Meaning, Mapping & Correspondence in Tangible User Interfaces

CHI '07 Workshop on Tangible User Interfaces in Context & Theory

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A Solid Diagram Metaphor for Tangible Interaction

Alan Blackwell, Cecily Morrison & Darren Edge: University of Cambridge

• Technical paradigms of UbiComp are founded on *implicit metaphors* of interaction design:

<table>
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<tr>
<th>Ubicomp Paradigm</th>
<th>Demonstrates Technology</th>
<th>Founded on Metaphor</th>
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<tbody>
<tr>
<td>Conversational NLP</td>
<td>NLP</td>
<td>Conduit</td>
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<tr>
<td>Inference</td>
<td>Sensing &amp; Machine Learning</td>
<td>Sentience &amp; Context</td>
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<tr>
<td>Solid Diagram Sensing</td>
<td>Sensing</td>
<td>Notation</td>
</tr>
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• *Solid Diagrams* provide a human-centric approach to the specification of *abstract data structures* in the physical world.
Tangible Interaction in a Mobile Context


- Many multimedia computing devices are portable
  - Mobile phones, Music players, Video players
- Opportunity to support tangible interaction “on the spot”
- Design experiments:
  - Linking mobile devices to tangible surfaces
  - Bimanual interaction with mobile devices
  - Interaction with small articulated tangibles
Putting TUIs in Context: A Unifying Framework for Next Generation HCI

Michael Horn, Orit Shaer, Audrey Girouard, Leanne Hirshfield, Erin Treacy Solovey, Jamie Zigelbaum*, Robert Jacob: Tufts University, *MIT Media Lab

• *Reality-Based Interaction (RBI)* takes advantage of
  – Interfaces *like* the real world
  – Interaction *in* the real world

• Design should consider the *Power—Reality* tradeoff
  – Favour realistic features over unrealistic
  – Use unrealistic to increase “power”
  – Use analogies for unrealistic
Generative Design Methods for the Tangible Social Interfaces (TSI)

Pamela Jennings: Carnegie Mellon University

• **Constructed Narratives** is a TSI for collaborative design
• Tangible blocks generated from *Shape Grammars*
• Interaction:
  – Users log in profile of self-id, origins, environment & values
  – Users construct a physical 3D block model
  – Links sensed and fed into semantic engine
  – Visual semiotics seed WordNet searches
  – Results printed on a digital 3D model
Meaning, Mapping & Correspondence

• Meaning
  – User interpretation of the world

• Mapping
  – Relationship between the physical and the digital
  – “Physical : Digital”

• Correspondence
  – Deriving meaning from perceptions of the world
  – “Shown : Meant”
Spatial Mapping

- **Physical Arrangement → Digital Interpretation**
- *Style of Mapping* (Ullmer & Ishii: Emerging Frameworks)
- *TAC Paradigm* (Ullmer; Shaer, Leland, Calvillo & Jacob)
- *Spatial Syntactic Relations* (Engelhardt: Language of Graphics)
  - **Solid Diagrams**
    - “Examples of structural diagrammatic relations in the world include registering which objects are touching which other object, and which objects are contained within particular spatial regions”
  - **Personalization**
    - “Many TUI projects demonstrate spatial layout as a means to intentional physical personalization”
Action Mapping

• Physical Input → Digital Output

• Indirection (Beaudouin-Lafon: Instrumental Interaction)
  – Hybrid Interaction
    • References Embodiment (Fishkin: TUI Taxonomy)
  – Five Properties
    • Behavioural mapping “temporal and spatial contiguity”

• Compatibility (Beaudouin-Lafon: Instrumental Interaction)
  – Five Properties
    • Behavioural mapping “covariation”
Attribute Mapping

• **Physical Attributes → Digital Information**

• **Coherence** (Koleva et al.: TUI Framework)
  
  – **Five Properties**
  
    • “Perceptual mappings are coherent when there is a direct correspondence between the surface or visual physical and digital properties of a tangible interface”

• **Integration** (Beaudouin-Lafon: Instrumental Interaction)

• **Multiplexing** (Fitzmaurice: Graspable UIs)
Temporal Mapping

- Physical Specification → Digital Behaviour

- *Abstraction & Notation* (Blackwell)
  - Solid Diagrams
    - “Most [implicit metaphors of interaction] focus on the immediate effect of communication to provoke system action or change of state. A further alternative is for the user to specify the structure of the required behaviour, rather than directly specifying the required actions”
Visual Correspondence

- **Visual Appearance → Action Possibility**
- **Affordance** (Gibson: Ecological Perception, Norman: POET)
  - Five Properties
    - “Perceptual affordances are opportunities for action within the environment for individuals with suitable sensory-motor skills”
  - Hybrid Interaction
    - “Sensorial affordances”
  - Mobile Context
    - “The size, form and controls on the [mobile phone] case afford certain kinds of interaction in themselves”
Tactile Correspondence

- Tactile Experience → Action Performance
- *Feedback* (Norman: POET)
  - Personalization
    - “Favourite ping-pong paddle”
    - “Emphasis on material properties could open up new avenues of physical personalization”
Representation Correspondence

- **Physical Representations → Conceptual Roles**
- *Iconic vs Symbolic* (Dourish: Where the Action Is)
  - Five Properties
    - “Semantic mapping between physical and digital representations may be literal, analogical, or metaphorical”
  - Augmented Toys
    - “Semantic mapping between the (virtual) role or function of an object and its appearance”
    - “Semantic distinction... can also [be] established by metonymic association”
  - Reality-Based
    - Interaction *like the real world*
Relation Correspondence

- **Object Relations → Conceptual Relations**
- *Preconceptual Image Schemata* (Lakoff: Spatialization of Form)
- **Indexical**
  - Everyday Manipulation
    - “Things that matter are close. Things that are close matter”
    - “Human everyday strategy to arrange objects in the real world into places”
  - Reality-Based
    - Information organization *in the real world*
### MAC Analysis

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<tr>
<th>More Physical</th>
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<th>Correspondence</th>
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<tbody>
<tr>
<td>More Digital</td>
<td>Spatial</td>
<td>Tactile</td>
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<td></td>
<td>Attribute</td>
<td>Visual</td>
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*Mapping and Correspondence (MAC) Analysis in TUI design is analogous to Cognitive Walkthrough in GUI design*
Discussion Points

• Utility
  – Conceptual level
  – Completeness

• Usability
  – Terminology selection
  – Examples

• Integration
  – Experience, Expectations and Learning
  – Needs, Activities and Context