InfoVis: a semiotic perspective

based on
Semiology of Graphics
by J. Bertin

Infovis is composed of

• Representation
  a mapping from raw data to a visible representation
• Presentation
  organizing this visible representation into the space available
• Interaction
  changing what is immediately viewable
Infovis is composed of

- **Representation**
  a mapping from raw data to a visible representation

- **Presentation**
  organizing this visible representation into the space available

- **Interaction**
  changing what is immediately viewable

From a communication perspective

“Communication is too often taken for granted when it should be taken to pieces.” (Fiske’91)

**Two basic schools of thought**

1. **Process**
   - the common sense approach
   - concerned with the transmission of messages
   - senders and receivers encode and decode
   - message is transmitted through some media (TV, voice, hair style, etc.)
   - to communicate is to effect another's state of mind or behaviour
   - effect should as intended, no intention -> no communication
   - involves examination of transmission and explanations of failure
   - sender responsible/ receiver viewed as quite passive
From a communication perspective

“Communication is too often taken for granted when it should be taken to pieces.” (Fiske’91)

Two basic schools of thought

2. Semiotics

• a study of signs and the cultures that use them
• a **sign** is defined as anything that stands for something other than itself
• an exchange of meaning
• recognition the understand a given set of signs differently
• alternate interpretations rather than failures
• a message is made up of signs, signs are then interpreted
• interpreter/receiver/reader rises in importance
• reading becomes active, discovering meaning, putting signs together in terms of ones background and culture
• different readings possible, in fact probable.

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Semiotics

• **semiotics** the study of signs and the cultures that use them
• a **sign** is something stands for something other than its self
• A sign can be

icon
symbol
Halloween
Christmas

index

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Representation

- A representation is
  - a formal system or mapping by which the information can be specified (D. Marr)
- For example: the number thirty-four
  - decimal: 34,
  - binary: 100010,
  - roman: XXXIV
- Different representations reveal different aspects
  - decimal: counting & information about powers of 10,
  - binary: counting & information about powers of 2,
  - roman: counting, adding

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Representations

- Good representations
  - capture essential elements of the event/world
  - deliberately leave out/mute the irrelevant
  - appropriate for the person and their interpretation
  - appropriate for the task, enhancing judgment ability
- How many buffalo?

Adapted from S. Greenberg
Representation

• Solving a problem simply means representing it so as to make the solution transparent ... *(Simon, 1981)*

• Good representations
  - allow people to *find* relevant information
  - information may be present but hard to find
  - allow people to *compute* desired conclusions
  - computations may be difficult or “for free” depending on representations

Adapted from S. Greenberg

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**Anscombe’s Quartet**

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N: 11.0
mean X's: 9.0
mean Y's: 7.5
standard error of slope estimate: 0.1
sum of squares: 110.0
regression sum of squares: 27.5
residual sum of squares of Y: 13.8
correlation coefficient: 0.8
r squared: 0.7
regression line: Y=3+0.5X

*Graphics Reveal the Data*
Bertin’s disclaimer

- **he considers**
  - printable, on white paper,
  - visible at a glance
  - reading distance of book or atlas
  - normal and constant lighting
  - readily available graphic means

Where does one start?

- **with marks!**
  - *for us, pixels?*
- **Visual Variables: how can we vary marks?**
  - by where we place them
  - by how we place them (Bertin calls this ‘implantation’)
  - by their visual characteristics (Bertin calls these retinal variables)
Visual Variables

- **position**
  - changes in the x, y, (z) location

- **size**
  - change in length, area, repetition

- **shape**
  - infinite number of shapes

- **value**
  - changes from light to dark

- **orientation**
  - changes in alignment

- **colour**
  - changes in hue at a given value

- **texture**
  - variation in pattern

- **motion**
Visual Variables

Characteristics of visual variables can be

- **selective**
  is a change in this variable enough to allow us to select it from a group?

- **associative**
  is a change in this variable enough to allow us to perceive them as a group?

- **quantitative**
  is there a numerical reading obtainable from changes in this variable?

- **order**
  are changes in this variable perceived as ordered?

- **length**
  across how many changes in this variable are distinctions perceptible?
Visual Variable: Position

- selective
- associative
- quantitative
- order
- length

Visual Variable: Size

- selective
- associative
- quantitative
- order
- length

- theoretically infinite but practically limited
- association and selection ~ 5 and distinction ~ 20

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Visual Variable: Size

- selective
- associative
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Size

points  lines  areas

Visual Variable: Shape

• selective

• associative

• quantitative

• order

• length
  - infinite

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Visual Variable: Shape

- selective
- associative
- quantitative

- order
- length
  - infinite

Shape

- Constant size variation in shape
- Quantity is read through the legend
Shape

- Points
- Lines
- Areas

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Visual Variable: Value

- selective
- associative
- quantitative

- order

- length
  - theoretically infinite but practically limited
  - association and selection \( \sim < 7 \) and distinction \( \sim 10 \)
Value

- Categories of value,
  - various degrees between black and white,
Visual Variable: Value

- Ordered, and cannot be re-ordered

Visual Variable: Value

- Value intensity can be mis-read as density
  (population of Paris)
Visual Variable: Colour

- selective
  -  
  -  

- associative
  -  
  -  

- quantitative

- order
  -  
  -  

- length
  - theoretically infinite but practically limited
  - association and selection ~ < 7 and distinction ~ 10
Colour

