From Function to Form

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Separation FORM from CONTENT
The Semiotic Triangle

- **Sense**: the sense made of the sign;
- **Sign vehicle**: the form of the sign;
- **Referent**: what the sign 'stands for'.

http://www.aber.ac.uk/media/Documents/S4B/semiotic.html
Applied Semiotics

http://users.bestweb.net/~sowa/peirce/ontometa.htm

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The function-form mapping problem

implemented functions

perceivable user interface forms

intended semantic

perceived semantic

DMM := designer’s mental model

UMM := user’s mental model
What is User-System Interaction about?

Goal:
Actual Performance
=>
Desired Performance
The interface architecture

socio-technical system
Three different function types

Primary functions
[application manager]

Secondary functions
[dialog manager]

Tertiary functions
[dialog manager]

Application object(s)
The function space

function space
FS

perceptible functions
PF

PFs of the
dialog manager
PDF

PFs of the
application manager
PAF

hidden functions
HF

HFs of the
dialog manager
HDF

HFs of the
application manager
HAF

set of all possible
function representations
RF

δ α
Information types

- **Physical**
  - **Static**
    - States
    - Descriptive
    - Relationships
    - Spatial
  - **Dynamic**
    - Discrete action
    - Continuous action
    - Events
    - Procedural
    - Causal

- **Conceptual**
  - **Static**
    - States
    - Descriptive
    - Relationships
    - Values
  - **Dynamic**
    - Discrete action
    - Continuous action
    - Procedural
    - Causal

Examples:
- Person sleeping
- Features of a computer
- Similarity between twins
- Dimensions of a room
- Switch light on
- Ski turn
- Start of a race
- Repair photocopier
- How an engine works
- Evidence is uncertain
- Person’s belief
- Classes of religious belief
- Prime numbers
- Choosing to agree/disagree
- Monitoring success
- Diagnosing a fault
- Explanation of gravity
The three important mappings

<table>
<thead>
<tr>
<th>User’s world</th>
<th>device</th>
<th>pixel world</th>
<th>semantic</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="User" /></td>
<td><img src="image2" alt="Device" /></td>
<td><img src="image3" alt="Pixel" /></td>
<td>function-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>function-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>function-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>...</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>function-n</td>
</tr>
</tbody>
</table>
## Button-Function Mapping (1)

### Recommended Controls for Functions

<table>
<thead>
<tr>
<th>Function Category</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selecting mutually exclusive options</td>
<td>Radio buttons</td>
</tr>
<tr>
<td>Selecting non-exclusive options</td>
<td>Check boxes</td>
</tr>
<tr>
<td>Performing an action</td>
<td>Command buttons</td>
</tr>
<tr>
<td>Selecting an item from a set</td>
<td>List boxes or drop-down list boxes</td>
</tr>
<tr>
<td>Entering or viewing large amounts of information at the same time</td>
<td>Tables</td>
</tr>
<tr>
<td>Setting attribute values</td>
<td>Text-entry fields</td>
</tr>
</tbody>
</table>

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![Example images of controls and functions](image-url)
Button-Function Mapping (2)

Examples from http://edocs.bea.com/wlintegration/v2_1/devplug/appgui.htm
Historical Trends for Icon Design

- Four different levels of abstraction can be found over the last 80 years.
- Actual icons get more abstract compared to the past.
An Icon Set for Different Sports

Exercise:
try to find out the different kind of sport represented by each icon.
An Icon Set for a Way-finding System
The Meaning of Icons

- The numbers in the table mean the percentage of all collected answers; each intended answer is underlined.

The Icon Set for Marshalling Signals

- [redrawn from Henry Dreyfuss, Symbol Sourcebook (New York, 1972), p. 152]
Redesign of Icons (1)

- Design Principle:
  - avoid excessive detail in icon design.

Redesign of Icons (2)

- **Design Principles:**
  - design the icons to communicate object relations and attributes whenever possible;
  - accompany icons with names.

Affordances introduced by Gibson

The Idea of ‘Affordances’

“What we perceive when we look at objects are their affordances, not their qualities”

An affordance is a collection of properties “taken with reference to the observer”.

An affordance is “neither an objective property nor a subjective property; or it is both if you like … It is equally a fact of the environment or a fact of behaviour”.

