

## **Dynamic and interactive displays**

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The term “dynamic display” is applied to displays capable to *change*, in contrast to static displays, such as paper maps and graphics. Changes in a dynamic display may occur in an automatic manner or in response to actions of the user. The term “interactive display” is applied to dynamic displays changing in response to user’s actions. Dynamic displays capable to change automatically are often called “animated displays”. An animated display may at the same time be interactive. At the minimum, the user may interactively stop, resume, and restart the play, but more advanced interaction possibilities may also be provided.

Computer animation is often used in a straightforward way to display dynamic phenomena. In particular, dynamic phenomena related to geographic space are most often visualized by means of *animated maps*. Many examples of such maps may be found on the WWW. Thus, animated maps depicting various topics of American history are available at AnimatedAtlas.com; the web site of the National Atlas of the United States® contains animated maps portraying the spread of invasive species during a range of years and the progression of vegetation growth during a year.

Another frequently encountered class of animated displays is fly-through displays, which present various objects or geographical areas as they appear from different viewpoints. Typically, fly-through displays allow very little or no interactivity. Animation may also be used to present large and/or complex content by portions. For example, different themes may alternate in an animated map of a geographic area: terrain, rivers and lakes, landmarks, vegetation, administrative boundaries, roads, etc.

Interactive displays and, in particular, maps and virtual globes are nowadays frequently

encountered on the Web. Well-known are Google Maps and Google Earth, online mapping and route planning services like Map24, and maps displaying election results (e.g. at NYTimes.com). Typically, interactive maps and globes (as well as other types of display representing large and complex data) provide facilities for view navigation. The most basic navigation tools are zooming and panning. Perspective views of three-dimensional objects or spaces provide tools for controlling the user's viewpoint into the scene. Visualization researchers suggest "intelligent" navigation techniques, which adjust the view to the user's focus of interest so that the visual prominence (in particular, size of graphical elements) and level of shown detail vary depending on the relevance of the information in different parts of the display for the user.

Another typical feature of interactive displays is providing additional information about objects or places in response to clicking on graphical elements representing these objects or places. The information may be shown in a popup window, which appears near the cursor position, in a dedicated area of the display, or in an adjacent sub-window.

Thematic maps, such as tourist maps and maps of election results, often support more advanced interaction, allowing the user to alter the information content of the display or the representation of the information:

- select information layers, e.g. accommodation, museums, restaurants, bar/nightlife, etc. on a tourist map, or toggling the visibility of the layers;
- select time moments or intervals in displays of time-related information;
- change the spatial scale, e.g. states or counties;
- change the theme, e.g. president elections or governor elections, absolute values or differences in comparison to the previous time;
- choose the visualization method, e.g. choropleth map or proportional symbols.

Interactive displays used for specialized services may be supplied with specific interaction facilities, such as selection of source, destination, and intermediate places in route planning.

Interactive displays play a very important role in exploration and analysis of data and information. Typically, the size, dimensionality, and/or other complexities of data that need to be analyzed preclude the possibility of simultaneous representation of all data items, dimensions, structural parts, relationships, etc., in a single display. Hence, the analyst has to understand the whole by looking at subsets, components, projections, aspects of the data. Interactive displays enable a dialogue between the analyst and the data. A fundamental interactive operation required for exploration and analysis is focusing, i.e. selection of subsets, projections, etc. for viewing. Since any view can only convey partial information, the analyst needs multiple views, which need to be linked so that the pieces of information contained in them could be fit together. Thus, multiple displays simultaneously present on the screen may be linked through identical marking of corresponding graphical elements, e.g. with the same color. The best known technique, often referred to as “brushing”, is simultaneous highlighting of graphical elements corresponding to objects selected by the user in one of the displays (Figure 1).

