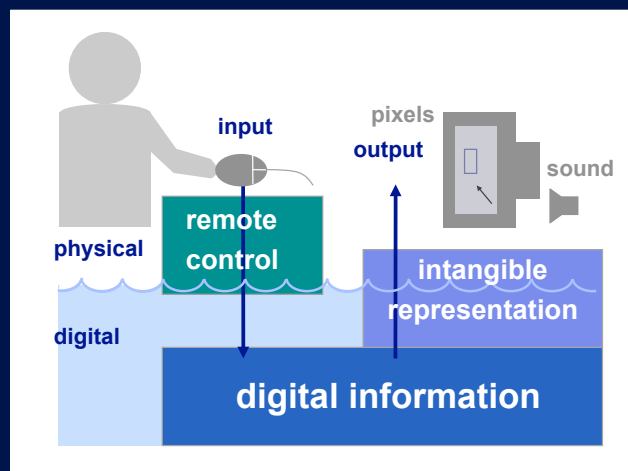


MAS.834 Tangible Interfaces

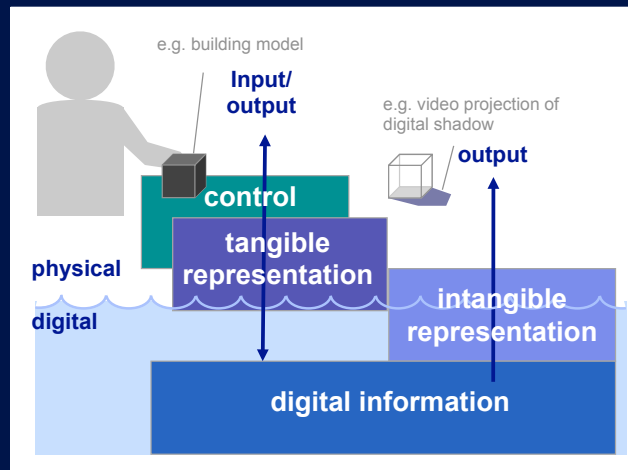
Painted Bits (GUI)

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



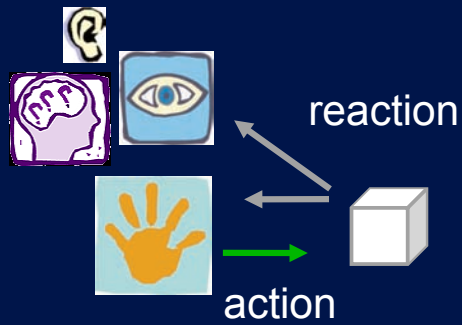
Tangible Bits (TUI)

Tangible representation as interactive control mechanism to manipulate the information represented in both tangible and intangible forms



