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Visualization of change in the Interactive Multimedia Atlas of Switzerland

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Abstract

In the Interactive Multimedia Atlas of Switzerland several methods are used to represent temporal and nontemporal changes. The article provides a description and an assessment of the applied techniques. The impact on modern multimedia cartography is discussed. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Multimedia atlases; Digital cartography; Visualization; Temporal change; Nontemporal change

1. Introduction

In the past decades, the development of modern information and communication technology led to an increased availability of digital information. New electronic media like CD-ROM and online services are also used in geosciences in order to publish and spread scientific results and spatial data. These media are mainly applied in the fields of data distribution and development of data-specific applications with digital documentation. Other applications are information systems and systems for integrated visualization techniques.

During the last ten year, various digital visualization techniques were also developed in geosciences in order to analyze and impart information. The ViSC initiative (visualization in scientific computing) must be mentioned particularly. Here, different scientific branches are promoting the development of digital visualization techniques for analyzing and viewing multidimensional data.

Thus, new demands are posed to cartography. This science deals with the development of graphic techniques for analysis and visualization of spatial information. Its main goal is the adequate and proper presentation of information, focussing on aspects of perception, communication and interpretation of spatial patterns, as well as environmental structures (Hake and Grünreich, 1994). A broad variety of topographic and thematic techniques have been developed in order to visualize the whole spectrum from plain maps up to complex panoramas.

ViSC techniques offer new possibilities to the cartographic community in presenting, analyzing and understanding multidimensional data. Previously, the conventional production of three-dimensional views, virtual presentations, overlays or animations has been extremely difficult and time-consuming.

2. Impact on atlas cartography

The development of visualization techniques has a strong influence on multimedia atlases. The recent advances in this area can be explained by the rapid

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development of computer technology. Particularly, the following aspects are relevant:

- Hardware development: computers become faster and cheaper at least every half year and therefore more spread. This fosters the dissemination of multimedia atlases.
- Software development: during the eighties, special software and very often programming knowledge was necessary in digital cartography. Today, maps can even be produced using user-friendly standard software. A major milestone promoting the development of multimedia atlases was the release of HyperCard in 1987: A broad variety of interactive functions facilitate the linking of information and visualization.
- Development of geographic databases: in geographic information systems (GIS), maps and spatial data are available in digital form. They are ready for analysis, interpretation and processing in order to create new presentations for multimedia atlases.

For quite a while, research in the field of utilization of various visualization techniques in multimedia atlases has been done. Up to now, due to hardware, software and memory limitations, developers hardly made use of the specific advantages of interactive media. The quality of the screen display has been largely ignored.

In many commercial multimedia atlas applications — Ormeling (1995) divides them in view-only-, interactive and analytic atlases — the presented maps are mainly based on scanned raster images or vector graphics. Animations, for instance, are built up using sequences of prepared single frames. Direct computer-controlled generation based on existing databases is hardly used.

3. Methods of visualization in the atlas of Switzerland

Since 1995, the Institute of Cartography at ETH Zurich is developing an interactive multimedia version of the Atlas of Switzerland, the Swiss national atlas (Sieber and Bär, 1996). The product can be situated in-between the interactive and the analytic atlases mentioned above. Within a predefined frame, interactions are allowed. Compared to other interactive atlases, cartographic visualizations are achieved according to the 'intelligent map concept' (Bär and Sieber, 1997). Beside conventional representations, maps are created directly from existing databases.

3.1. Visualization from graphical data

The direct use of graphics data is the most popular way to integrate map images in the Interactive Multimedia Atlas of Switzerland. First, the map is created using a design program and then transferred to an authoring program, usually as a combination of raster image and overlayed vector graphics. A major drawback is the need of memory which is increasing with mapsize and pixel resolution. In contrast to pure view-only atlases, the Interactive Multimedia Atlas of Switzerland offers some maps of this type which allow limited interactivity: different layers can be selected separately.

Therefore, two varying exemplary thematic areas have been chosen: Display of statistical data (population statistics 1850–1990 of the Swiss Federal Statistical Office) and digital terrain modeling using the DEM 25 of the Swiss Federal Office of Topography with 25 m resolution. Experiments have been carried out in order to generate map presentations using directly these raw datasets.

