Modelling Languages: (mostly) Concrete (Visual) Syntax

Hans Vangheluwe

http://msdl.cs.mcgill.ca/
The Structure of Modeling Languages

Bran Selić

Modelling Languages/Formalisms
Syntax and Semantics

Concrete Formalism F
Modelling Languages/Formalisms
Syntax and Semantics
Textual Languages

“This sentence is very short”

• Individual letters in an alphabet
• Combined into words
• Combined into sentences in a language

• Valid letters in words specified by regular expressions
• Valid words in a language specified by a grammar

• letters/words are combined by “is to the right of”
The Spoofax Language Workbench

Rules for Declarative Specification of Languages and IDEs

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syntax-directed editor
(textual concrete syntax)
syntax-directed editor
(visual concrete syntax)
Visual Languages
A Classification Framework to Support the Design of Visual Languages

G. Costagliola*, A. Delucia†, S. Orefice‡ and G. Polese*
Graph

Visual Languages
Connection Types

(a)  (b)  (c)  (d)
Iconic
\[ \frac{\sqrt{x+y+z}}{2} - t \]
Visual Language Classes

- Connection
  - Graph
  - Plex

- Geometric
  - Box
  - Iconic
  - String
Hybrid Languages

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POLICY TIER
DEFINITION TIER

CALENDAR-FORM METAPHOR
COMBINATION LOCK METAPHOR

Visual Languages
Syntax-directed Visual Editors: model behaviour
Syntax-directed Visual Editors: model behaviour
Generate Syntax-directed Visual Editors

Visual Languages
Syntax-directed Visual Editors: freehand (early stages of multi-domain project)
Different Media:
Gestural Interaction, Sound, ...
The “Physics” of Notations: Towards a Scientific Basis for Constructing Visual Notations in Software Engineering

Daniel L. Moody, Member, IEEE
Introduction

- Visual notations pre-date textual ones
- Visual notations are important for Modelling and Software Engineering
- Humans are excellent pattern recognizers
- Need cognitively efficient and effective notations.

Cognitive effectiveness = speed, ease and accuracy with which a representation can be processed by the human mind
Introduction/Rationale

Visual notations are often introduced without underlying theory or rationale.

```
Physics'' of Notations
```

Many visual notations for same concepts.

No rigorous way to compare effectiveness and hence no clear design goal.
Communication Theory

``Physics'' of Notations
Encoding: 8 visual variables to (graphically) encode information

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<th>PLANAR VARIABLES</th>
<th>RETINAL VARIABLES</th>
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<td>Horizontal Position</td>
<td>Shape</td>
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<td>Vertical Position</td>
<td>Brightness</td>
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<td>Orientation</td>
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<td>Texture</td>
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</table>

- **Shape**: circle, square, triangle
- **Brightness**: low, medium, high
- **Size**: small, medium, large
- **Orientation**: 0°, 45°, 90°
- **Colour**: red, green, blue
- **Texture**: different patterns
Decoding

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Physics'' of Notations
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Appropriate notations »
offload some of the burden from cognitive to perceptual

Note: “dual channel theory”:
auditory/verbal channel and visual/pictorial channel are processed in parallel

Principles for Designing Efficient and Effective Visual Notations

``Physics'' of Notations
Semiotic Clarity (semiotics = study of signs and sign processes)

```
Physics'' of Notations
```
Perceptual Discriminability

``Physics'' of Notations
(a) Divers programming Aqua2 during pool trials.
(b) A diver programming Aqua2 during an HRI trial held at a lake in central Québec.

c) Example of command acknowledgement given on the LED screen of the Aqua2 robot during field trials.

Perceptual Discriminability

should be easy to **distinguish** visual symbols

ability to distinguish is determined by **visual distance**
larger visual distance » faster, more accurate recognition

- **number** of visual variables on which they differ and the **magnitude** of the differences
- **shape** is the main visual variable
Perceptual Discriminability

Software Engineering notations mostly use rectangle variants

Use **redundant** visual encoding to **increase distance** (e.g., textual + visual)
Semantic Transparency

The meaning of a symbol can be inferred from its appearance (intuitive).

Symbols can be:
Semantic Transparency: semantically immediate symbols

``Physics'' of Notations
Semantic Transparency

```
Physics'' of Notations
```
Semantic Transparency

The meaning of a symbol can be inferred from its appearance (intuitive)

Symbols can be:

- Semantically Immediate
- Semantically Opaque

Software Engineering notations are usually abstract (non-intuitive)
Semantic Transparency: semantically perverse symbols

``Physics'' of Notations
Semantic Transparency

The **meaning** of a symbol can be **inferred** from its **appearance** (intuitive)

Symbols can be:

- Semantically Immediate
- Semantically Opaque
- Semantically Perverse

Domain-specific icons and visual arrangement should be intuitive
Complexity management (# elements in diagram » cognitive overload)
Modularization/Hierarchy

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Physics'' of Notations
```
Cognitive Integration (different notations)

- Conceptual integration (coherent mental model)
- Enable navigation and transition between notations

``Physics'' of Notations
Visual Expressiveness

Number of visual variables used (UML, mostly shape, no colour)

8 degrees of visual freedom (0 = non-visual – 8 = visually saturated)
Visual Expressiveness

Different visual variables have **different capacity** to encode information

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<th>Power</th>
<th>Capacity</th>
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Dual Encoding

Combine **Textual** and **Visual**

**Supplement** rather than duplicate (e.g., multiplicity values)

*Graphical encoding* | *Textual encoding* | *Dual coding (graphics + text)*
---|---|---
0..1 \[\rightarrow\] 3..15 | 0..1 | 3..15

**Reinforce** meaning
Graphic Economy

- Not too many symbols. If many, provide **legend**
- Limit on human discrimination capability (6 levels per variable)
- Upper limit on graphic complexity

How?
Cognitive Fit

Adapt choice of visual notation to
• Task
• Audience (novices vs. experts)

Adaptation may be dynamic ("learn" about Task/User proficiency)

Representation medium matters
## Interactions among principles

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