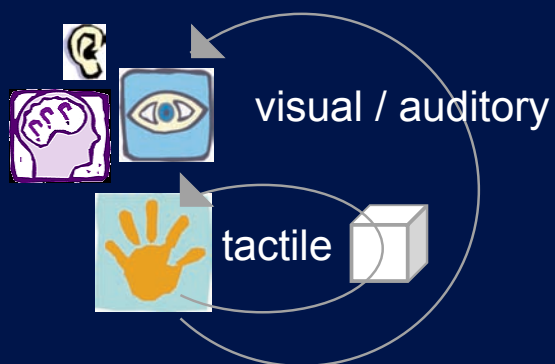
Double Interaction

Physical Interaction



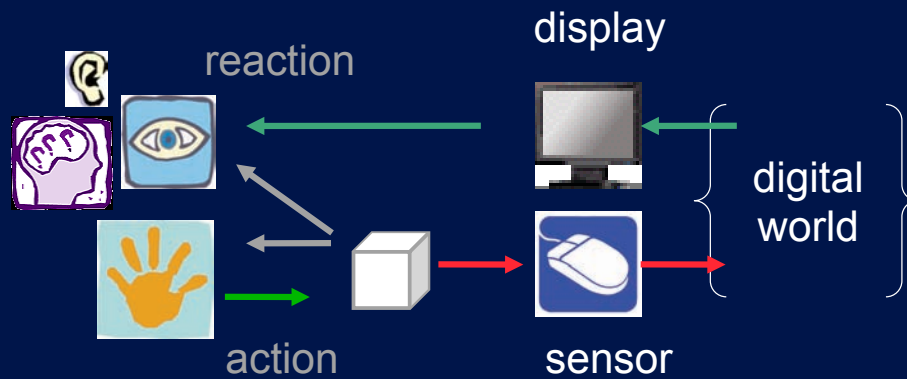
Physical Interaction

Physical Interaction



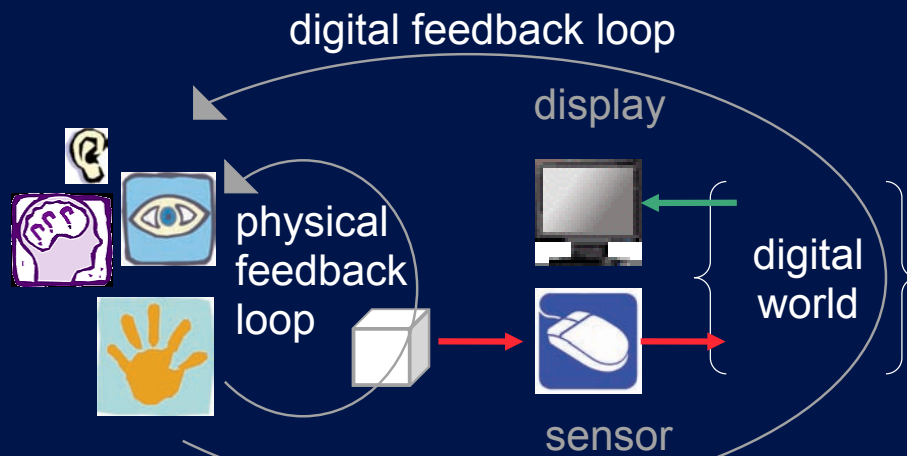
Physical Interaction

Double Interaction Loops: Physical and Digital



Physical Interaction + Digital Interaction

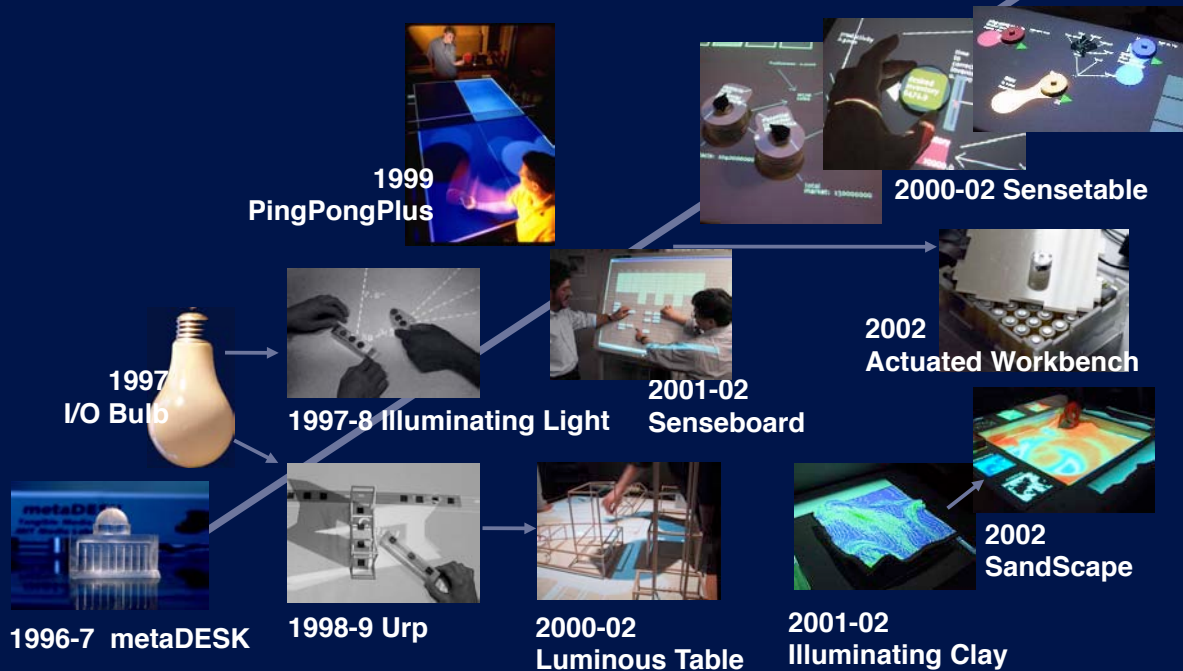
Double Interaction Loops: Physical and Digital



Physical Interaction + Digital Interaction

5 workbench

Evolution of Workbench for Collaborative Design and Tangible Thinking



光影

digital light & shadow

I/O Bulb and Luminous Room

Underkoffler and Ishii, 1997 - 1999

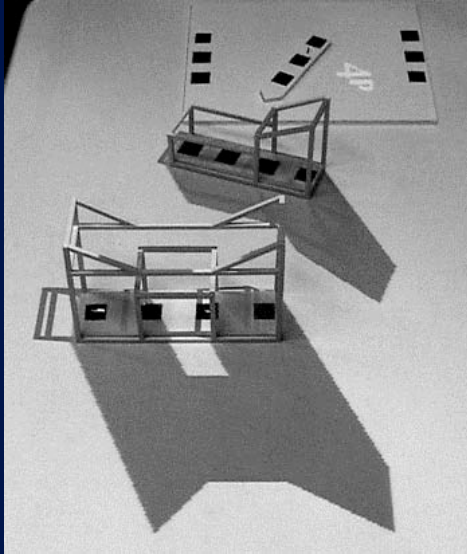
- **I/O Bulb**
 - High resolution output, two-way information
- **Luminous Room**
 - Multiple I/O bulbs illuminating architectural space
- **Give life to architectural surfaces and physical objects.**
- **Enable direct manipulation of digital world by grasping and manipulating objects with digital shadows.**



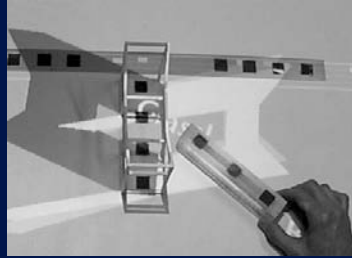
Urp:

Urban Planning Workbench (an I/O Bulb AP)

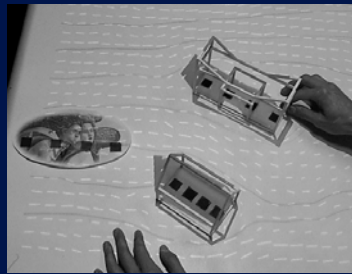
Underkoffler and Ishii, 1997 - 1999



digital shadows



light reflections

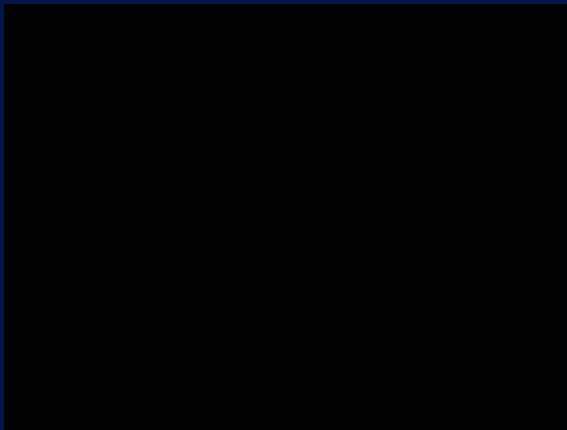


wind

Urp:

