Tangible Bits

Designing the Seamless Interface between People, Bits, and Atoms

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At the Border

Where the land meets the sea, there is a border.
Living at the Border

Harsh, but also fertile environment.

At the Border
between Physical and Digital

*We live on the border where bits meet atoms. In the flood of pixels from the ubiquitous GUI screens, we are losing our sense of body and places. Pixels impoverish human senses.*
My Art Work in 1959

Shared Drawing in 1992

Collaborative Visual Thinking

speak
gesture
point
read
write
draw
**ClearBoard**
Seamless integration of interpersonal and shared drawing spaces

Ishii and Kobayashi, 1992

**Seamless Media Design - Kids**
TED 4 @ Kobe, 1993 & DOP 2 @ Amsterdam, 1994

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Seamless Media Design
TED 4 @ Kobe, 1993 & DOP 2 @ Amsterdam, 1994

QuickTime™ and a decompressor are needed to see this picture.

PDA in 1958 - Abacus
Eyes are in charge, but hands are underemployed.

Tangible User Interfaces

• Giving physical forms to digital information, making bits
  – directly manipulable with our hands
  – perceptible through our peripheral senses
• Seamless coupling between digital and physical worlds.
Ambient Media in Nature

water, sand, wind, light, shadow, cloud

Pinwheels: wind of bits
Ren, Frei, Dahley, Wisneski, and Ishii, 1997-2000

- Ambient information display spinning in a "wind of bits."
- Architectural space will be an ambient interface between humans and online digital information.
Pinwheels: wind of bits
Ren, Frei, Dahley, Wisneski, and Ishii, 1997-2000

Water Lamp: rain of bits
Dahley and Ishii, 1997

Water ripple shadow created by a "rain of bits."
ambientROOM
Architectural Space as Interface

Ripple shadows on ceiling

Light projection on side wall

Bottles as containers of bits

Open a bottle to release bits into air

Ambient sound of rain drops

Clock to navigate time

QuickTime™ and a decompressor are needed to see this picture.
inTouch: Haptic Interpersonal Communication Medium

"Reach out and touch someone."

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inTouch: Tangible Telepresence
Brave, Dahley, Frei, Su, and Ishii, 1998

“Synchronized Distributed Physical Objects” create an illusion of touching the same object using force-feedback technology.

inTouch-0: mechanical mockup
inTouch-1: early electronic prototype
inTouch-2: distributed prototype

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inTouch: Haptic Interpersonal Communication Medium

“Ghostly Presence”

- **tangible telepresence**
  - Movement of local objects suggests the *physical presence* of remote users.

- **traditional remote collaboration systems**
  - Remote users remain isolated behind computer screen.

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**PSyBench**  
**Brave, Bulthaup, Ishii, 1998**

Physically Synchronized Workbench for Remote Collaborative Design (very early crude prototype)

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**Curlybot**  
**Frei, Su, Ishii, 2000**

A toy that can record and playback physical motion.

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Curlybot
Frei, Su, ishii, 2000

- Children readily establish an affective and body syntonic connection with curlybot.
- They can develop intuitions for concepts such as differential geometry, through play away from a traditional computer.

Coincidence of input and output spaces

inTouch 98
interpersonal communication
curlybot 00
computation / mathematics and expression / narrative

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Painted Bits (GUI)

General input devices as remote-controllers of intangible representation (pixels on a screen)

Tangible Bits (TUI)

Tangible representation as interactive control mechanism to manipulate the information represented in both tangible and intangible forms
Triangles:
Physical / Digital Construction Kit
Gorbet, Orth and Ishii, 1998

- Physical embodiment of digital information topology
- Tactile feedback of digital connection from magnetic edge connectors
- Physically persistent representation

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Evolution of Table 1996-2002
Towards “Tangible Collaborative Thinking”

1997
I/O Bulb

1999
PingPongPlus

1997-8 Light

1998-9 Urp

2000 Luminous Table

2001-2 Senseboard

2000-2 Sensetable

1996-7 metaDESK

2001-2 Clay

metaDESK and Tangible Geospace
Ullmer and Ishii, 1997

phicons
(physical icons)

activeLENS

passiveLENS

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metaDESK and Tangible Geospace
Ullmer and Ishii, 1997