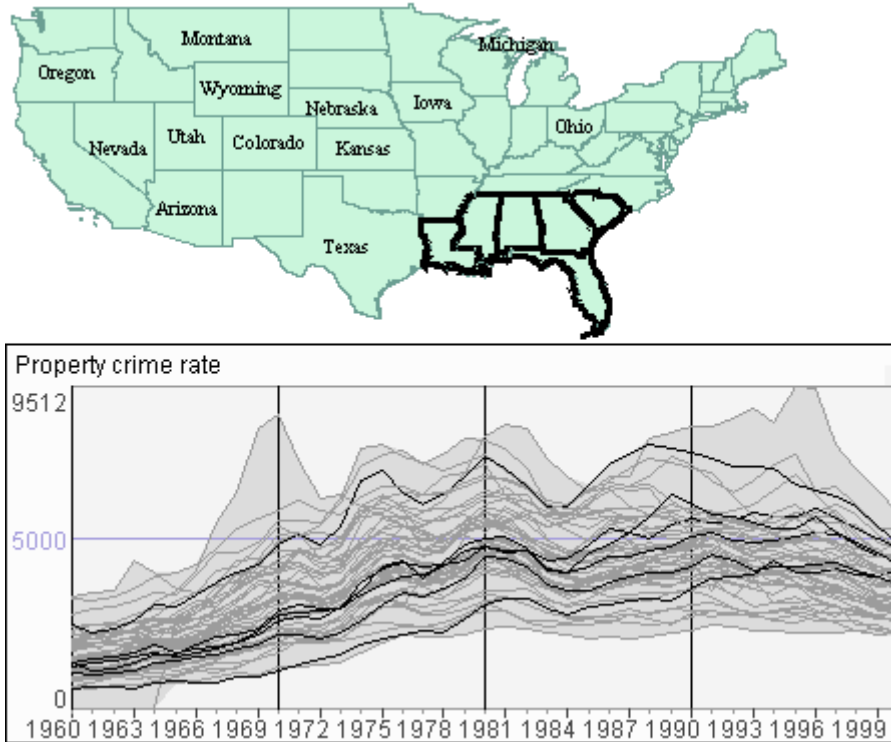


Figure 1. A map is dynamically linked to a time graph display by simultaneous highlighting of corresponding graphical elements. The user has selected several states on the map; the states are marked by thick black boundaries. Simultaneously, the lines on the time graph representing the temporal dynamics of the property crime rates in these states are also shown in black.

Another well-known technique, which supports both focusing and linking, is dynamic filtering (also known as conditioning): all displays show only the data satisfying user-specified conditions and dynamically update their content when the user interactively changes the conditions. Data may be filtered according to values of one or more attributes as well as according to their spatial and/or temporal references (Figure 2).