Urban Planning Workbench

Underkoffler and Ishii, 1997 - 1999

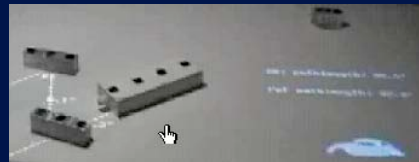


Luminous Room with multiple I/O Bulbs

Underkoffler and Ishii, 1997 - 1999

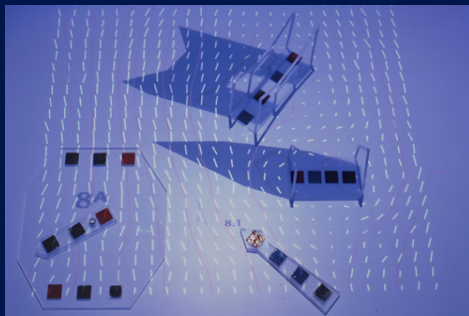


Distributed Illuminating Light



Integration of Tangible and Intangible Representations

Principle of Tangible Interface Design



Urp 99

Luminous Table

in Urban Design Studio at MIT

Ben-Joseph, Ishii, Underkoffler, Chak, Yeung, Piper, 1999-2001

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



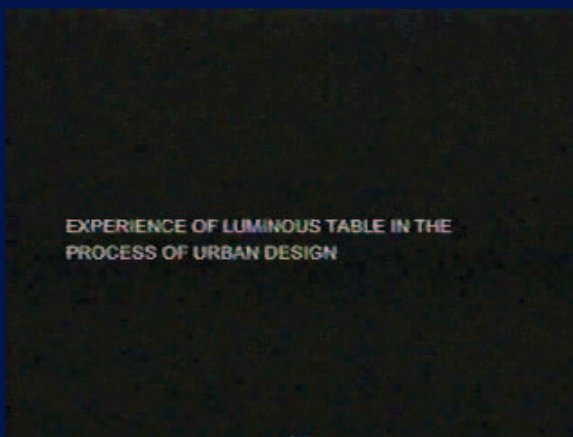
video



Luminous Table

in Urban Design Studio at MIT

Ben-Joseph, Ishii, Underkoffler, Chak, Yeung, Piper, 1999-2001



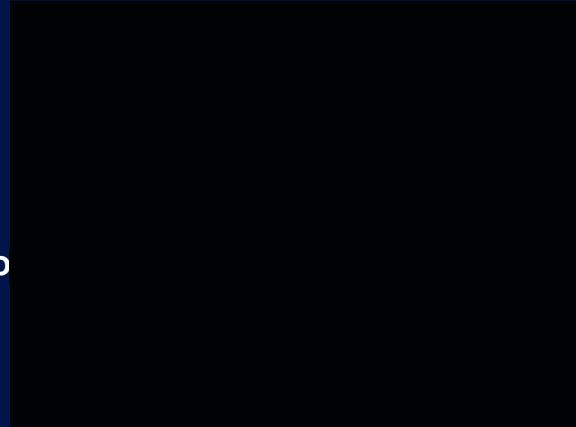
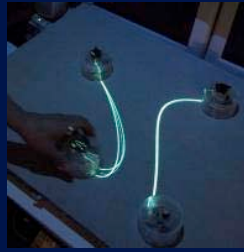
Urban Planning Workbench used in
the spring 2000 / 2001 MIT courses



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



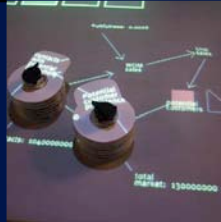
Business

System Dynamics Simulation for Supply Chain Analysis

Patten, Hines, Malone, Murphy-Hoye & Ishii 00-03

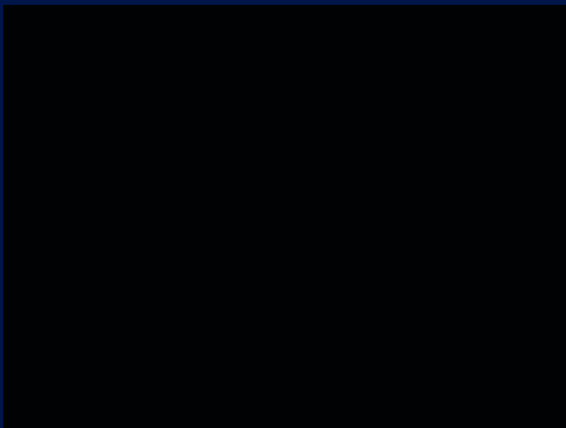


Collaboration with Intel
and MIT Sloan School

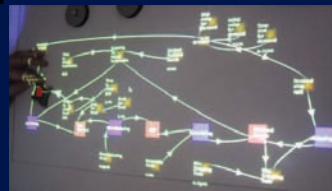


System Dynamics Simulation for Supply Chain Analysis

Patten, Hines, Malone, Murphy-Hoye & Ishii 00-03

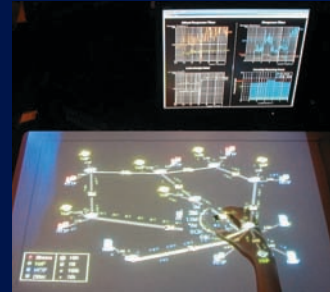


Collaboration with Intel
and MIT Sloan School



IP Network Design Workbench NTT Comware + TMG

- Event-Driven Simulation + NTT Comware's network design consulting expertise
- TUI supports cooperative direct manipulation of IP Network simulator.



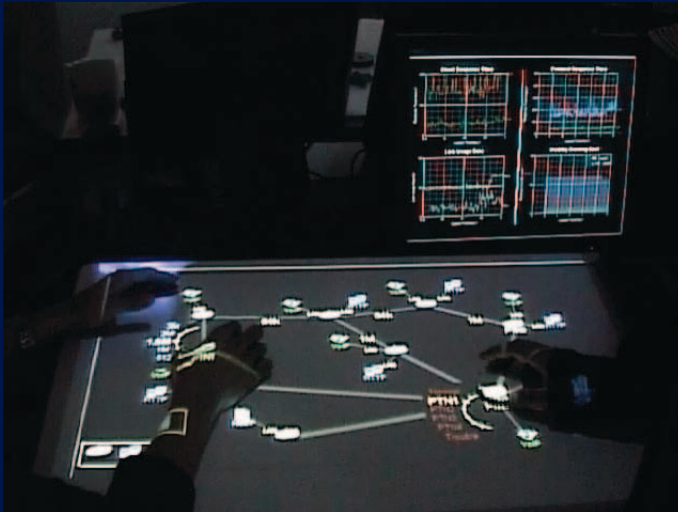
IP Network Design Workbench: NTT Comware + TMG (sensetable)

- Based on Event-Driven Simulation Engine and NTT Comware's NW consulting expertise
- This workbench helps designers to evaluate the effects of changing topology, bandwidth, server location in real time, to optimize the network performance.
- TUI supports cooperative direct manipulation of IP Network simulator.