I/O Bulb and Luminous Room
Underkoffler and Ishii, 1997 - 1999

- I/O Bulb
  - High resolution output, two-way information
- Luminous Room
  - Multiple I/O bulbs illuminating architectural space

- Give life to architectural surfaces and physical objects.
- Enable direct manipulation of digital world by grasping and manipulating objects with digital shadows.
Urp:
Urban Planning Workbench

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.
Luminous Room
with multiple I/O Bulbs

Distributed Illuminating Light

Integration of Tangible and Intangible Representations
Luminous Table
in Urban Design Studio at MIT

Urban Planning Workbench used in the spring 2000 / 2001 MIT courses

QuickTime™ and a Video decompressor are needed to see this picture.

Luminous Table
in Urban Design Studio at MIT

Urban Planning Workbench used in the spring 2000 / 2001 MIT courses

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Sensetable
Patten, Ishii, Pangaro, 2000

- TUI platform to track multiple objects and their states on a table with video projection
- System Dynamics simulation for Supply Chain Analysis

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Sensetable
James Patten & Hiroshi Ishii

- TUI platform to track multiple objects and their states on a table with video projection

- Applications
  - Music “Audiopad” in collaboration with Ben Recht
  - System Dynamics simulation for Supply Chain Analysis
  - Chemistry

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.
Actuated Workbench
Dan Maynes-Aminzade and Gian Pangaro & Hiroshi Ishii

- Magnetic forces to move objects on a table in two dimensions.
- Augment existing “Sensetable” providing an additional physical dynamic display capability.

Applications
- Synchronization of distributed “Sensetables” in realtime remote collaboration
- Clearing up inconsistencies that arise from the computer’s inability to move the objects on the table
Senseboard

Jacob, Ishii, Pangaro, Patten 2001

- TUI platform to allow users to arrange small magnetic pucks bound to digital data and function on a grid of tag readers with video projection
- Application: organizing and grouping information

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Senseboard

Jacob, Ishii, Pangaro, Patten 2001 (video)

QuickTime™ and a decompressor are needed to see this picture.

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**Illuminating Clay**  
**Piper, Ratti, and Ishii  2001**

- Physical Clay as Input and Output Surfaces for Landscape Simulation  
  - land erosion, visibility, shadow casting, etc.
- 3D Laser Scanner + Video Projector

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**Illuminating Clay**  
**Piper, Ratti, and Ishii  2001 (video)**

QuickTime™ and a decompressor are needed to see this picture.
Illuminating Clay
Ben Piper, Carlo Ratti & Hiroshi Ishii

• 3-D Tangible Interface for Landscape Analysis
  1. Physical Manipulation
  2. 3-D Capture
  3. Computational Analysis
  4. 3-D Projection

QuickTime™ and a decompressor are needed to see this picture.
Evolution of Table 1996-2002
Towards “Tangible Collaborative Thinking”

1996-7 metaDESK
1997 I/O Bulb
1997-8 Light
1998-9 Urp
2000 Luminous Table
2000-2 Sensetable
2001-2 Senseboard
2001-2 Clay
1999 PingPongPlus

PingPongPlus
Ishii, Lee, Wisneski, Orbanes 1999

- Digital augmentation of ping pong play with "reactive table."
- Ball tracking using microphone array underneath table.
- From competition to collaboration
PingPongPlus
Ishii, Lee, Wisneski, Orbanes 1999

QuickTime™ and a decompressor are needed to see this picture.

musicBottles
Ishii, Fletcher, Mazalek, Lee, Choo, Berzowska, Paradiso, 98-00

Transparency of an interface that weaves itself into the fabric of everyday life.
**musicBottles**
Ishii, Fletcher, Mazalek, Lee, Choo, Berzowska, Paradiso, 98-00

- Glass bottles as "containers" and "controls" for digital information
- Seamless extension of metaphors and physical affordances into the digital domain

**musicBottles (jazz)**

QuickTime™ and a decompressor are needed to see this picture.
musicBottles (techno)

QuickTime™ and a decompressor are needed to see this picture.

musicBottles (classical)

QuickTime™ and a decompressor are needed to see this picture.
Origin: Weather Bottle

• Present for my mother
• Model: soy sauce bottle in her kitchen

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Tangible Bits

- Reconciliation of our dual citizenship in the worlds of bits and atoms.
- Interaction Design
  - informed by sciences (HCI),
  - materialized by technologies (CS, EE, ME), and
  - shaped by industrial design, media arts and practical real-world applications.
Design?

