MULTIVARIABLE "SEEING MAPS" THROUGH INTERACTIVE ANIMATIONS

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ABSTRACT

Over the last 5 years we have seen an increasing variety of small interactive map applications and animations on the Internet and World Wide Web. However, many of these maps, which are presented in electronic media, often reflect the paper map and do not utilize new possibilities. This paper is focused on the presentation geographic related information by communication on a global level. By using interactive animations, the map reader can adjust the presentation of the transmitted information in a way that suits each individual. The information is transmitted on an "individual level". The paper introduces some examples on simple interactive map animations where more than one phenomena are represented by variables. The interactive animations make it possible to both study the relation between different variables, and to emphasize a single variable for communication to the user on a global level.
Key words: Dynamic maps. Interactive maps. Visualization. Map animations.

1. INTRODUCTION

Today the Internet has become a very important source for distribution of information. A lot of the information that is distributed trough "the Web" (World Wide Web) has a spatial component, and much of this information can be presented in maps. Millions of maps are made on the fly an distributed trough the Internet every day. MapQuest, the world's biggest distributor of web-based maps, produces alone 20 million maps per day (according to their own web site). Maps generated as a result of a particular request by a client are usually adapted to a specific use. This may for example be a map that shows the shortest route between the user's home and a desired destination. These maps are often on the "private" part of the visualization cube in MacEachren (1994). Another group of web-based maps consists of ready prepared presentations where the map designer wants to communicate a certain message of broad public interest. However, in both cases it is necessary to use cartographic presentations that can be comprehended by wide and diversified groups of non-professional users.

Animation of maps have been discussed since the 1970's (Ormeling, 1995), and in the last decade numerous map animations for diverse purposes have been introduced. In the effort to make good maps in a computer-based environment, we need cartographic techniques that are developed for this purpose. At the same time the computer-based environment offers new possibilities that exceed methods of traditional cartography. As Peterson (1999) states: it is important to break loose from the paper-based thinking. However, both the cartography for static maps in a web environment, and the interactive map animations are in an early stage compared to traditional maps that have evolved over a long time. By looking at various maps in the web environment it becomes rather obvious that there still are a great potential for making better cartographic presentation on the web.

Many natural phenomena have a temporal component. Phenomena like weather or geological structures changes over time, of course following different time scales. Most of the existing map animations are focused on the visualization of how these and other phenomena are changing over time. In such presentations time itself is a important variable that has to be included as an easy perceivable component of the map. According to Bertin (1981) only one variable, in addition to the position, should be presented on a thematic map when the aim is to make a "seeing map", or in other words; keep the perception of the contents on a global level. Midtbø (2001) shows some methods for how the temporal variable may be visualized during the animations, while the map still communicates the information on a global level as a "seeing map".

This paper is also concentrated on the use of interactive animations for the presentation of more than one variable in addition to the position on the map. However, in this case the presented phenomena are of a static character. The animation techniques are not utilized for the presentation of changing phenomena, but for supporting a better perception of multiple variables representing static information. Simultaneously the objective is to keep the communication with the map on, or close to, a global level.

2. INTERACTIVE ANIMATIONS

The Internet does not only provide a efficient way of distributing cartographic presentations. The computer-based environment opens the possibilities for both a higher level of interaction between the user and the map, and animation of phenomena in the map itself. In several thousand year people have made maps of their geographic environment, and in the last century maps evolved to present phenomena that are not necessarily visible in our physical environment (thematic maps). All these maps follow the simplified model of cartographic communication in Figure 1.

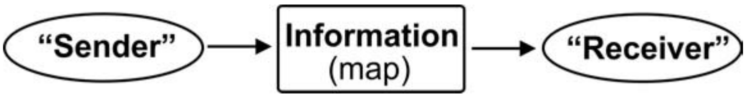


Figure 1. Simplified communication model for ready prepared presentations

This model will even be adequate for a map animation. The animated map is controlled by the sender (map maker), and the map user receives the information in a “passive” way. However, when the map turns into an interactive presentation the user will be able to influence the transmitted message in order to extract the content of the message in a more efficient way. In this case Figure 2 will be a better description of the situation. The figure emphasizes the fact that the map has changed from a ready prepared presentation into a visualization where the user is able to make changes in the visual message he/she receives.