IP Network Design Workbench

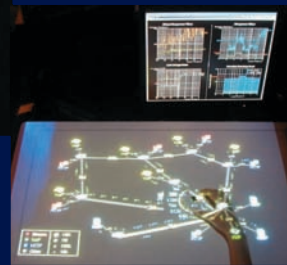
NTT Comware R&D Dept.
MIT Media Lab., Tangible Media Group

IP Network Design Workbench NTT Comware + TMG



- Event-Driven Simulation
- TUI supports cooperative direct manipulation of simulator to evaluate the effects of changing topology, bandwidth, server location in real time, to optimize the network performance.

Thanks to Mr. Kase, Mr. Hirano, Mr. Narita, Ms. Kobayashi, Mr. Tanaka, and many other NTT Comware people.



BusinessWeek Nov. 3, 2003



Data Workbench

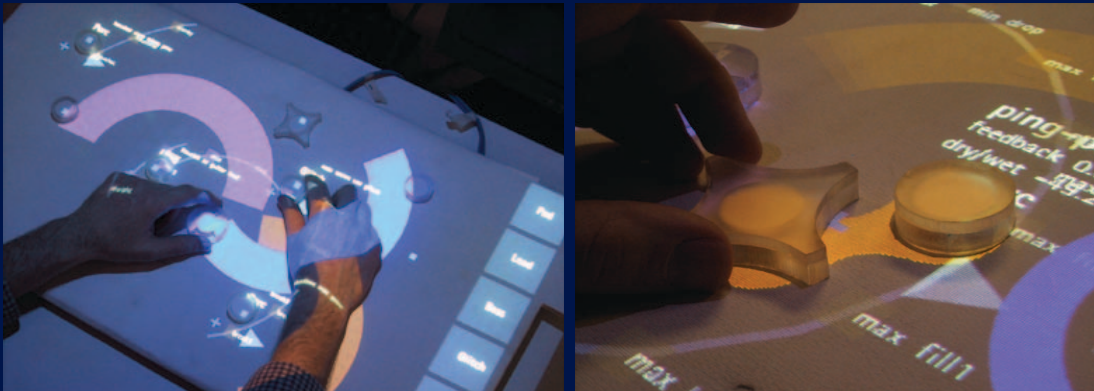
Want to upgrade your company's computer network—or redesign it from scratch? This "senseable" has a built-in antenna that reads what's happening to objects on the table representing network routers, storage systems, mail servers, and the like. The data are transmitted to a computer that instantly remodels the network and projects the new design. Additional information about the cost and capacity of the upgraded network is displayed on screens.

音樂

music

Audiopad

James Patten and Ben Recht (Physics & Media)



- A new way to perform electronic music.
- Designed to combine the expressive power of traditional musical instruments with the modularity of a computer
- Based on the Sensetable project.

Audiopad

James Patten and Ben Recht* (*Physics & Media Group)



- A new way to perform electronic music.
- Designed to combine the expressive power of traditional musical instruments with the modularity of a computer
- Based on the Sensetable project.

Sensetable: TUI Platform + Applications

TMG

TMG + Intel + Sloan

NTT Comware + TMG

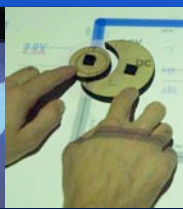
Applications



Urp
[fluid dynamics]



Audiopad



CircuiTUI



Supply Chain Visualization
[System Dynamics]

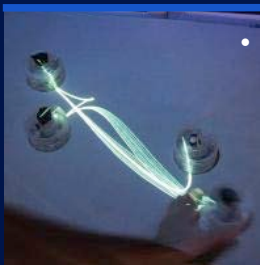


IP Network Designer
[Event Driven Sim]



Business Process Analyzer
[Event Driven Sim]

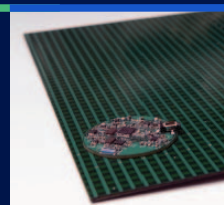
Hardware platform



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



NTT Comware Sensetable Product 2003



Patten Studio

駆動

Actuation

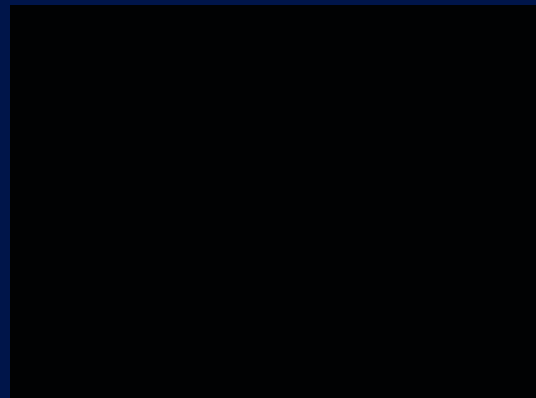
Actuated Workbench

Dan Maynes-Aminzade, Gian Pangaro & Hiroshi Ishii 02



Function

Magnetic forces to move objects on a table in two dimensions.

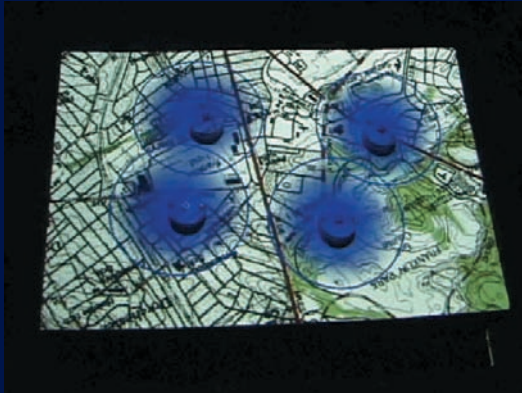


Application

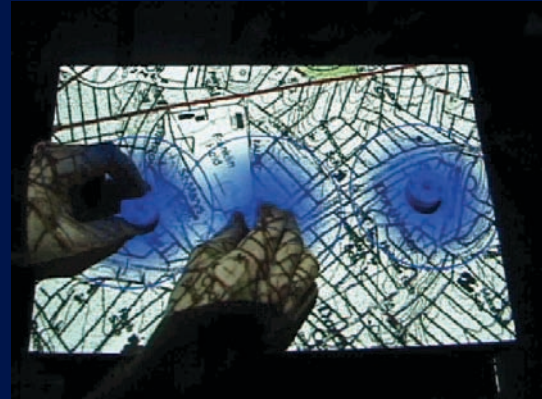
Augment existing “Sensetable” providing an additional physical dynamic display capability.