• Categories of colour,
  - changes in hue at equal value
Colour

points  lines  areas

Encoding

• Common advice says use a rainbow scale
  • Marcus, Murch, Healey
  • problems with rainbows
Visual Variable: Orientation

- selective
- associative
- quantitative
- order
- length
  - ~5 in 2D; ? in 3D
Visual Variable: Orientation

- selective
- associative
- quantitative
- order
- length
  - ~5 in 2D; ? in 3D

Orientation

- Categories of orientation,
  - variations is line or line-pattern ranging from the vertical to the horizontal
Orientation

points  lines  areas

Visual Variable: Texture

- selective
- associative
- quantitative
- order
- length
  - theoretically infinite
Visual Variable: Texture

- Selective
- Associative
- Quantitative
- Order
- Length

Texture

- Categories of texture,
  - changes in fineness or coarseness of the marks in an area
  - can be combined changes in characteristics
Texture

points  lines  areas

Textures
Visual Variables on a computer?

- **motion**
  - direction? speed? speed, frequency, onset, ‘personality’

- **transparency**

- **saturation**
  - colour as Bertin uses it largely refers to hue

- **flicker**
  - frequency, rhythm, appearance

- **depth**
  - occlusion, aerial perspective, binocular disparity

- **illumination**

Visual Variable: Motion

- **Selective**
  - motion is one of our most powerful attention grabbers

- **associative**
  - moving in unison groups objects effectively

- **quantitative**
  - subjective perception

- **order**

- **length**
  - distinguishable types of motion?
Visual Variable: Motion

- Selective
  - motion is one of our most powerful attention grabbers

- associative
  - moving in unison groups objects effectively

- quantitative
  - subjective perception

- order

? length
  - distinguishable types of motion?
The Plane

• Points
  - “A point represents a location on the plane that has no theoretical length or area. This signification is independent of the size and character of the mark which renders it visible.”
  - a location
  - marks that indicate points can vary in all visual variables

• Lines
  - “A line signifies a phenomenon on the plane which has measurable length but no area. This signification is independent of the width and characteristics of the mark which renders it visible.”
  - a boundary, a route, a connection

• Areas
  - “An area signifies something on the plane that has measurable size. This signification applies to the entire area covered by the visible mark.”
  - an area can change in position but not in size, shape or orientation without making the area itself have a different meaning

Information from 4 French communes

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Point Representations

Line Representations
Line Representations

Area Representations

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Area Representations

- Area proportional to size

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- Population

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- Density of population

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First group: Diagrams

- When correspondences can be established between
  - all the divisions of one component and
  - all the divisions of another

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Second group: Networks

- When correspondences can be established among all the divisions of the same component
  - and can be arranged according to geometric order

  steps
  1. record correspondences
  2. deduce simplest structure

fig. 3 - all components capable of conversing
fig. 4 - recording information
fig. 5 - organizing spatially

Supposing one group speaks, one listens - diagrams such as fig. 6 or fig. 7.

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Third group: Maps

- When correspondences can be established among all the divisions of the same component

  steps
  1. Reproduce geometric order
  2. record correspondences

fig. 9 - map of towns and roads
fig. 10 - network of this information
fig. 11 - diagram of this information

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Fourth group: Symbols

- When correspondences are not established in the representation but between the marks in the representation and the reader
  - learned
  - culturally tied - meaning comes from agreement

- diagrams, networks, maps support internal processing
- symbolism (language) relies on external processing

Traffic accident victims France 1958

- pedestrians 28,951
- bicycles 17,247
- motorcycles 74,887
- 4 wheel vehicles 63,071
Traffic accident victims France 1958

Linear Construction

- Straight line represents the total
- quantities are shown proportionally
  - fig 1 - as given
  - fig 2 - sorted horizontal
  - fig 5 - sorted vertical
  - fig. 3 - spatially proportional - partial quantities related to same base
  - fig 4. - countable representation
- uses only 1 dimension of the plane - leaves the other free for ...
Orthogonal Construction

- Spatial differentiation of parts
- Juxtapose categories with quantity
  - Fig. 6, 7 - categories horizontal, quantities vertical
  - Fig. 9 - categories vertical
  - Fig. 8 - proportion as % emphasized
  - Fig. 10 - linked categories ... trends
- Total is not portrayed but separate quantities easier to compare

Rectilinear Elevation

- Quantity is represented by area
- 2nd dimension is not used, variation in marks (v - size) is used
  - Fig. 11, 12 - areas lined up horizontally
  - Fig. 13 - diagonal arrangement
  - Fig. 14, 15 - superimposed
- Total is not portrayed but comparison of parts more difficult
Circular Construction

- Circular version of rectilinear construction
- total is portrayed
- amounts designated by angle at centre and length of circumference
  - fig 18, is fig. 5 curved
  - fig 16, 17, 19 - portion or whole circle
- comparing centre angles is easier than circumference lengths (fig 19 vs fig 18)

Polar Construction

- Polar construction is a circular version of orthogonal construction
  - fig. 20, is fig. 6 curved
  - fig. 23 - visual measure of quantity added
- total not portrayed
- parts less easily comparable
Circular Elevation

- As in rectilinear elevation areas are proportional to quantity
  - fig. 24, is fig. 11 curved
  - fig. 27 - uses area, fig 22. - uses length
  - fig. 26 area of circle, fig 23 - length of line
  - fig 25. - Nightingale Rose

References