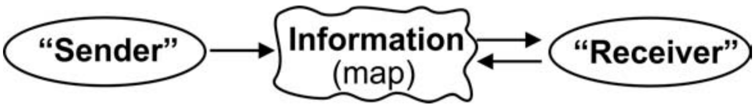


Figure 2**.** Simplified communication model when the map user can interact with the presentation

When people read maps they will perceive and understand the content of the map individually. Someone will comprehend the message fast, while others need more time to gain the same information. When the information in the map becomes more complex, most people need some time to understand the relationship between phenomena in the map. Since people have an individual way of perceiving and understanding graphics, it is likely that an individual adjustment of the map content will have a positive effect. A ready prepared static map presentation, *or* a map animation, are both presented equally to all readers of the map. And while the static map presentation at least can be studied for a required period, the non-interactive animation has to be perceived at the same speed of the whole audience. To meet the requirements for individually perception of the animation, some interaction between the user and the map animation can be introduced. The map reader can be made able to control the animation by jumping into the animation at different stages, choose the content of the map, and choose objects to be compared etc. Today the most common way for the interactions is “mouse operations” in the map. This can for example be mouse-click or mouse-over operations, adjustment of a scroll-bar, setting parameters in menus and so on. In the future voice registration may become a more common interaction tool.

Peterson (1999) uses the term *active legend* as an interface between the user and the interactive map animation. In Peterson (1999) the legend responds to mouse-over events and results in substitution of the content of the map. In this way the user can explore relations between various phenomena by moving the mouse in certain pattern on the legend. In Midtbø (1997) legends are used to choose contents of the map by mouse-clicks. In addition to such methods, van den Worm (2001) shows how legends can be moved around in the map to get it inside the “field of view”. He also uses the opposite connection between map and the legend, and highlights the legend when certain elements in the map are activated by a mouse-click.

These examples show how the map can be manipulated trough some simple user interactions. However, is this map *animations?* Should not an animation recreate a dynamic situation? Peterson (1999) discusses the issue and claims that the important part of an animation is what happens between the frames. In this paper there is no start and end points in most of the proposed animations. However, the content of the map is changing as the result of user interaction. This change can be movement, change in size, change in value, change in transparency etc. It can also be visualization of the transition between highlighting different variables. The paper uses the term interactive map animation - with emphasize on *interactive*.

3. METHODS FOR THE ANIMATIONS

Trough the Internet and World Wide Web numerous examples on map animations can be found. Many of these animations are relative complicated to use and understand for the ordinary user of the web. This has to be expected when the message transferred trough the map is complicated, and maybe intended for groups of user with some foreknowledge on the subject. However, even simple messages sometimes seem to be made more difficult than necessary. Reasons for this may be that the “sender” (maker of the animation) has problem sorting out the useful information, or he/she may simply not have the knowledge on how to pass on the information in the most efficient way. There are also several examples on overloading the animation with effects. The animation itself becomes more important than the message.

An interactive map animation has to be understandable at two levels. First the user has to learn how to use the animation. The interaction between the user and the map should be easy to identify and not hidden in a lot of other information. Second, the message in the interactive animation itself must be easy comprehensible for the intended user of the map animation. These issues are the main objectives of this paper. The information from the map is made accessible on a global level for the user by a combination of visual variables, dynamic variables and common animation techniques. Bertin (1981) describes the visual variables: *location, size, value, texture, colour, orientation, shape.* Several authors have discussed an extension of this list by for example looking at colour saturation as a separate variable in addition to the original colour hue. In some of the animations referred to by this paper *transparency* is used as a variable to tone down some features, and by that point out other features. Transparency can be seen as a “relative” to colour saturation. As a rule colour saturation changes along an axis from grey to 100% colour saturation. With respect to transparency, the axis for the colour saturation goes from the background of the figure to 100% saturation.

The visual variables in Bertin (1981) are based on the static presentation of maps on paper. When the map becomes dynamic DiBiase (1992) identifies three new variables: *duration, rate of change* and *order*. MacEachren (1995) supplements this list with *display date, frequency* and *synchronisation*. The last may be used when more than one feature is represented. However, these variables in large degree depend on non-interactive animations. When the user are able to interact, he/she can interfere the duration, speed etc. of the animation, and most of these variable becomes less usable. It is however possible to avoid this by introducing small interactive animations within the animation, or by locking the interaction possibilities for shorter periods. Dynamic variables can also be invoked as single variables which the user can not control in the animation. When it comes to Bertin’s visual variables it is important to note that it is not only the variables themselves that is of important. In an animation the *change* of location, *change* of size etc. play an important role.