Actuated Workbench

Dan Maynes-Aminzade and Gian Pangaro & Hiroshi Ishii 02-03



without actuation



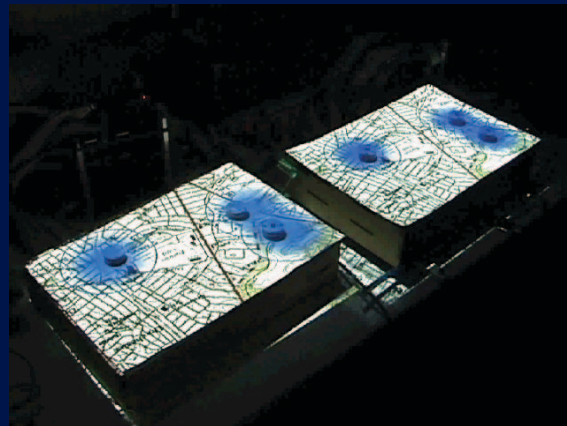
with actuation

Application 1

- Clearing up inconsistencies that arise from the computer's inability to move the objects on the table

Actuated Workbench

Dan Maynes-Aminzade and Gian Pangaro & Hiroshi Ishii 02-03

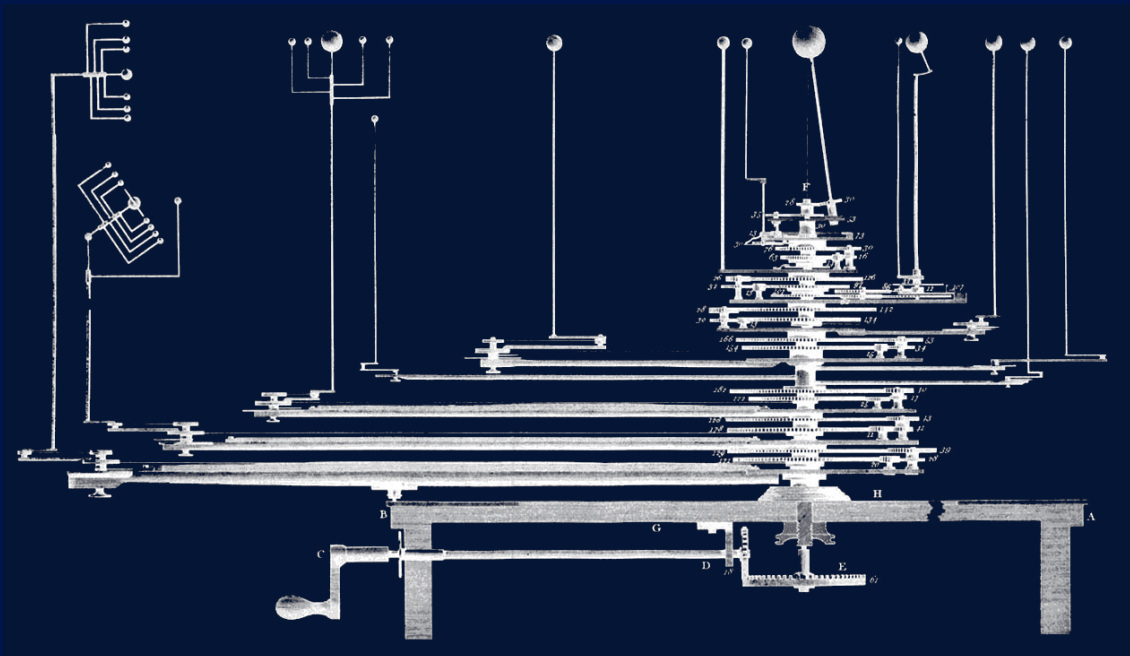


- Synchronization of distributed “Sensetables” in realtime remote collaboration

触考

Tangible Thinking

Mechanical Representation of Knowledge: Orrery

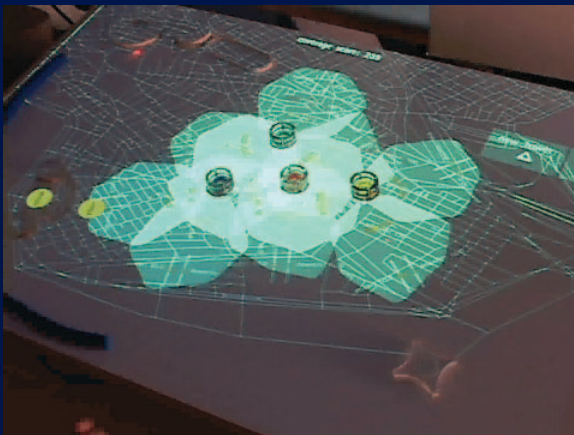


機械 制約

Mechanical Constraints

PICO Interaction Techniques

James Patten and Hiroshi Ishii CHI 2007



legible



flexible

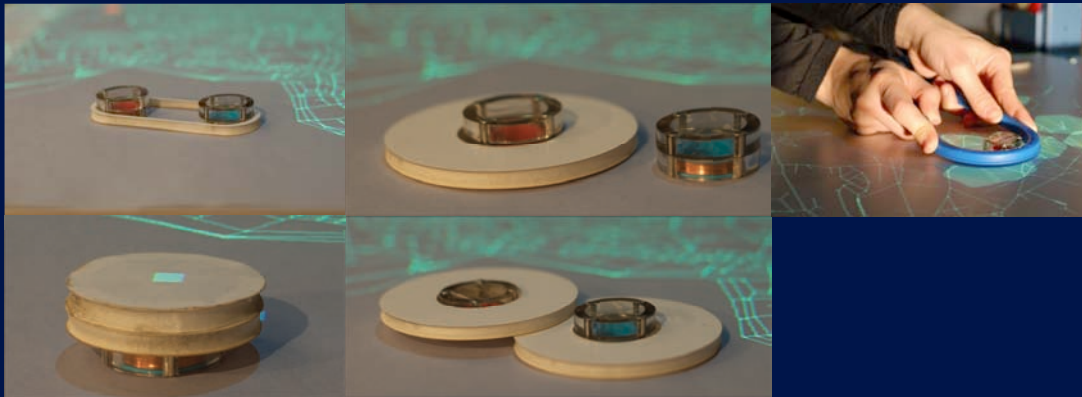


ad hoc

Mechanical constraints, coupled with computer-controlled actuation, provide a novel and effective way to interact with computers.

