Visualization Methods for Space-Time Information

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Early Research by Cartographers


Three Dynamic Visual Variables (DiBiase et al. 1992)

- Duration
- Rate of Change
- Order
Three More Dynamic Visual Variables (MacEachren, 1995)

- Display Date
- Frequency
- Synchronization

FIGURE 6.38. Frequency variation can be used to create jumpy or smooth color cycling. The technique of color cycling discussed above is actually the result of manipulation and/or control of period duration, scene duration, magnitude and rate of change from scene to scene, and frequency. Examples of the interaction among these three variables are illustrated for the schematic color cycling scenes.
Five categories of spatio-temporal information (Vasiliev, 1996)
Nine animation metaphors for cartography (Gersmehl, 1990)

- Slideshow
- Teleprompter
- Pointer
- Flipbook
- Sprite
- Stage and Play
- Color Cycling
- Metamorphosis
- Model and Camera
Dynamic visual variables and animation use (Blok 2005)

<table>
<thead>
<tr>
<th>Type of Interaction</th>
<th>Main dynamic visualization variable involved</th>
<th>Moment of display</th>
<th>Order</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection/deselection of:</td>
<td></td>
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<tr>
<td>time: moments, periods</td>
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<tr>
<td>location: zooming</td>
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<tr>
<td>thematic attributes: 1 or 2 thresholds, interval</td>
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<tr>
<td>graphic representation: classification and colour</td>
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<td>Manipulation of start/end of the animation:</td>
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<tr>
<td>play forward; step; to the beginning/end; stop</td>
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<td>tuning</td>
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<tr>
<td>Manipulation of the display sequence:</td>
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<tr>
<td>based on time: play backward, alternate moments</td>
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<tr>
<td>based on thematic attributes: alternate values</td>
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<tr>
<td>based on graphic representation: alternate classification/colour</td>
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<tr>
<td>Manipulation of the length of display time:</td>
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<tr>
<td>based on time: change of display speed</td>
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<tr>
<td>based on thematic attributes: value, interval</td>
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<tr>
<td>Repetition:</td>
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<tr>
<td>based on time: blinking moments</td>
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<tr>
<td>based on thematic attributes: blinking values, intervals</td>
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<tr>
<td>looping</td>
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</tbody>
</table>
### Main Dynamic Visualization Variable Involved

**Type of Interaction**

<table>
<thead>
<tr>
<th>Selection/or deselection of:</th>
<th>Measure of display</th>
<th>Order</th>
<th>Duration</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>- time moments, periods</td>
<td>-</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>- location: zooming</td>
<td>-</td>
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<td>●</td>
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<tr>
<td>- thematic attributes: 1 or 2 thresholds, interval</td>
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<td>●</td>
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<tr>
<td>- graphic representation: classification and colour</td>
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</tbody>
</table>

**Manipulation of the start/end of the animation:**

- play forward; stop, to the beginning/end; stop
- -

**Manipulation of the display sequence:**

- based on time: play backward, alternate moments
- based on thematic attributes: alternate values
- based on graphic representation: alternate classification/colour

**Manipulation of the length of display time:**

- based on time: change of display speed
- based on thematic attributes: value, interval

**Repetition:**

- based on time: blinking moments
- based on thematic attributes: blinking values, intervals
- -

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**Order**

<table>
<thead>
<tr>
<th>Scene 1</th>
<th>Scene 2</th>
<th>Scene 3</th>
<th>Scene 4</th>
<th>Scene 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Rate of Change</td>
<td>Order</td>
<td>Scene 1</td>
<td>Scene 2</td>
</tr>
<tr>
<td>Low intensity</td>
<td>Medium intensity</td>
<td>High intensity</td>
<td>Low intensity</td>
<td>Medium intensity</td>
</tr>
<tr>
<td>Short scene duration</td>
<td>Medium scene duration</td>
<td>Long scene duration</td>
<td>Short scene duration</td>
<td>Medium scene duration</td>
</tr>
<tr>
<td>Chronological order</td>
<td>Chronological order</td>
<td>Chronological order</td>
<td>Chronological order</td>
<td>Chronological order</td>
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</tbody>
</table>

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**Durations**

<table>
<thead>
<tr>
<th>Moment of change</th>
<th>Line</th>
<th>Area</th>
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<tbody>
<tr>
<td>-2.00 s</td>
<td></td>
<td></td>
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<tr>
<td>-1.00 s</td>
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</tr>
<tr>
<td>0.00 s</td>
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<td></td>
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<tr>
<td>1.00 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.00 s</td>
<td></td>
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</tr>
</tbody>
</table>