The construction of animations based on visual and dynamic variables may also depend on the software development tool that is available. Some tools are flexible on how the features are situated and operated in the application, while other tools are stricter on how the features can be organized.

4. MULTIVARIABLE “SEEING MAPS”

Keates (1982) describes the human eye/brain capacity in the perception process. The eye has two types of sensory cells; cones and rods. The cones are mainly centred close to Foeva and have a "direct connection" to the brain. These photoreceptors cover a small sharp-sight area, while the second type, rods, cover the peripheral sight area. The rods will respond to small changes in intensity (value), but are insensitive to differences in wavelength. The human brain will be able to comprehend the overall situation on the map in a very fast operation trough the parallel working sensory cells in the eye. In this process the peripheral sight, sensed by the rods, are utilized to form the immediate idea of the distribution in the map. Bertin (1981) uses this fact when he proposes to make “seeing maps” for communication of the map content on a global level. These maps do mainly answer the question: "where is this phenomenon".

A map that communicates the information a global level has to be very selective. According to Bertin (1981) this kind of map should only use one variable in addition to the location. If we have more features they should be presented on separate maps. However, when the features are represented by variables on separate maps, it is be more difficult to study the mutual relation between two or more features. This is also one of the reasons why pie charts still are quite common on atlases etc. They are showing the relationship between comparable features in a map in a applicable way. However, when using pie charts, the communication on the global level disappears (or are at least strongly reduced), and the map can be classified as a “reading map”. Generally speaking: when we want to compare features by using many variables on a map, the map easily becomes overloaded and less suited for communication on a global level. This lead to a question: can simple animation techniques help this situation? Can we in a better way compare several variables on one map, and still be able to study individual variables on a global level? This paper presents a few methods and ideas on how this can be carried out. A central point is how to separate a single variable from the complete presentation in a way that is suitable for the individual user. Some users may want to study each feature for a longer time, while for other user it is the transition between the variables that is helpful.

When we want to compare several features, represented by variables in the map, these features have to be represented by the same type of visual variable. It is no sense in comparing the number of one phenomenon with the number of another phenomenon, where the first is represented by size as the visual variable and the other is represented by value.

The examples in this paper mainly use size as the visual variable to be compared. This will give some methods for separation of the features:

- *Colour (hue):* This is a variable with selective and associative qualities. Some colour combinations can be used to highlight certain features. However, if other features are to be highlighted the colours have to be switched between the features. This may cause confusion. In this paper colour is used to separate various features from each other on the basic map (before any animation).
- *Transparency:* At 0% transparency nothing of the background can be seen trough the object. By increasing the transparency the object blends gradually with the background until it disappears at 100% transparency. Transition between transparency levels may be sudden, or it can change gradually. Transparency is particularly useful when one feature is going to be temporary emphasized by user interaction.
- *Position:* Features which have a spatial component are of course connected to a certain location or area. However, change in location can also contribute when we want to emphasize one feature.
- *Exchange based on choice of feature:* In this case each feature is shown in the map alone, and all comparison between features is mad possible by rapid exchange of features. The animation can for example be controlled by active legends.
- *Exchange based on choice of location:* In some cases the values of variables in the map are given from their relation to a certain location. When we choose another location the values of the variables may change. The animation can be controlled by an active map that is updated by using a pointer in the map itself (mouse).

3. EXAMPLE ANIMATIONS

On the basis of the previous sections, this paper here proposes some methods for interactive map animations. In these animations variables can be compared, and individual features can be emphasized for better communication on a global level. The animations are made by Macromedia Director MX. This software includes an own scripting language and offers high flexibility in the choice of animation techniques. On the other hand Director is rather poor in handling large external data sets. The animations can be studied at: http://www.geomatikk.ntnu.no/prosjekt/multivar/animations.html

- *Active movable legends:* This example is close up to the method introduced by Peterson (1999). The map responds to movement of the mouse pointer between different fields in the legend. However, while Peterson (1999) uses a preset legend (Figure 3a), the legend in this animation can be manipulated by the user. The squares that represent various features can be moved around and arranged in diverse sequences (Figure 3b). In this way it is easier to compare two or more features in a wanted sequence.