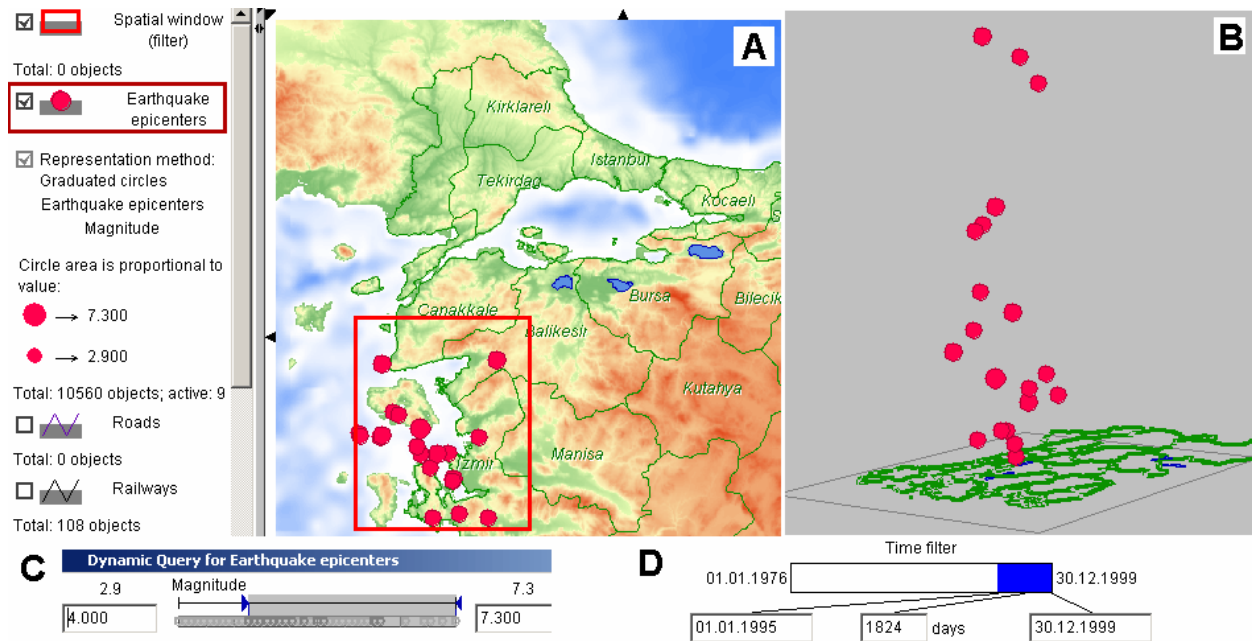


Figure 2. Dynamic filtering. The map (A) shows the spatial positions of earthquake epicenters; the perspective view (B), where the vertical dimension represents time, shows the positions of the earthquakes in space and time. Both displays show the same subset of the data selected by means of three different filters: 1) spatial window, which has been drawn by the user within the map display; 2) attribute filter (C), which selects the earthquakes with the magnitudes 4 or more; 3) temporal filter (D), which selects the earthquakes that occurred in the period from the beginning of 1995 till the end of 1999. All three filters may be interactively changed by the user; in response, the displays will immediately change their content to satisfy the new filter conditions.

Apart from focusing and linking, the role of interactive displays is to help the analyst to discover unobvious patterns in data. Two major groups of interaction techniques intended for this purpose are display manipulation techniques and data manipulation techniques. Display manipulation is interactive modification of the method of encoding elements of the data by

graphical elements and their properties. For example, Figure 3 demonstrates the process of the interactive change of the color scale in a choropleth map. This operation allows the analyst to explore more comprehensively the spatial distribution of the attribute values.

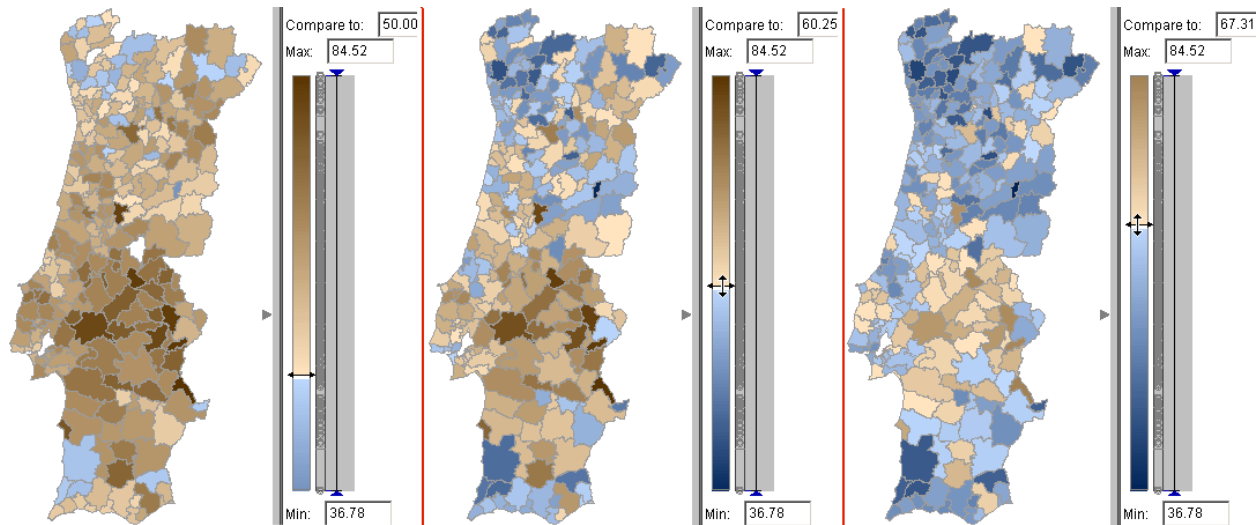


Figure 3. On the left, the percentages of female among unemployed people in the districts of Portugal are represented on a map by means of a diverging, or double-ended color scale: shades of blue represent values below 50% and shades of brown are used for values over 50%. Moving the slider along the color bar on the right of the map changes the reference value and, hence, modifies the color scale. The middle and right screenshots correspond to the reference values of 60.25% and 67.31%, respectively.

