





Glyph-Based Visualization Metrics and Formalizations

Rita Borgo Swansea University



History of Visual Communications

- Glyph = Greek γλυφή, glyphē, "carving"
- Symbols: unit of knowledge representation
 - Paleolithic Age, 18000 BC
- Pre-writing:
 - Petroglyphs
 - Hard-wired in human brain ([EM91])
 - Pictograms
 - Ideograms
 - Logograms







Visual Communications Today...

Pictograms and Ideograms today





Theory of Signs and Sign Systems

SIGN = STIMULUS PATTERN + MEANING



- Semiosis (*Peirce*, [PB55]): process by which a culture produces signs and attributes specific meanings.
- Semeiotic (*Eco* [Eco 79]): the science of signs, into the conditions which are necessary in order for representations of objects to function as signs.



Semeiotics: Theory of Signs and Sign Systems

• Semiosis (*Peirce*, [PB55]): process of cooperation between signs, their objects, and their "interpretants" (mental rep.)



Sign Systems: Icons, Indices and Symbols

- Sign Classification (*Peirce* [Pei55]):
 - Icons: resembles the quality of the object its stands for
 - Functional Domain: items all share topological similarity with the object they are related.
 - Examples: images, metaphors and diagrams.
 - Indices: demonstrates the influence of its object (sensory feature)
 - Functional Domain: abstractions that rely on a physical cause/effect relation with the object to which they relate to.
 - Examples: clock, thermometer, fuel gauge.

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- Symbols: is interpreted a reference to its object
 - Functional Domain: abstractions which rely on a code conventionally used in order to determine meaning.
 - Examples: mathematical symbols, alphanumeric characters.







Sign Systems - Codes

- Code: framework within which signs assume a meaning.
- Coding:
 - one of the fundamental concepts in semiotics and
 - represents a deterministic functional relation between a *signifier* and a *signified*.
- Codes (*Chandler* [Cha02]):
 - Social: verbal languages, body language, commodity and behavioural codes.
 - Textual: scientific, aesthetic, rhetorical, media.
 - Interpretative: ideological and perceptual codes (visual perception).







Sign and Glyphs

• Are Glyphs signs?



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WWW.Eg.ol

A Formal System: Semiotic Algebra and Grammar

- Algebra: signs are always part of a formal system (Saussure [SBSR83], Goguen [Gog03]):
 - Sorts (subparts of a sign):
 - colour, location, size;
 - hierarchical relationships: inheritance, partial ordering etc.;
 - constructor rules:
 - whole/part relationships
 - generate complex signs = sorts + additional features;
 - importance rank = partial ordering between constructors.
- Grammar: syntax of visual signs by Bertin [Ber83]
 - First attempt using formal rules.
 - Six visual primitives (fundamental visual variables).
 - Each primitive rated in function of the signified datasets.







fuzziness

transparency

orientation

WWW.EE.OTE

Design Pipeline and Metrics

- Design Space: Pettersson [Pet10] "the main goal in information design is clarity of communication; in order to fulfil this goal, all messages must be accurately designed, produced and distributed, and later correctly interpreted and understood by members of the intended audience."
- Design Metrics: Eco [Eco79] "a general semiotic theory should include not only a theory of how codes may establish rules for systems of signification but a theory of how signs may be produced and interpreted to clarify aspects of communications."



Design Space – Perceptual Codes

- Perceptual Codes:
 - Gestalt Principles
 - Proximity (> colour similarity)
 - Similarity
 - Continuity (> colour similarity)
 - Closure
 - Symmetry
 - Figure/Ground:
 - Area (or surroundedness), symmetry, parallelism, extremal edges.
 - Prägnanz (simplest always favoured)

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Design Space – Visual Channels

- Visual Channels:
 - Primitive visual representations to convey variable values: colour, size, shape, orientation.
 - Retinal Variables (Bertin [Ber83])
 - Visual Encoding Variables
 (*Ware* [War04])
 - Taxonomy by Chen and Floridi [CF12]:
 - Geometric
 - Optical
 - Topological/Relational

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• Semantic

Colour > Size > Shape > Orientation

Geometric Channels	Optical Channels	Topological and Rela- tional Channels	Semantic Channels
 size / length / width / depth / area / volume orientation / slope angle shape curvature smoothness 	 intensity / brightness colour / hue / saturation opacity / transparency texture (partly geometric) line styles (partly geometric) focus / blur / fading shading and lighting effects shadow depth (implicit / explicit cues) implicit motion / motion blur explicit motion / animation / flicker 	 spatial location connection node / internal node / terminator intersection / overlap depth ordering / par- tial occlusion closure / contain- ment distance / density 	 number text symbol / ideogram sign / icon / logo / glyph / pictogram isotype

Visual Channels Taxonomy [CF12]



Design Criteria – Metaphoric Associations

- Maguire et al. [MRSS*12]:
 - Semantic Relevance:
 - Semantic criteria: associative, selective, ordered and quantitative (Bertin, [Ber83]).
 - Familiarity can support selectivity with almost any shape.
 - Channel Composition:
 - Glyphs likely to feature a number of visual channels.
 - Constructive composition may affect how individual channels are perceived.
 - Measurable Euclidean Distances.
 - Pop-out Effects:
 - Identification of a target within a few nanoseconds of initial exposure to the visual search space.
 - Visual Hierarchy:
 - visual system strategies (top-down, bottom-up) vs.
 - saliency of features



Design Criteria – Visual Orderability

- Chung et al. [CLP*13]:
 - Typedness
 - Visual Orderability
 - Channel Capacity
 - Separability
 - Searchability
 - Learnability
 - Attention Balance
 - Focus and Context

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 - → Pop-out Effects
 - Visual Hierarchy





Design Criteria – Normative Ratings

Measurements and Norms (*McDougal* [MdBC00])

- Criteria:
 - Concreteness
 - Visual Complexity
 - Meaningfulness
 - Familiarity
 - Sematic Distance
- Relationship between:
 - Concreteness vs. visual complexity
 - Concreteness vs. meaningfulness
 - Meaningfulness vs. familiarity vs. semantic distance

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- Quantifiable Metrics:
 - Subjective Rating
 - Icon-based metrics: sum of the components of an icon such as letters, lines, arrows etc.
 - Automatic visual measure: image analysis of icon features such as edge detection, perimeter determination etc.

Are Glyphs just Signs?

- Glyphs ⊂ Signs
- Signs: well established theory
 - Semeiotics: Formal System
- Glyph: well established practice
 - Design Space
 - Design Metrics
- Is that all folks?
 - Before: Ad-hoc methods based on intuitions
 - Now: metrics meets challenges (field mature enough)