Mechanical constraints

Guiding the motion of physical objects to guide the computational process



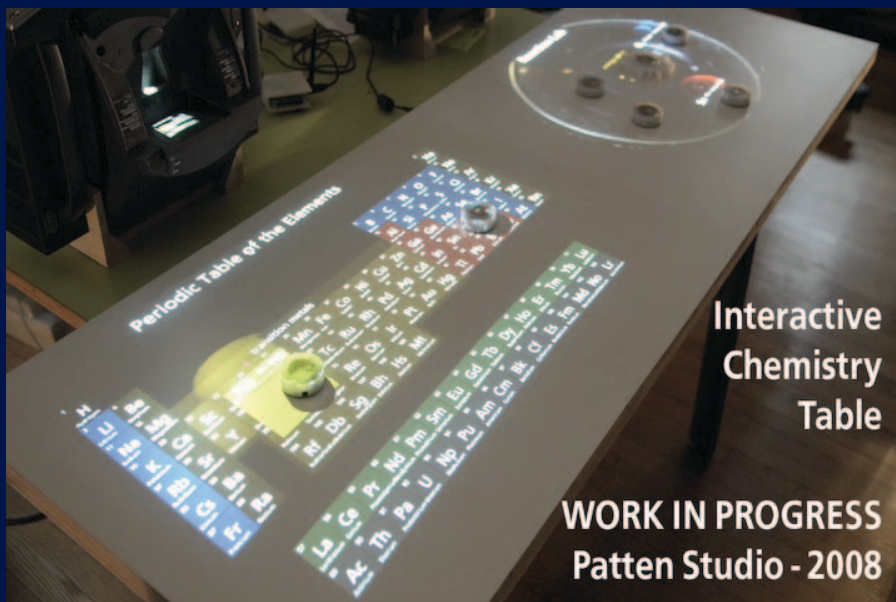
Mechanical constraints

- legible
- flexible
- ad hoc



Sensetable

James Patten, Patten Studio

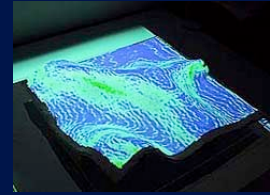


3D連続

3D Continuous

Illuminating Clay

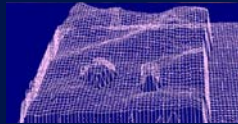
Ben Piper, Carlo Ratti & Hiroshi Ishii 01



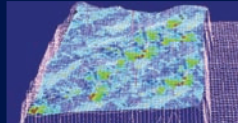
- 3-D Tangible Interface for Landscape Analysis



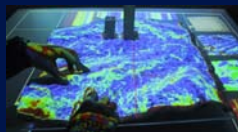
1. Physical Manipulation



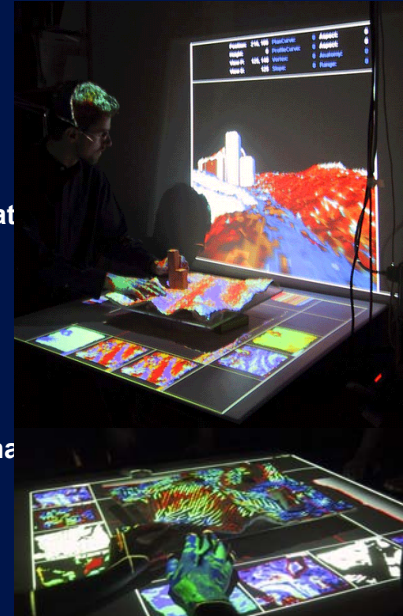
2. 3-D Capture



3. Computational Analysis

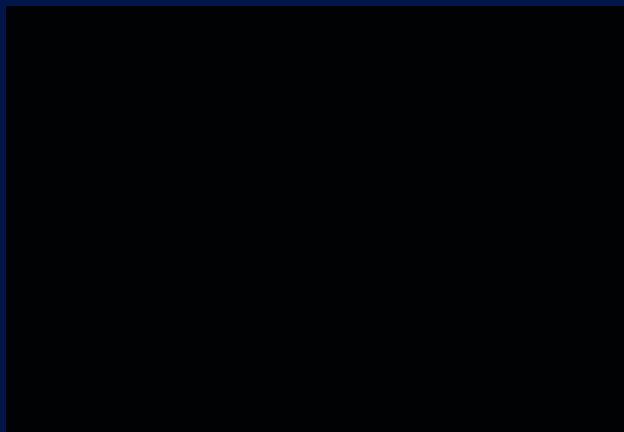


4. 3-D Projection

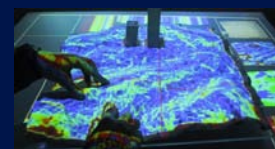
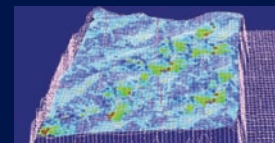
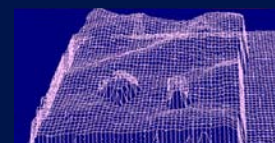


