación en la cartografía a raíz de los nuevos enfoques y métodos tanto en las ciencias como en la sociedad. Se discuten dos razones principales que causan la falta de animación en la cartografía: la fijación en el mapa impreso y la ausencia de un enfoque comprensivo hacia la animación cartográfica. Finalmente, se propone una variedad de temas para más investigación.

RESUMEN