The Perceptual Prototype

• Which shape represents the most typical bird?
The Concept of Natural Mappings

• **Definition** [see Norman, D., 1988, p. 75ff]:
  
  – A design solution based on a natural mappings reduces the need for additional explanatory information in memory!
  
  – Natural mappings guarantee a minimum number of cognitive transformation steps.
  
  – If a design depends upon labels, it may be faulty. Labels are important and often necessary, but the appropriate use of natural mappings can minimize the need for them. Wherever labels seem necessary, consider another design!
Design of Light Switch Panels

- Problem:
  - no direct mapping between switches and corresponding lamps
Design of Door Handles (1)
Design of Door Handles (2)

Open-pull

Open-push
Screenshot from Kai Krause's Photo Soap
Mac example of affordances
the complete action cycle

Feed-back information

feedback control of action

goal-, subgoal-setting

Feed-forward information

planning of execution
selection of means

mental operation

physical operation

synchronisation in space

synchronisation in time
## The History of Usability Definitions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>suitability for the task</td>
<td>suitability (activity adapted)</td>
<td>suitability for the task</td>
</tr>
<tr>
<td>self-descriptiveness</td>
<td>feedback about system states</td>
<td>self-descriptiveness</td>
</tr>
<tr>
<td>conformity with user expectations</td>
<td>appropriate format and pace of information presentation</td>
<td>conformity with user expectations</td>
</tr>
<tr>
<td></td>
<td>information and instruction of</td>
<td>suitability for learning</td>
</tr>
<tr>
<td></td>
<td>ease of use applicable to</td>
<td>suitability for</td>
</tr>
<tr>
<td></td>
<td>hearing and participation of</td>
<td>individualization</td>
</tr>
<tr>
<td>controllability</td>
<td></td>
<td>controllability</td>
</tr>
<tr>
<td>error robustness</td>
<td></td>
<td>error tolerance</td>
</tr>
</tbody>
</table>
Mapping form to expertise

Benefit

high

visual representation

textual representation

concrete representation

low

knowledge and experiences in application domain
### Media selection and combination

<table>
<thead>
<tr>
<th>Information type</th>
<th>Preferred media selection</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Realistic still or moving image</td>
<td>Photo of a person</td>
</tr>
<tr>
<td>Conceptual</td>
<td>Text or speech, designed image</td>
<td>Explain sales policy</td>
</tr>
<tr>
<td>Descriptive</td>
<td>Text, speech, realistic image</td>
<td>Chemical properties</td>
</tr>
<tr>
<td>Spatial</td>
<td>Realistic/designed image</td>
<td>Diagram of a building</td>
</tr>
<tr>
<td>Value</td>
<td>Text/tables/numeric list(s)</td>
<td>Pressure reading</td>
</tr>
<tr>
<td>Relationship</td>
<td>Designed images, graphs, charts</td>
<td>Histogram of rainfall/month</td>
</tr>
<tr>
<td>Procedural</td>
<td>Image series, text</td>
<td>Evacuation instructions</td>
</tr>
<tr>
<td>Discrete action</td>
<td>Still image</td>
<td>Make coffee</td>
</tr>
<tr>
<td>Continuous action</td>
<td>Moving image</td>
<td>Monoeuvres while skiing</td>
</tr>
<tr>
<td>Events</td>
<td>Sound, speech</td>
<td>Fire alarm</td>
</tr>
<tr>
<td>States</td>
<td>Still images, text</td>
<td>Photo of weather conditions</td>
</tr>
<tr>
<td>Causal</td>
<td>Still &amp; moving image, text, speech</td>
<td>Video of rainstorm causing flash flood</td>
</tr>
</tbody>
</table>
### Examples for media design

<table>
<thead>
<tr>
<th></th>
<th>representational</th>
<th>abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>visual</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• <strong>concrete</strong></td>
<td>picture, e.g.</td>
<td>speed → speedometer, e.g.</td>
</tr>
<tr>
<td></td>
<td><img src="speedometer.png" alt="Speedometer" /></td>
<td></td>
</tr>
<tr>
<td>• <strong>signified</strong></td>
<td>symbol, e.g.</td>
<td>danger → alarm flasher, e.g.</td>
</tr>
<tr>
<td></td>
<td><img src="symbol.png" alt="Symbol" /></td>
<td>blue light of a police car</td>
</tr>
<tr>
<td><strong>auditory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• <strong>verbal</strong></td>
<td>speech, e.g.</td>
<td>speech, e.g.</td>
</tr>
<tr>
<td></td>
<td>&quot;Stop the machine!&quot;</td>
<td>&quot;Attention, please!&quot;</td>
</tr>
<tr>
<td>• <strong>spatial</strong></td>
<td>onomatopoeia and mimic,</td>
<td>tone, e.g.</td>
</tr>
<tr>
<td></td>
<td><em>e.g. event generated</em></td>
<td>beep-beep-beep…</td>
</tr>
<tr>
<td></td>
<td><em>sound pattern</em></td>
<td></td>
</tr>
</tbody>
</table>
Ideas of Edward Tufte