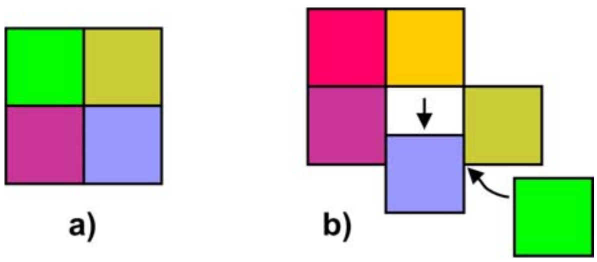


Figure 3. Fixed and movable active legends

- *Moving focus:* In this case we have only one feature represented by a variable. But the value of the variable changes depending on choice of location on the map. Let us use migration as an example. Lines of variable thickness may represent migration from (or to) different sites from our chosen starting site. By moving the mouse pointer to another site, one end of the lines will follow the mouse pointer and the thickness of the lines will changes according to the migration numbers.

- *Group of scalable circles:* Here the variables representing several features can be compared at the same time. A group of variables are connected with lines (Figure 4). In the initial picture all the circles are 100% visible. But when the mouse pointer is touching one of the features in the legend, all the other features are made vaguer in the map by increasing the transparency value. However, it is not sufficient to use transparency only. The features are related to a certain site or area, and to achieve communication of each variables on a global level, the variables representing these features need to have a correct location. This requirement is fulfilled by moving the circles in a way that the emphasized feature always has the true location. The rotation of the circles is done in a smooth

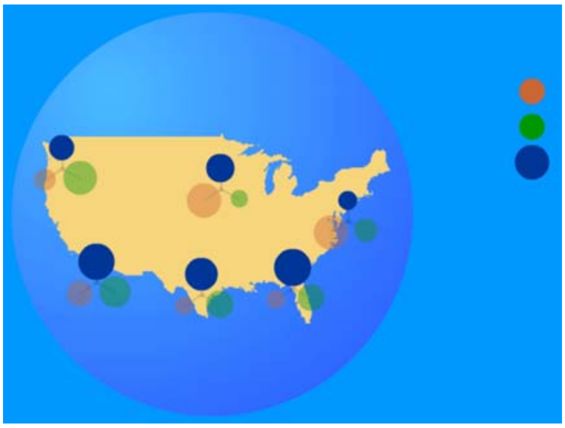


Figure 4: Group of scalable circles movement to make it easy for the map-reader to comprehend the replacement. An abrupt movement is more confusing for the user.

- *Pie chart with transparency:* Traditional pie charts usually represent phenomena which have several sub-classes (for example population and different age groups in percent of the whole population). The phenomenon itself is reflected by giving the whole pie a corresponding size, while the sub- classes are represented by slices in the pie. Pie charts are applicable for a local comparison of the sub-elements. On the other hand, by using pie-charts distributed over a map, the possibilities for communication of the detailed information on a global level are strongly reduced. However, it is still possible to improve some of this by emphasizing single pie slices, while the others are made vaguer by increasing the transparency (Figure 5).

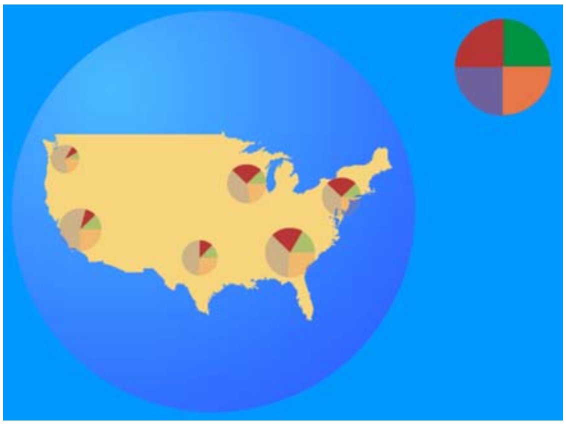
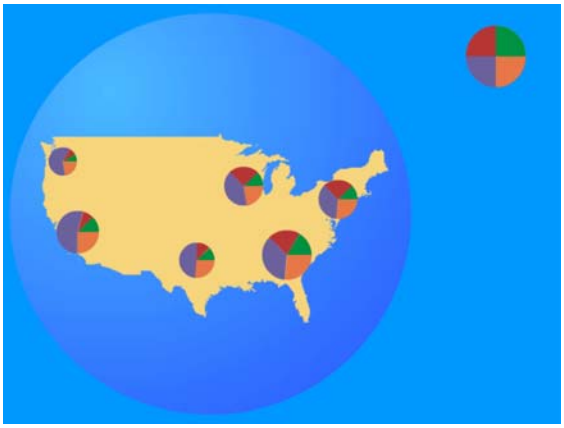