3.2. Visualization of two-dimensional data

The motivation for generating maps directly from statistical data is explained by the possibility of improved queries, easy updating, broad analytical functions, fast change of symbolization, classification and coloring. Compared to applications using prepared digital maps, there is less memory but more computer power needed.

The maps consist of statistical data combined with georeferenced objects such as administrative boundaries or centroids with a corresponding name list. A basemap can be built up in the background by selecting the features desired (shaded relief, lakes, rivers, etc.).

In order to provide attractive and readable representations, high demands regarding the quality of screen maps are made. Limited screen resolution, limited display of large format maps, conflicts between screen resolution and minimal dimensions, characteristics of shapes and forms, generalization, symbolization and overlay of various layers can cause major problems. Methods like anti-aliasing (smoothing of pixelated lines) and well chosen, flexible map layers have been applied successfully in the Interactive Multimedia Atlas of Switzerland in order to solve these problems. Using the principle of 'intelligent zooming', the degree of generalization is specified by the zoom factor.

3.3. Visualization of three-dimensional data

On the computer screen, analytical shadings of terrain models are superior to wireframe representations due to the possibility to properly visualize morphological details in the same available virtual space. More-

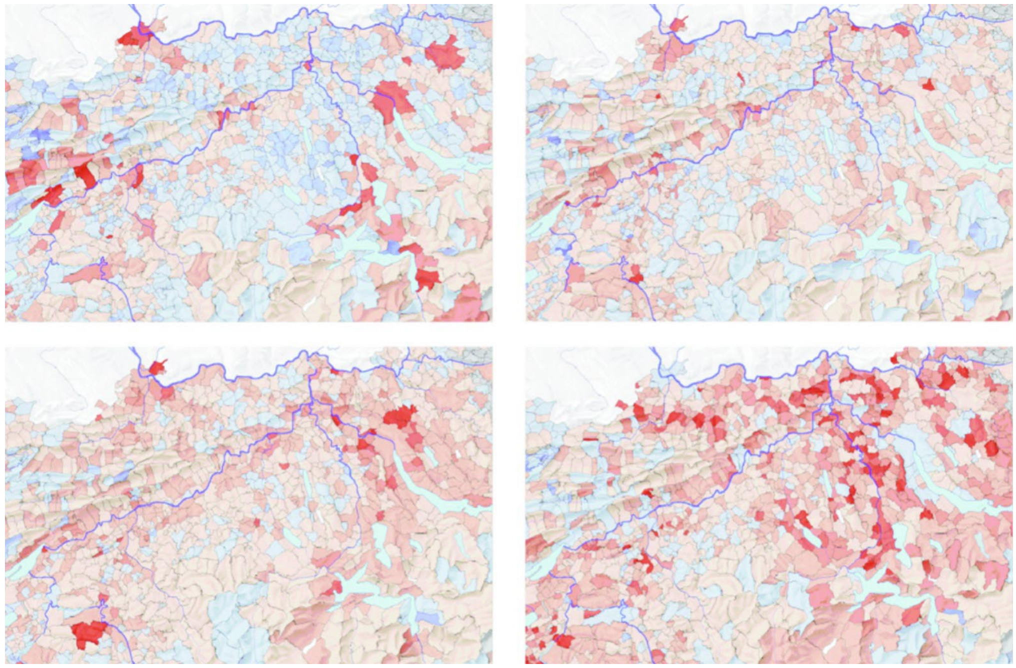

Fig. 1. Four images of animation showing change of population in Switzerland between 1850 and 1990. They show changes from 1870 to 1880 (upper left), from 1910 to 1920 (upper right), from 1940 to 1950 (lower left) and from 1980 to 1990 (lower right).

over, they provide a realistic impression and can be combined with colored height information, thematic overlays and morphometric analyses containing variables such as slope, aspect, curvature or structural lines.

Related to the quality of presentation and to the demand for computing performance, the ray-tracing procedure is the best suited visualization method. However, achieving a reasonable graphic quality of overlayed line elements is still a major problem.