This map drawn by Charles Joseph Minard portrays the losses suffered by Napoleon’s army in the Russian campaign of 1812. Beginning at the left on the Polish-Russian border near the Niemen, the thick band shows the size of the army (442,000 men) as it invaded Russia. The width of the band indicates the size of the army at each position. In September, the army reached Moscow with 100,000 men. The path of Napoleon’s retreat from Moscow in the bitterly cold winter is depicted by the dark lower band, which is tied to temperature and time scales. The remains of the Grande Armée struggled out of Russia with 10,000 men. Minard’s graphic tells a rich, coherent story with its multivariate data, far more enlightening than just a single number bouncing along over time. Six variables are plotted: the size of the army, its location on a two-dimensional surface, direction of the army’s movement, and temperature on various dates during the retreat from Moscow. It may well be the best statistical graphic ever drawn.
Literature map — foundations of quantitative graphics

Foundations of quantitative graphics

Semiology of graphics
Bertin [9,8]

Collections of graphical techniques
Tukey & Tukey [104]
Schmid [91]
Chambers et. al. [18]
White [108]
Pettersson [74]
Cleveland [23]

Theory of graphical perception
Cleveland & McGill [24]
Cleveland [22]

Tuft's trilogy
Tuft [101,102,103]

Experimental classification of images
Loth et. al. [62]
Literature map — automated design of graphics

- Foundations of quantitative graphics

Automated design of graphics

- Automated design of presentations (APT) by Mackinlay [63]

Task analytic approach (BOZ) by Casner [17]

Extended data characterisation (SAGE) by Roth & Mattis [89]

Literature map — scientific visualization concepts

Foundations of quantitative graphics

Visualisation idioms
Haber & McNabb [45]

Fibre bundle data model
Butler & Pendley [15]
Butler & Bryson [13]
Haber, Lucas & Collins [46]

Automated design of graphics

Problem-oriented matrix of techniques
Wehrend & Lewis [107]
Why Metaphors...

- Domain knowledge
- Metaphorical description
- Common sense knowledge
- Basic concepts
- Common sense
- Domain specific
What is a Metaphor?

"The rock is getting brittle with age."

geological expert

literal interpretation

professor emeritus

metaphorical interpretation

[Ortony, 1979; Lakoff & Johnson, 1980; Kittay, 1984]
Wellknown Metaphors...

desktop
office
room
geospatial information system (GIS)

euclidean
- virtual 3D

symbolic
- link structure

semantic ?
concept ?
lay out ?
A Method for Metaphor generation / elicitation

steps of development...

1.) epistemological basis
2.) selection procedure of the domain expert
3.) selection criteria of the 'metaphor engineer'
4.) criteria for metaphor extraction / identification
5.) mapping rules of metaphor to design
GUI versus NUI/TUI: interaction models
Ullmer & Ishii, 2000

INPUT / OUTPUT

physical

digital

INPUT

OUTPUT

control

model

view

control

graspable representation

Non graspable representation

model

INPUT / OUTPUT

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Design Metaphors

- Tool
- Channel
- Substitute

long time ago 2000 history
Trend in Interface Design
Design Styles

1900

mechanical style

electronic style

2000

mechatronic style

time
Design Forms

mechanical style
- dedicated form
  - (e.g. typewriter, etc)

electronic style
- channel forms
  - (e.g. PC, TV, Radio, etc)

mechatronic style
- active forms
  - (smart memory alloys)
- connected forms
  - (ambient intelligence)
- given forms
  - (ubiquitous computing)

time
- 1900
- 2000
Interaction Props with Active Form

unloaded state  
Nitinol tubes  
loaded state