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**Structured Time**

- Time vs. Distance
- Time vs. Distance with a Scale
- Time vs. Distance with a Scale and Zones

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**Space vs. Time**

- Space = Globe
- Space = Satellite

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**Example of Color Cycling**

Frequency variations can be used to create ‘punchy’ or ‘smooth’ color cycling. The technique of color cycling discussed above is actually the result of manipulating and controlling of period duration, scene duration, magnitude, and rate of change from scene to scene, and frame. Examples of the interaction among these variable are illustrated by the schematic color cycling scenes.
<table>
<thead>
<tr>
<th>Method</th>
<th>Single map / multiple maps</th>
<th>Static / dynamic displays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change map</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>Juxtaposition (&quot;small multiples&quot;)</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>Superimposition (&quot;time series&quot;)</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>Space-time cube</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>Map + graph</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>“Fluid flow” map – 2-D</td>
<td>Dynamic only</td>
<td>Dynamic only</td>
</tr>
<tr>
<td>“Fluid flow” map – 3-D</td>
<td>Dynamic only</td>
<td>Dynamic only</td>
</tr>
</tbody>
</table>
web maps

static maps
- view only
- interactive interface and/or contents

dynamic maps
- view only
- interactive interface and/or contents
Click on the image to view streaming video

<table>
<thead>
<tr>
<th>GIF (768x576)</th>
<th>JPEG (768x576)</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image 1" /></td>
<td><img src="image2.jpg" alt="Image 2" /></td>
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<tr>
<td><img src="image3.jpg" alt="Image 3" /></td>
<td><img src="image4.jpg" alt="Image 4" /></td>
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<tr>
<td><img src="image5.jpg" alt="Image 5" /></td>
<td><img src="image6.jpg" alt="Image 6" /></td>
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<tr>
<td><img src="image7.jpg" alt="Image 7" /></td>
<td><img src="image8.jpg" alt="Image 8" /></td>
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<tr>
<td><img src="image9.jpg" alt="Image 9" /></td>
<td><img src="image10.jpg" alt="Image 10" /></td>
</tr>
<tr>
<td><img src="image11.jpg" alt="Image 11" /></td>
<td><img src="image12.jpg" alt="Image 12" /></td>
</tr>
</tbody>
</table>
Examples

Static ⇒ dynamic
Change map

Minneapolis-St.Paul 2002 Landcover
Non urban classes
- Agriculture
- Forest
- Water
- Wetland
Urban classes
- Grass
- Urban

1986 - 2002
Change from non urban to urban
Superimposition

Jet Stream 6AM Position
Superimposition

Exploration 1830–1845
Superimposition

Mount Mazama and Mount St. Helens Ash Fall

Progress in Upper Atmosphere of St. Helens Ash Plume, in Hours, 1980

Depth of Mazama Ash Deposits 6,600 Years Ago

Mt St Helens 1980

Mt Mazama

Minimum Extent of Mt Mazama Ash
Superimposition with history

Spread Of The Gypsy Moth
1890-1971
Juxtaposition – “small multiples” (Tufte)
Juxtaposition with aging

Map showing dam construction from 1880 to 1998 in Oregon, with markers indicating dams constructed during specific time periods.
Juxtaposition with aging
Map + graph
Annual Graphs Of Temperature And Precipitation

*30 year average precipitation (1961-1990)
Space-time cube (Kraak, 2003)
Space-time cube (Kraak, 2003)
Fluid flow maps – 3D

http://redrock.ncsa.illinois.edu/image_89video.html
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“Fluid flow” maps

- Apparently continuous display
- John Nelson – “fluctuation”

- Field of fluid dynamics is based on conservation laws
  - Mass
  - Linear motion
  - Energy

- Web maps ⇒ simulacrum
“As a user of the Earth, Google Earth provides a safe space for unlimited voyeurism. You have instant access to forbidden or dangerous places—North Korea, Mecca, the Kremlin, the favellas of Rio, the top of Everest. But mostly it's fun to hop around. Freed from physical constraints, the Google Earther perceives the planet as small, manageable, knowable, and interconnected. This bonhomie can be exhilarating.”

- Unknown blogger
Challenges

- Clustering
- Variable duration of time steps in display - “fish eye lens” (Tobler)
- Conflation of space-time data
- Real-time data feeds
- High resolution space-time data
- …
Questions?

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