In the atlas project, shaded relief representations allowing the free choice of any view, block diagrams and panoramas are implemented. The combination of a name-list and geocoded spatial boundaries allows queries of geographical names regardless to the chosen projection.

In order to achieve an efficient data management and representation, the terrain models are already stored in different resolutions. The resolution is specified by the extent of the selected area and the available memory. In panoramic views, a sequence of successive models with decreasing resolution towards the background is used.

4. Techniques for visualization of changes

Based on the direct visualization from two- and three-dimensional databases, new possibilities in change representation result. They can be divided in traditional cartographic and computer-aided animated visualizations.

Traditional cartographic representations have the following limitations:

- They are static: situations can be reproduced, but processes and changes can hardly be presented directly.
- They are isolating: only a limited number of objects with their attributes and their spatial, causal and functional relations can be shown, otherwise their legibility and differentiation is seriously affected. The direction and the angle of viewpoint are fixed by the author of a map.
- They can only be presented in one preselected way: in a single cartographic representation only a certain aspect of data and their attributes can be shown. A complete overview of the data structure cannot be provided.

5. Temporal changes

5.1. Animations

Using computer-based animated representations and the possibility of interaction, traditional cartographic visualization methods can be improved to compensate the limitations mentioned. Unlike a traditional map, the animation is a sequential way of presentation: a sequence of varying single frames covering a certain time interval. Time is the third variable besides the *x*- and the *y*-coordinates and further thematic variables. In temporal animations, it can be used to represent events in real time. In nontemporal animations, time is used to reveal connected features and to put them in a logic sequence (Dransch, 1995).

In temporal animation, events are shown directly in real time, although time is mostly scaled. Thus, changes can be shown generically and immediately. The animation allows visualizing the movement of an object by changing its position or it can show the change of quality and quantity of objects and events. It is important to achieve a perceptable representation of dynamical and chronological aspects of change. The user will be able to recognize if the change is erratic, stetic, unstetic or continuous; if it is permanent, periodic or episodic and if its rate is constant, accelerated or slowed down.

To create a temporal computer-animation, different techniques are used:

- Frame by frame animation: Using this technique, each single frame of the animation is generated before all frames are joined into one animation. The Interactive Multimedia Atlas of Switzerland contains several examples of this kind: In addition to the statistical maps mentioned above, an animation showing the change of population in Switzerland between 1850 and 1990 is included. This animation is a

