Pondering the Concept of Abstraction in (Illustrative) Visualization

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Visual Abstraction

- Omnipresent in visualization and visual arts
- Somewhat intuitively understood, formal definition not available
- Contribution to visualization theory kernel
- Abstract; Latin *abstrahere* = drawn away
Related Work

- Summary visualization
- Data and task abstraction
- Map Generalization
- Topology
- Semiotics

[Weinkauf and Theisel 2004]

[Munzner et al. 2009]

[Ruas 2008]
Abstraction is a transformation which preserves one or more key concepts and removes detail that can be attributed to natural variation, noise, or other aspects that one intentionally wants to disregard from consideration.
Visual representation is any graphical form that refers to something and can be perceived as a stimulus of the visual system and that is further processed by means of perceptual and cognitive machinery.
Definition of Visualization

Visualization is a multi-stage transformation of digital data into visual representations which are cognitively consumable by humans. The outcome of such transformation is also termed as visualization.
Visual abstraction is a concept-preserving transformation used in visual arts and data visualization, which transforms (digital) information into visual representations by removing details attributed to natural variation, noise, etc.
Aspects of Visual Abstraction
Axes of Abstraction

- **Inspiration:** abstraction in visual arts

- **Abstraction axes:** abstraction could/should be ordered, measurable

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Mondrian: Trees to Abstraction
Proposition: Data gets abstracted in various ways in visualization, controlled by users or intent.

The results are points in a multi-dimensional *abstraction space*. The control of a single attribute of visual abstraction forms an *axis of abstraction*.

from: McCloud, 1993
Groups of Abstraction Axes plus Scale
Geometric Abstraction

- change or removal of geometric elements of the visualization
- e.g., simplification (GIS), geometry relocation, topology, different representations (structural biology), dimensional projections, etc.

[Iván Viola & Tobias Isenberg]
Photometric Abstraction

- change of illumination and/or shading of depicted elements

[v. d. Zwan et al., 2011]

[Parulek et al., 2014]
Temporal Abstraction

- portrayal of dynamic/procedural phenomena as direct animation, explicit story graph, or implicit rule-based state machine.

[Image of the Matrix]

[Tanahashi & Ma, 2012]

[Liu et al., 2013]
Abstraction Across Multiple Scales

- **Proposition:** Visual abstraction as removal of details naturally connects one scale of representation with another.
- but vast ranges of scale as in biology, astronomy, etc.
  - each scale/scale transition to use unique axes & their instantiations
  - ideally, scales are connected seamlessly, visual integration of scales

[Hsu et al., 2011]
**Abstraction Spaces**

- **Proposition:** Axes are *orthogonal* to each other if the changes they cause in the visual representation are independent of each other and unique to the axis.

- **result:** *abstraction spaces*

[v. d. Zwan et al., 2011]
Abstraction Spaces

\[ \text{[Mohammed et al., 2018]} \]
Abstraction Spaces

[Mohammed et al., 2018]
Fundamental Questions

- Discrete vs. continuous (global) abstraction along an axis?

[Theisel et al., 2003]

[Everts et al., 2015]
Fundamental Questions

- Discrete vs. continuous (global) abstraction along an axis?
- Global vs. spatially local abstraction along an axis?

[Lueks et al., 2011]

[Agrawala & Stolte, 2001]
Fundamental Questions

- Discrete vs. continuous (global) abstraction along an axis?
- Global vs. spatially local abstraction along an axis?
- Independence/systematics of several axes of the same type?

[Born et al., 2010]
[Theisel et al., 2003]
[Everts et al., 2015]
Fundamental Questions

- Discrete vs. continuous (global) abstraction along an axis?
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- Independence of axes between abstraction types?

[Parulek et al., 2014]
Fundamental Questions

- Discrete vs. continuous (global) abstraction along an axis?
- Global vs. spatially local abstraction along an axis?
- Independence/systematics of several axes of the same type?
- Independence of axes between abstraction types?
- Forking of axes?

[Cipriano & Gleicher, 2007]
[v. d. Zwan et al., 2011]
Practical Opportunities for a Visual Abstraction Theory
Automatizing Visualization Design

- Selection of visual representations requires certain structuring.
- Which visual representations are in principle at hand?
- What is the appropriate level of visual abstraction having a certain intent and audience in mind?
- Visual abstraction theory can provide a scaffold for such process.

[Tietjen et al., 2005]
Uncertainty in statistics: box plot

In visual crafts: visual abstraction

Understanding visual abstraction gives us a new way to encode uncertainty in an intuitive manner

http://ottenjr02.blogspot.com/

https://pxhere.com/en/photo/1059702
Discussion

- Visual abstraction may serve a many purposes: describe, simplify, reveal, summarize, generalize, guide, categorize, interpret, explain...
- Is visual mapping equivalent to visual abstraction?
- What is a visual metaphor?
- Abstraction of visual data
- Abstraction by visual means
Without well-defined terminology we cannot build a theory.

Visual abstraction is at the heart of any visualization scenario.

To lay foundations of visualization science community effort is needed.
Thank you, and let the discussion begin!

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