Illuminating Clay

Ben Piper, Carlo Ratti & Hiroshi Ishii



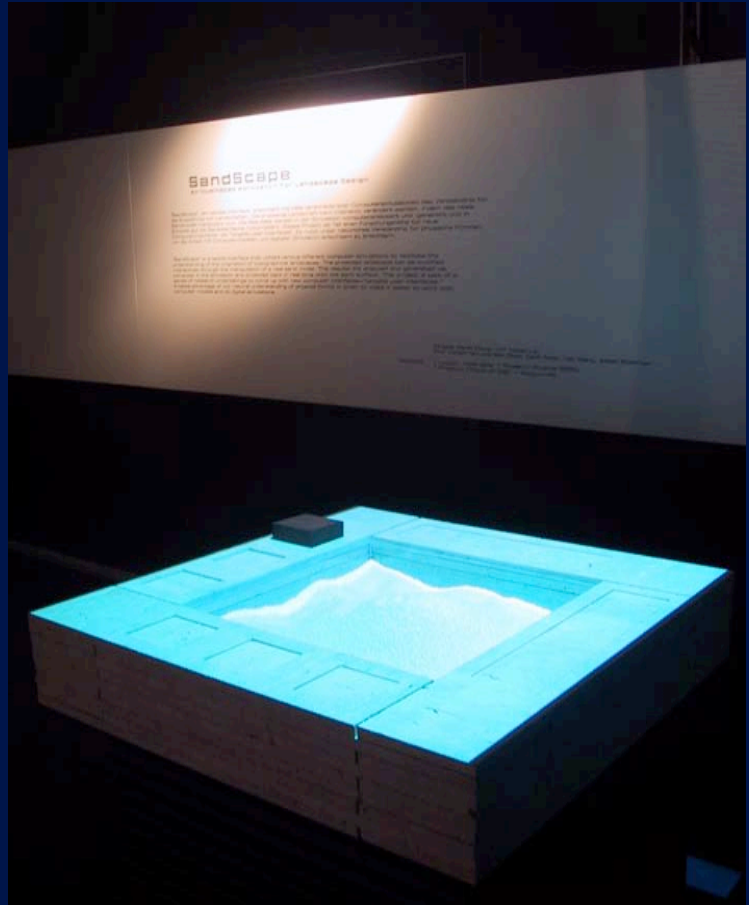
- Physical Clay as 3-D Physical Input & Visual Display for intuitive manipulation and understanding of spatial relationships
- 3D Laser Scanner + Video Projector



SandScape

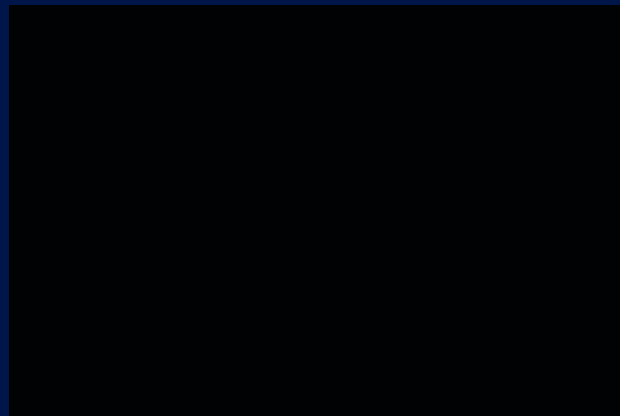
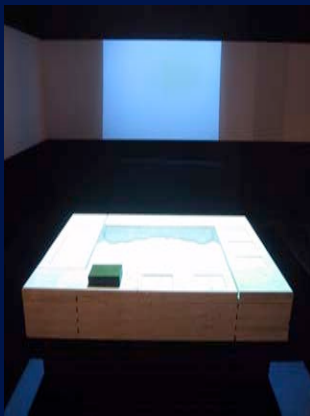
Hiroshi Ishii,
Carlo Ratti,
Ben Piper,
Yao Wang, and
Assaf Biderman

Tangible Media Group
MIT Media Laboratory

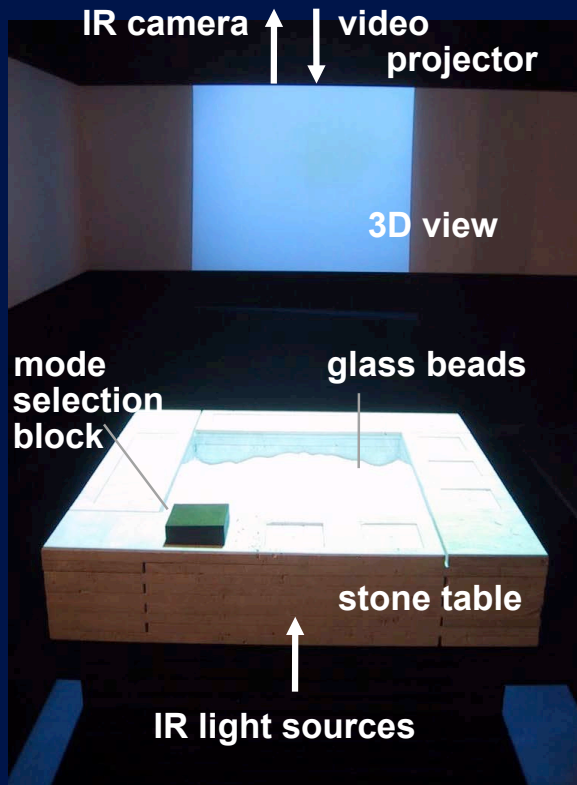


SandScape

Ars Electronica Center



Users can alter the form of the landscape model by manipulating sand while seeing the resultant effects of computational analysis projected on the surface of sand in real-time.



System

A ceiling mounted IR camera captures the radiance of the light passing through the sand model to determine the geometry of the surface.

The resulting landscape analysis is projected back on to the surface.

表現

Design Media

Physical Design Media

- Clay
- Cardboard
- Wooden Blocks
- Found Objects



Frank O. Gehry, Architect

Physical Outcomes
Stata Center 2002



Lack of Continuity Between Physical and Digital Representation in Design

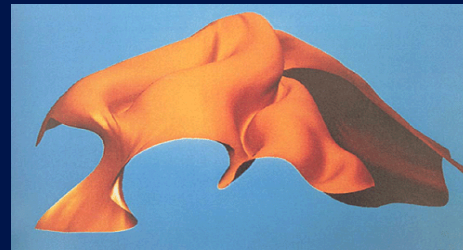
Physical

Ease of manipulation
Clearer communication
Aids spatial understanding



Digital

Greater precision
Easy distribution
Quantitative analysis



How can we merge these media?

Tangible Design Media for Seamless Form Giving & Computational Reflection

Physical



Upper Stream



Digital

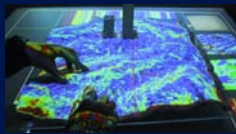
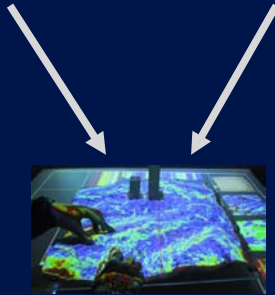
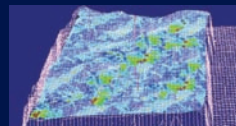
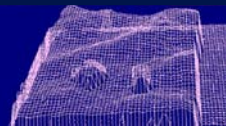


Lower Stream

Rough and rapid form giving with hand for ideation

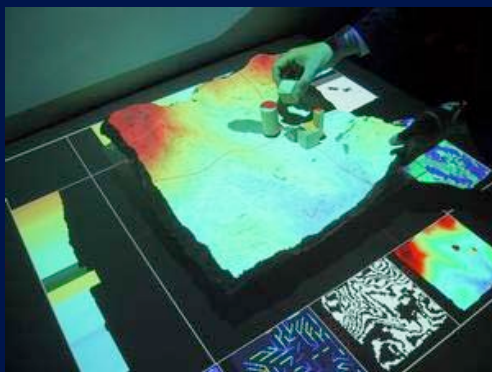


Precise and quantitative computational reflection



simultaneous form giving + computational reflection

Representation of Idea Matters ...