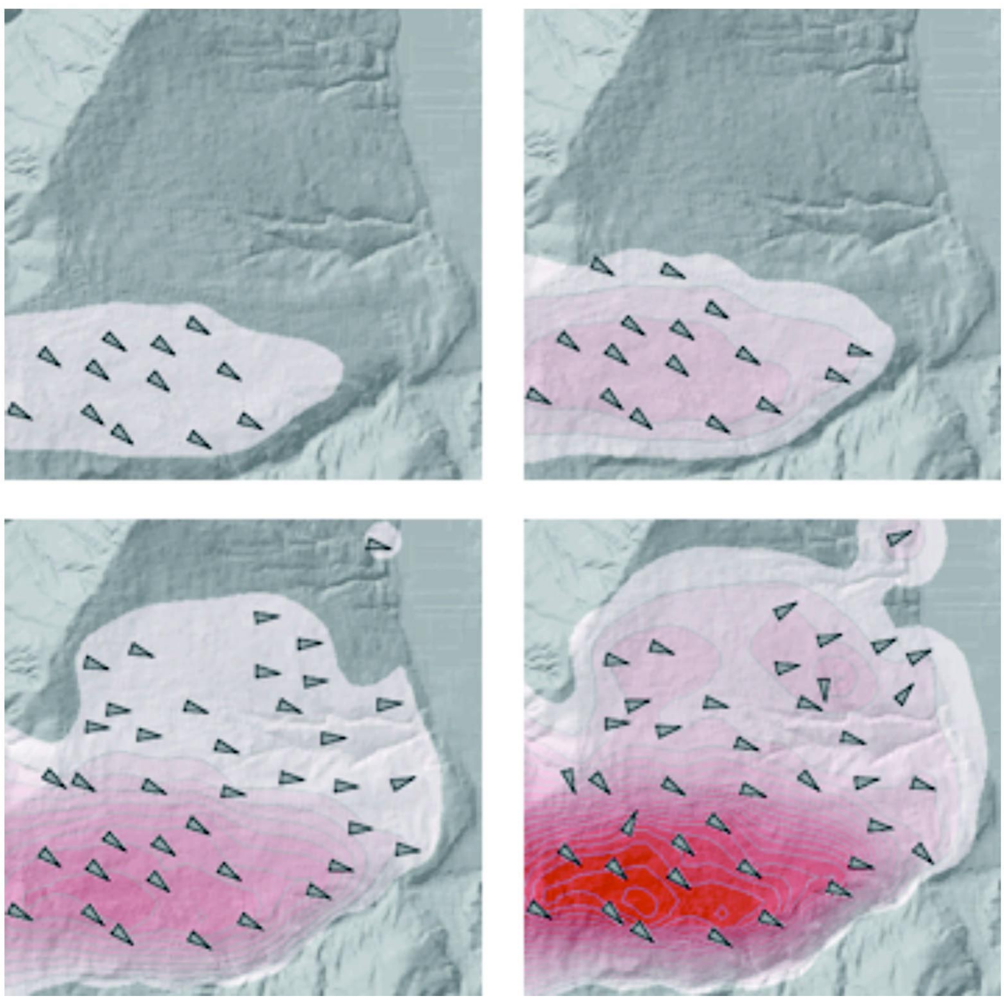

Fig. 2. Visualization of landslide: four images of frame by frame animation. Mosaic maps show displacement between 1927 and 1932 (upper left), between 1927 and 1938 (upper right), between 1927 and 1958 (lower left) and between 1927 and 1995 (lower right). Arrows represent direction of displacement at control points at same moments.

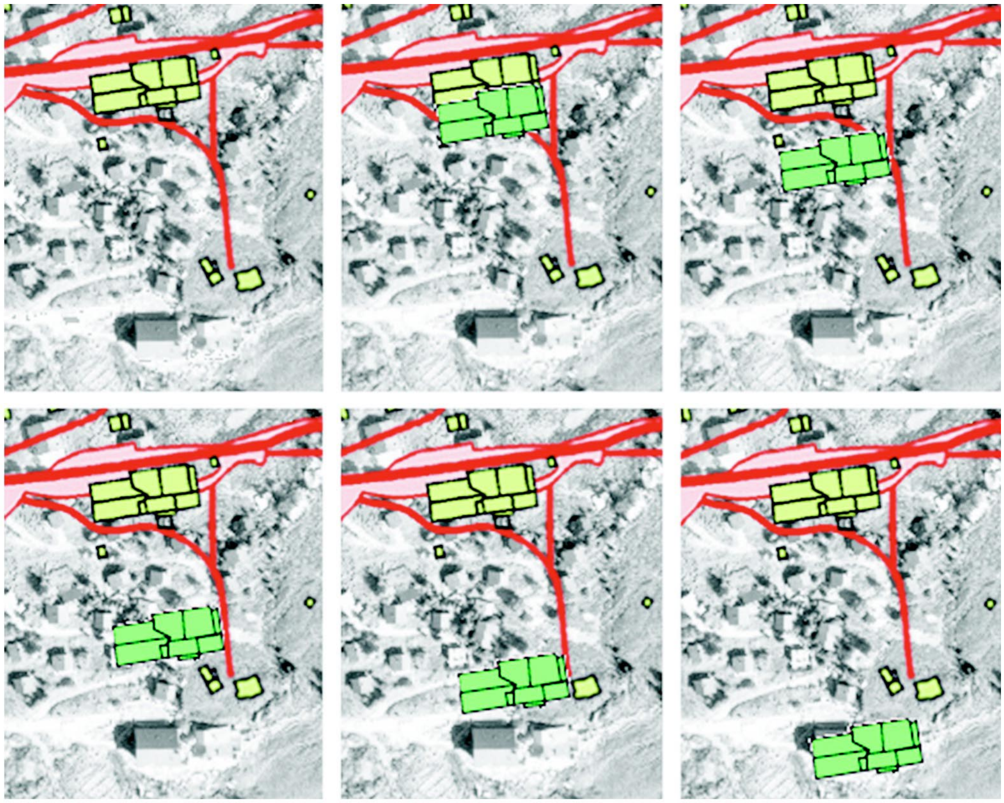

Fig. 3. Six images from keyframe animation (from upper left to lower right) visualizing displacement of buildings during landslide.