Conceptual “eyeglasses”
– Inspire people’s imagination and creativity

Acknowledgments

• Tangible Media Group
  Graduate students and UROPs
• Things That Think, Digital Life @ MIT Media Lab
• Friends in ACM SIGCHI, SIGGRAPH, IDSA, ICSID
• Ars Electronica Center, NTT-InterCommunication Center
Thanks!

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Research?

- Increment
  - Local optimization
  - Solve known problems
  - Reflection-driven
- Secure home
  - Orthodox
  - Established discipline
  - Homogeneity
## Research?

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<th>No</th>
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<tbody>
<tr>
<td>• Innovation</td>
<td>• Increment</td>
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<tr>
<td>– Mutation</td>
<td>– Local optimization</td>
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<td>– Identify new problems</td>
<td>– Solve known problems</td>
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<td>– Invention-driven</td>
<td>– Reflection-driven</td>
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<tr>
<td>• No home</td>
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<tr>
<td>– Heterodox - heretic</td>
<td>– Orthodox</td>
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<td>– Inter-disciplinary</td>
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<td>– Diversity</td>
<td>– Homogeneity</td>
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## I.C.I.C.S at UBC

- Highly interdisciplinary
  - Enjoy identity crisis.
  - Appreciate diversity.

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I.C.I.C.S at UBC

• Highly interdisciplinary
  – Enjoy identity crisis.
  – Appreciate diversity.

• New vision, no roadmap
  – Invent new paradigms, rather than do incremental work, because life is short.

• Success is a danger
  – Do not stop. Keep redefining yourself.
Drawing Instruments
What we have lost in the flood of PCs

Aesthetics which value haptic interaction with specialized physical objects ... but much richness has been lost.

Eyes are in charge, but hands are underemployed.

"By pointing, by pushing and pulling, by picking up tools, hands act as conduits through which we extend our will to the world. They serve also as conduits in the other direction: hands bring us knowledge of the world. Hands feel. They probe. They practice."

Malcolm McCullough
“Abstracting Craft: The Practiced Digital Hand ” 1996
Tangible Bits Research

- Started as Scientific Study (Human-Computer Interaction) in ACM SIGCHI & SIGGRAPH in 1996
- Developed Technologies to implement and test ideas
- Design and Arts

Thanks!

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http://tangible.media.mit.edu/
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Principles of Tangible Interface Design (1)

Coincidence of input and output spaces

inTouch 98
interpersonal communication
curlybot 00
computation / mathematics and expression / narrative
Principles of Tangible Interface Design (2)

Augmentation of existing objects

Bottles 99 containers

Principles of Tangible Interface Design (3)

• Integration of tangible and intangible representations

I/O bulb
Oullim

- Aufheben (German)
- People, Bits, and Atoms
  - Body, Cyberspace, and Physical Space
- Arts, Design, Sciences, and Technologies
  - Analysis and Synthesis

Tangible Bits Exhibition
June 23 - July 9, 2000
NTT InterCommunication Center (ICC), Tokyo, Japan
Bottles as Interface

The core concept utilizes glass bottles as "containers" and "controls" for digital information. Physical manipulation of the bottles - opening and closing - is the primary mode of interaction with digital information.

Senseetable & Senseboard as Generic TUI Platforms

TUI Applications
- Supply Chain Vis.
- Urban Planning
- others

TUI Application Program Interface

Senseetable / Senseboard Hardware
Get in Touch Exhibition
September 2001 - August 2002
Ars Electronica Center, Linz, Austria

“The Computer for the 21st Century”

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

Mark Weiser
July 23, 1952 - April 27, 1999
Tangible User Interfaces

- Giving physical forms to digital information, making bits
  - directly manipulable with our hands
  - perceptible through our peripheral senses
- Seamless coupling between digital and physical worlds.

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Designing the Seamless Interface among People, Bits, and Atoms

Redesigning the Future
11/9/01, Tokyo

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