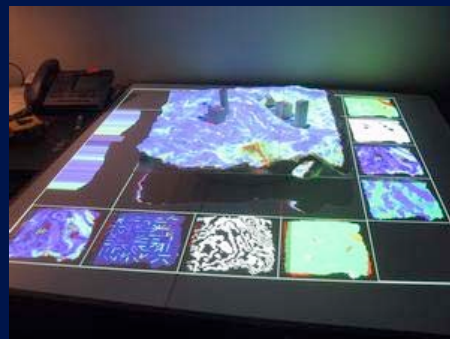


... because the mental operations are made possible by the representation.

... GUI/CAD is not for ideation.

e.g.

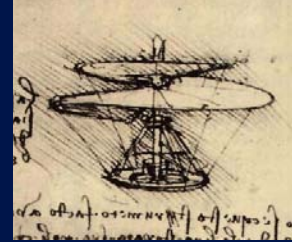
- Mathematical representation
- Drawings
- Physical models
- Computational models



Media for Design Thinking

- Visual Thinking

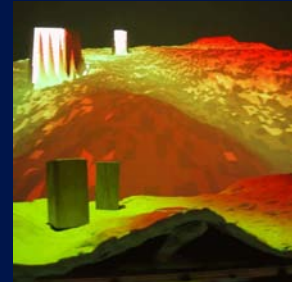
- sketch



- Tangible Thinking

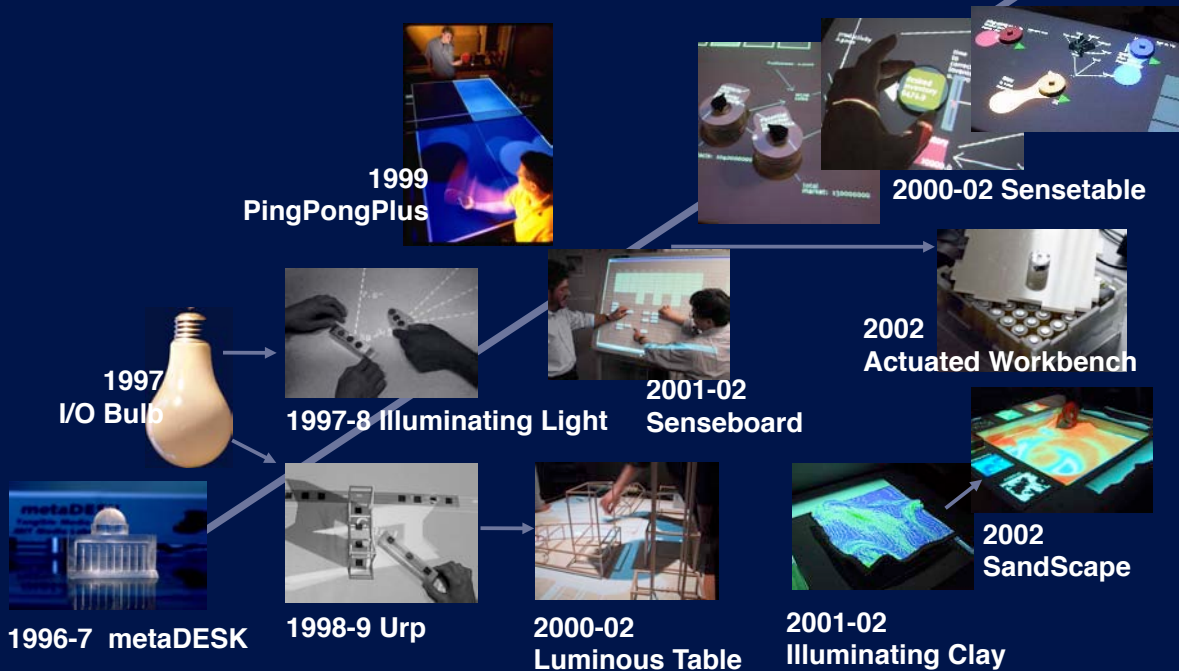
- tactile manipulation of physical representations coupled with digital computation

- design + analysis



Evolution of Workbench

for Collaborative Design and Tangible Thinking



遊

play

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

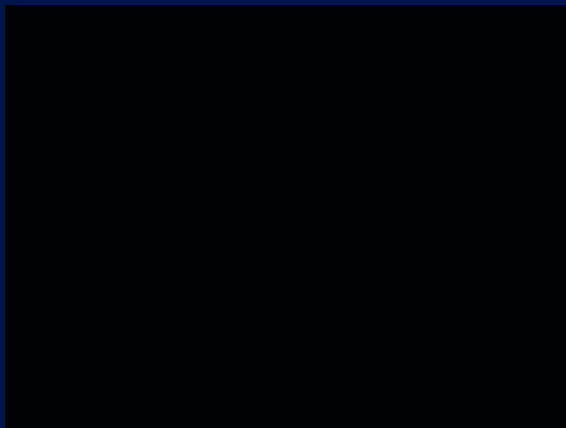


- Digital augmentation of ping pong play with "reactive table."
- Ball tracking using microphone array underneath table.
- "From competition to collaboration"

- ICC, Tokyo 2000
- Centre Pompidou, Paris 2003
- Victoria and Albert Museum, London 2005



PingPongPlus at Centre Pompidou, Paris 2003



- Digital augmentation of ping pong play with "reactive table."
- Ball tracking using microphone array underneath table.
- "From competition to collaboration"



Invisible

extension of body - good fit



- customize
- personalize
- adapt
- co-evolve

Visible

center of focus - goal of task

- Critical representation of task
- Ball has to be always visible in the foreground with a table as reference
- You need an interface (paddle) to control the ball

