PIBA-DIBA or How to Blend the Digital with the Physical

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TUls are Hybrid UIs

Tangible User Interface aims at a different direction from GUI by using tangible representations of information that also serve as the direct control mechanisms of the digital information. By representing information in both tangible and intangible forms, users can more directly control the underlying digital representation using their hands.

Tangible Representation as Control

Figure 4 illustrates this key idea of TUI to give tangible (physical and graspable) external representation to the digital information. The tangible representation helps bridge the boundary between the physical and digital worlds. Also notice that the tangible representation is computationally coupled to the control of the underlying digital information and computational models. Urp illustrates examples of such couplings, including the binding of graphical geometries (digital data) to the physical building models, and computational simulations (operations) to the physical wind tool. Instead of using a GUI mouse to change the location and angle of graphical representation of a building model by pointing, selecting handles and keying in control parameters, an Urp user can grab and move the building model to change both location and angle.

Intangible Representation

Although the tangible representation allows the physical embodiment to be directly coupled to digital information, it has limited ability to represent change in many material or physical properties. Unlike malleable pixels on the computer screen, it is very hard to change a physical object in its form, position, or properties (e.g. color, size) in real-time. In comparison with malleable “bits”, “atoms” are extremely rigid, taking up mass and space.

To complement this limitation of rigid “atoms”, TUI also utilizes malleable representations such as video projections and sounds to accompany the tangible representations in the same space to give dynamic expression of the underlying digital information and computation. In Urp, the digital shadow that accompanies the physical building models is such an example.

The success of a TUI often relies on a balance and strong perceptual coupling between the tangible and intangible representations. It is critical that both tangible and intangible representations be perceptually coupled to...
Input Space 1
  e.g. Interaction with Physical Objects

Input Space 2
  e.g. Interaction with Digital Objects

Blended Space
  e.g. Hybrid Physical-Digital Interaction

Fauconnier & Turner (1998)
Blended Space

Optimality principles
Metaphor

Input Space 1
e.g. Interaction with Physical Objects

Input Space 2
e.g. Interaction with Digital Objects

Blended Space
e.g. Hybrid Physical-Digital Interaction
Input Space 1
e.g. Interaction with Physical Objects

Input Space 2
e.g. Interaction with Digital Objects

Blended Space
e.g. Hybrid Physical-Digital Interaction

PIBA-DIBA lists
Input Space 1
e.g. Interaction with Physical Objects

Input Space 2
e.g. Interaction with Digital Objects

Blended Space
e.g. Hybrid Physical-Digital Interaction

Haptic properties of objects enable eyes-free manipulation

Objects can be easily copied
## PIBA-DIBA

<table>
<thead>
<tr>
<th>Physical is better at</th>
<th>Digital is better at</th>
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<tr>
<td>Physical matter (atoms)</td>
<td>Binary substance (bits)</td>
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<tr>
<td>Spatial extent (extension within physical reality)</td>
<td>Non-void extent (memory space)</td>
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<tr>
<td>Spatial position (unique)</td>
<td>Ubiquitous (no unique position)</td>
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<tr>
<td>Spatial locality (surrounding objects)</td>
<td>Referential locality (object references, links)</td>
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<td>Analogue interaction alphabet</td>
<td>Digital interaction alphabet</td>
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Israel, Hurtienne & Weber (2012)
### Invoices in Inbox

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PIBA:
Manipulable, tangible feedback, use of sensorimotor skills

DIBA:
Simple processing and change of visual attributes
### Editing and Posting Invoices

**Belegkopf**
- **Name:** Festzeitbetriebe
- **Oracle:** Kasseler Str. 50
- **Ort:** DE
- **Referenz:** R050729
- **Belegdatum:** 29.03.2007
- **Buchungskreis:** 0100
- **Buchungsdatum:** 20.04.2007
- **Belegtyp:** KR

**Geschäftspartner**
- **Kreditur:** 726108
- **USt:**

**Steuern & Summen**
- **Währung:** EUR
- **Bruttobetrag:** 404,84
- **Steuerkennz:** VR 19,00%
- **Mehrw. st:** 64,64
- **USt:** Ungepl. NebKost. 0,00

**Positionen**
- **Sachkonto:** M467000
- **Nettobetrag:** 340,20

**Zahlung**
- **Belegdatum:** 20.03.2007

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**Text:**
- **Festmobiliar t...**
- **Nettobetrag:** 340,20
- **S. Mehr...** Mehrwertsteuer 64,64
PIBA: simple grasping of pen, analogue manipulation

DIBA: Simple copying, editing, deleting, saving of discrete information
PIBA: Manipulable, tangible feedback, use of sensorimotor skills, coding of meaning

DIBA: Simple sending of information
Using PIBA-DIBA

= product design + software engineering

Decide

Analyze

Evaluate

Justify

Teach & educate
Does the Digital Take Over?