Figure 5. Pie carts with transparency

- *Pie chart with movements:* Normally the centre of the pies will be located in certain sites or in the centre of a represented area. When emphasizing single slices of the pie we will introduce an error in the global perception of this sub-element. This because the centre of each slice lies outside the centre of the pie itself. By using animation techniques this problem can be reduced or eliminated. In the example shown in Figure 6 all the pies are moved until the emphasized slice represents the reference point of the pie. In addition the pies are rotated in a way that the emphasized slices always are situated on the top of the pie. The "dancing map" is introduced!

The use of transparency is important in some of these examples. This technique relies on the fact that the peripheral sight is utilized for communication of the map on a global level. The highlighted figures of high intensity will be easy perceived, while the eye will overlook the vague figures with high level of transparency.



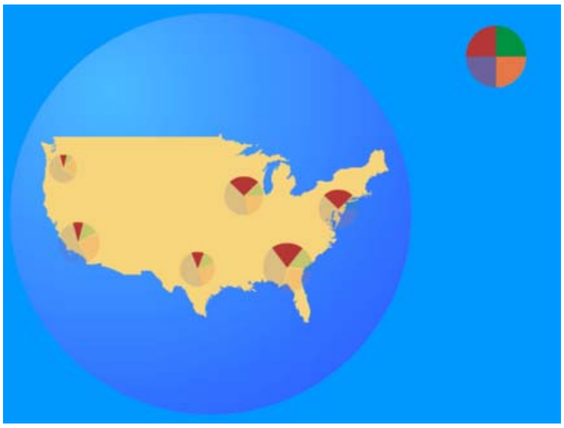


Figure 6. Map with moving pie charts before and after a phenomenon is highlighted

4. CONCLUSION

Methods for presentation of dynamic, interactive maps in an electronic media are still at an early stage. However, the increasing use of small map applications, especially on the Web, makes it more necessary to study how the information in the map application should be passed on to the user. Many of the maps we see on the Web today reflects the paper-based static maps we have known for ages. It is reasonable to believe that human perception of static maps can be utilized in a corresponding way for interactive map animations, and by these animations communicate the information in a more efficient way.

By increasing the interaction between the map user and the map itself, the comprehension of the content of the map can be adapted to each individual in a better way. The user can adjust the stream of information according to her/his "receiving capabilities".

This paper has given some examples on how some simple animation methods can be used to make the content of the map available for communication on both a local and a global level. By using interactive animation we utilize the qualities of maps made for a global communication level, together with the fact that people can perceive changes in the map over short time periods. The paper discusses pros and cons of some ideas for interactive map animations, while further research within this topic have to include studies on how people react to the interactive use of the map.
The intention of this paper was not to give a complete overview over all possible methods for multivariable "seeing maps". Nevertheless, some ideas are discussed that may contribute in the further development of small thematic map applications made for electronic media.

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Biography

Terje Midtbø made his PhD in 1993 at Norwegian Institute of Technology. The title of the thesis was “Spatial modelling by Delaunay networks of two and three dimensions”. Since then he has filled an academic position at the Norwegian University of Science and Technology (NTNU), where the former Norwegian Institute of Technology is included. In the period 1993-2000 he was Associate Pofessor, and from 2000 he entered the position as Professor in Geomatics (Cartography). At NTNU he has been working with education and research within Geographical Information Science and Cartography. In his work he has interests within data structures for terrain modelling, methods for distribution of geographic informationon the Internet and handling of geographic phenomena with a temporal component. The last years he has, for one thing, studied map animations and how these can improve the communication of map information. In the period July 2002 – July 2003 he spent his sabbatical year at National Center for Geographic Information and Analysis, University of California at Santa Barbara. He is a member of the board of the Norwegian Association for Geomatics and Geogaphic Information Science (GeoForum).