## 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:

Ubicomp ParadigmDemonstrates TechnologyFounded on MetaphorConversationalNLPConduitInferenceSensing & Machine LearningSentience & ContextSolid DiagramSensingNotation

• Solid Diagrams provide a human-centric approach to the specification of abstract data structures in the physical world

#### Tangible Interaction in a Mobile Context

Alan Blackwell, Gareth Bailey, Ignas Budvytis, Vincent Chen, Luke Church, Lorisa Dubuc, Darren Edge, Mattias Linnap, Vilius Naudziunas & Hugh Warrington: *University of Cambridge* 

- 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)



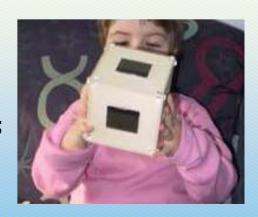
### Temporal Mapping

- 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

	Mapping	Correspondence
More Physical	Spatial	Tactile
	Attribute	Visual
	Action	Relation
More Digital	Temporal	Representation

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