sequence of 13 single maps representing each decade of the period (Fig. 1(A–D)). In Fig. 2(A–D), another example covers the visualization of a landslide: The dynamics, characteristics and main directions of the landslide are shown parallel in a sequence of pictures by displaying an area interpolation of the measurements, control points and a terrain model.

- Keyframe animation: The animator creates only single keyframes. The "inbetweens" are generated using interpolation methods. In Fig. 3(A–F), the visualization of another landslide is shown. In this case, the very large object displacement of up to 200 m made it necessary to implement a keyframe animation. An aerial photograph of the affected area after the incident serves as a background for the presentation. Overlayed are the digitized buildings at their original places. By clicking on a single building, it moves to the place after the incident. The positions before and after the landslide of any building were used as keyframes for this animation, the in-betweens were calculated by the software using a linear interpolation.
- Procedural or algorithmic animation: In an algorithmic animation, the whole animation is generated by software control. The animator defines the objects to be animated, the desired changes and the temporal flow of the animation in a script. It is not planned to implement procedural or algorithmic animations in the Interactive Multimedia Atlas of Switzerland. The display quality of the animated maps can hardly be supervised.

The use of these techniques is largely depending on the available hard- and software. The output of the animation is generated within the computer instead of producing an analog image. Therefore, frame by frame can be saved after generation. It can then be played on the computer. An instantaneous output without storage is also possible, but it requires efficient hardware.

5.2. Comparisons

To visualize changes, the most conventional and easiest way is to compare two or more images showing different stages of an event. Time is often used as one component: One frame displays the state before and the second one the state after the incident. Another example with a landslide shows a comparison. Time is the major variable: Two aerial photographs, one taken

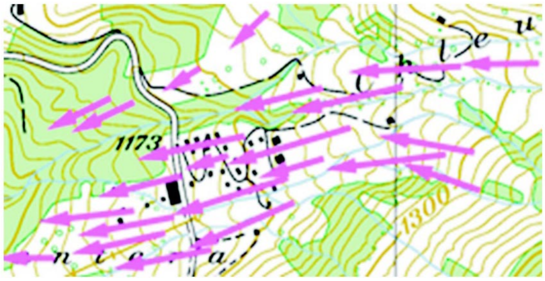

Fig. 4. Single image representation with displacement shown by vectors.

before and one after the incident, are presented side by side.

5.3. Fading

The technique of fading can be situated in-between comparison (static) and animation (dynamic): Therefore it is therefore pseudo-dynamic. The user can recognize a smooth transition between the two images. Static elements which exist in both images allow a good orientation. The changes are more including such static components.

5.4. Tracing

Many (temporal) animations are area-related. They could also be line- or point-related. A static background allows orientation and perception of the movements. Compared to traditional, purely static presentations (Fig. 4) where changes are represented by vectors, the user is able to perceive the dynamics of the incident in an animation (Fig. 5(A–D)). In the example, the background map and the vectors are in the same scale due to the extremely large displacement. With small displacements, this is not always possible, of course. If the vectors are displayed in a larger scale than the map, the user gets a disturbed impression of the landslide.

6. Nontemporal changes

6.1. Animations

The nontemporal animation makes use of the time of presentation in order to generate a sequence of map frames or other data. The following subgroups can be defined:

- Animations generated step-by-step: the step-by-step generation of a map in an animation process can be used to provide to the user an overview of the subject. A logic order may help to recognize and understand spatial and thematic inter-connections. In the Interactive Multimedia Atlas of Switzerland, the step-by-step generation is not implemented as a prepared, guided animation. It can be controlled interactively by the user. He can decide in which order the layers are displayed.
- Animations with changing representations: the same data is shown in different ways with either changing graphic presentation or data processing or both. This allows the user to obtain a comprehensive view of the data and the internal structure.
- Animations with changing contents: to visualize spatial inter-connections and inter-connections in contents, varying subjects which are part of a selected range are using this kind of animation.