Data manipulation is interactive transformation of data elements represented in a display. For example, Figure 4 demonstrates interactive transformation of time-referenced data. Initially, the animated map represents the original data values corresponding to the geographic areas and consecutive time moments. These values can be interactively converted into differences or ratios with respect to the previous time moments. The resulting map exposes previously unnoticeable spatial patterns.



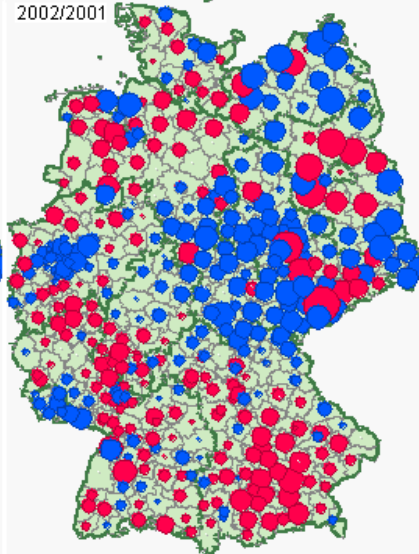
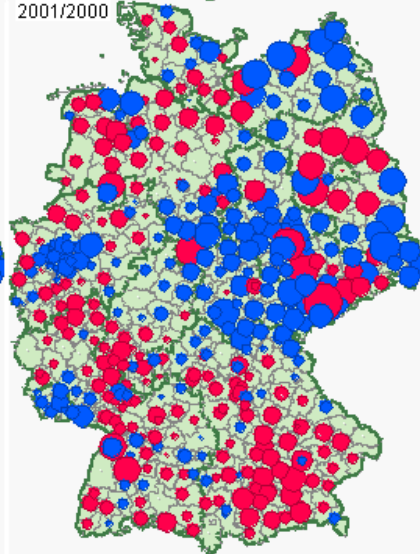
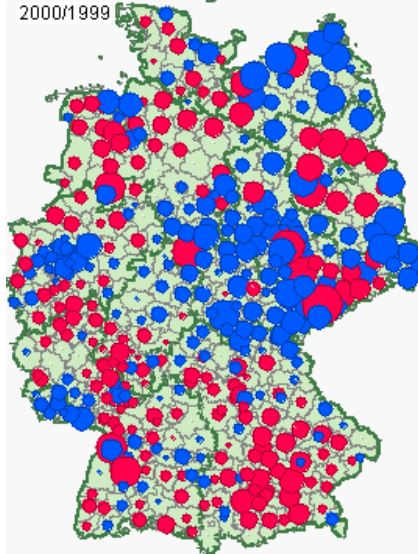
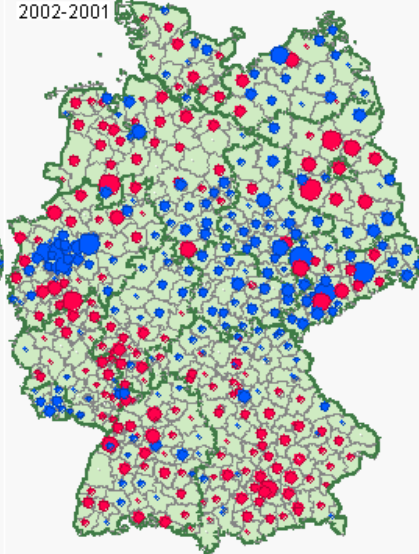
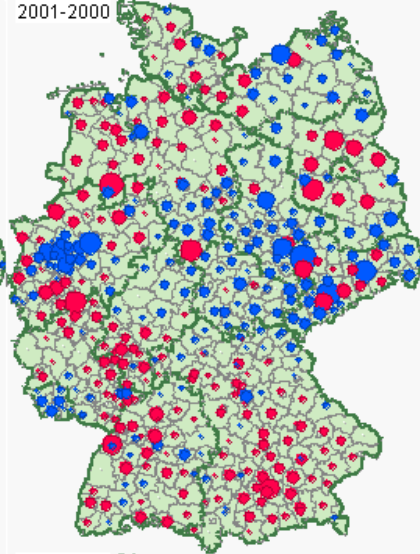
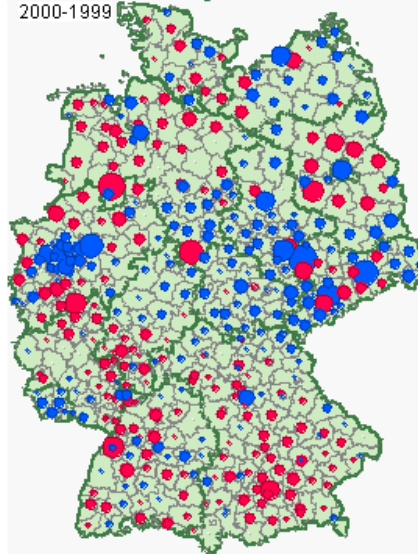
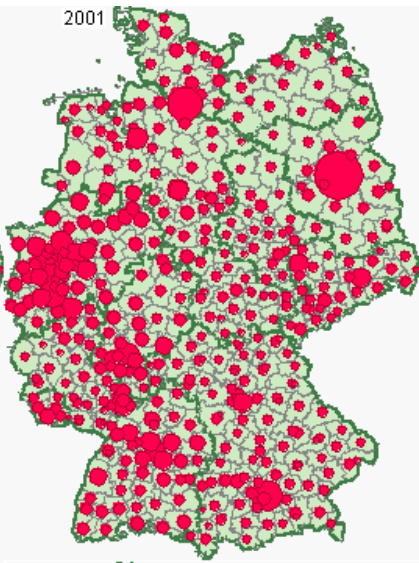
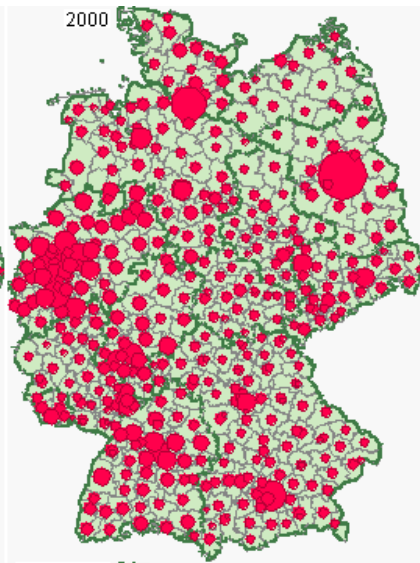
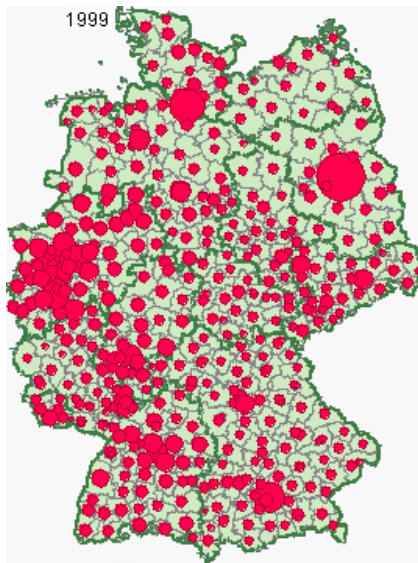


Figure 4. Interactive data transformation applied to an animated map of the population dynamics in Germany. Each row contains screenshots of the states of the animated map corresponding to three consecutive years. Upper row: the map represents the absolute population numbers. Middle rows: the data have been transformed from the absolute values to the differences between two consecutive years. The blue circles represent negative differences. Lower row: the same data have been transformed to ratios between consecutive years. The blue circles represent ratios below 1, the red circles – ratios over 1.

### **Further Readings**

Slocum, T.A., McMaster, R.B., Kessler, F.C., and Howard, H.H. (2009). *Thematic Cartography and Geovisualization*, Third Edition, Pearson Prentice Hall, Upper Saddle River, NJ, Chapter 21 (Map Animation), pp. 389-407

Andrienko, N. and Andrienko, G. (2006). *Exploratory Analysis of Spatial and Temporal Data: A Systematic Approach*, Berlin: Springer, Sections 4.4-4.6 (Display Manipulation, Data Manipulation, Querying), pp.207-396

Andrienko, N., and Andrienko, G. (1999), Interactive maps for visual data exploration, *International Journal of Geographic Information Science*, 13(4), pp.355-374