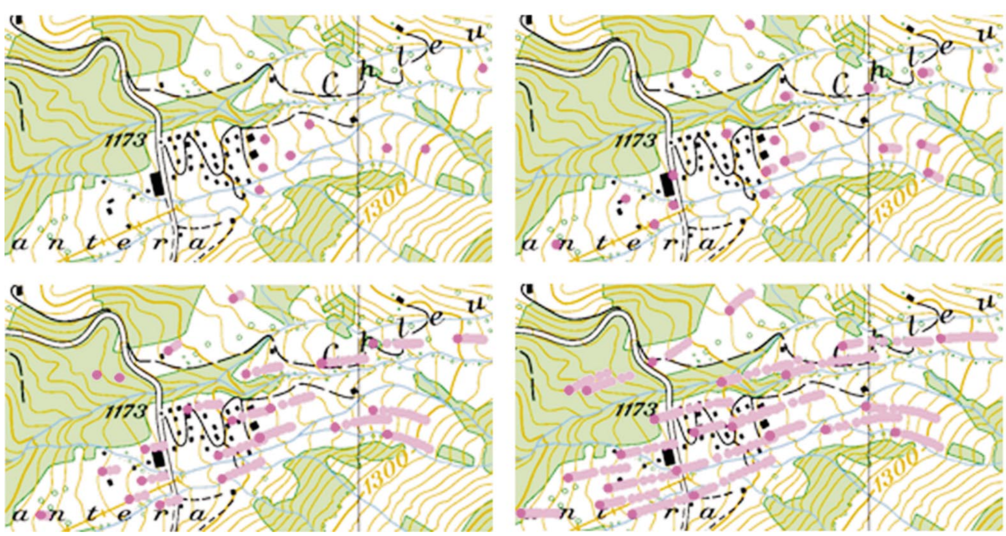

Fig. 5. Tracing of geodetic points; same incident as Fig. 4 (upper left to lower right).

- Animations with changing combinations of subjects: an animation of this type allows showing a sequence of maps with differently linked subjects. Very often, a large number of spatial, overlayed objects and attributes must be presented on one map in order to visualize all spatial relations and relations in contents. On traditional single maps, this is extremely difficult. However, in a sequence of maps, the user can combine different objects and attributes as needed, in order to allow an easier recognition and understanding of their context.

It is important to know that most users correlate an animation with time even in the case of nontemporal animations. Therefore, the danger of misunderstandings is evident, especially for nonskilled users. The Interactive Multimedia Atlas of Switzerland is intended to be used by experts and laymen. Therefore nontemporal animations are only used to build up base maps interactively.

6.2. Comparisons

As mentioned above, a comparison can be a temporal or a nontemporal visualization: an event can be presented from different point of views. Another possibility is offered by emphasizing different classes of a category in two or more images.

6.3. Switching

Switching is another technique to visualize changes. It is a further developed version of a simple comparison and therefore especially suited to be used on screen. The single stages are neither presented side by side nor in the same time, but in succession: The user has the possibility to choose the rate of change and the sequence of the images. There are different solutions to implement this interaction: By clicking on the image or a special button or by operating a slider. The latter has the advantage that not for every change of images a manual action is needed. This kind of visualization is well suited for nontemporal changes.

7. Outlook

Only a part of the possibilities to visualize changes has been realized yet by our group. In the Interactive Multimedia Atlas of Switzerland, the following objectives are planned for the near future: Integration of externally implemented visualization techniques and examination and development of visualization techniques mentioned, but not yet implemented. The latter is especially the case for procedural animations: They would need less memory. The higher computer performance needed should be neglectable by using state-of-the-art personal computers. The integration and visualization of three-dimensional data will also open a wide and interesting scope for further developments and research in the young field of multimedia atlases.

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