Interaction Design

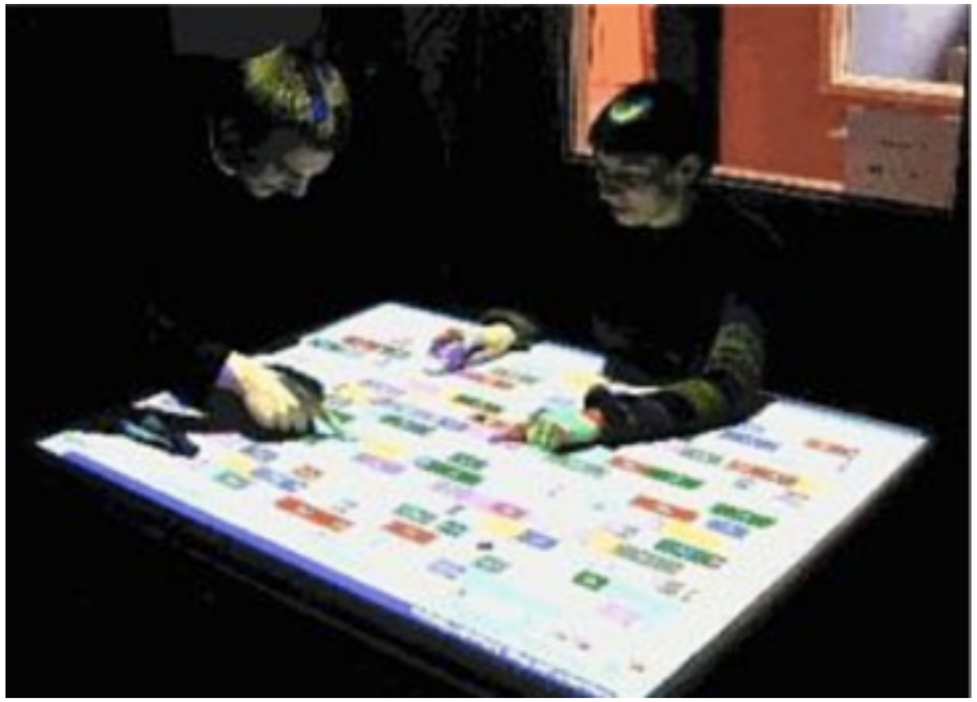
Chapter 9 (July 6th, 2011, 9am-12pm): Physical Interaction, Tangible and Ambient UI

Physical Interaction, Tangible and Ambient UI

- Shareable Interfaces
- Tangible UI
  - General purpose TUI frameworks
  - Specialized TUIs
  - TUIs in everyday objects
  - Communicative TUIs
  - Ambient UIs
- Wearable UI
- Robotic UI
- Summary

Shareable interfaces

- Shareable interfaces are designed for more than one person to use
  - provide multiple inputs and sometimes allow simultaneous input by co-located groups
  - large wall displays where people use their own pens or gestures
  - interactive tabletops where small groups interact with information using their fingertips, e.g., Mitsubishi's DiamondTouch and Sony's Smartskin



Advantages

- Provide a large interactional space that can support flexible group working
- Can be used by multiple users
  - can point to and touch information being displayed
  - simultaneously view the interactions and have the same shared point of reference as others
- Can support more equitable participation compared with groups using single PC

Research and design issues

- More fluid and direct styles of interaction involving freehand and pen-based gestures
- Core design concerns include whether size, orientation, and shape of the display have an effect on collaboration
- horizontal surfaces compared with vertical ones support more turn-taking and collaborative working in co-located groups
- Providing larger-sized tabletops does not improve group working but encourages more division of labor

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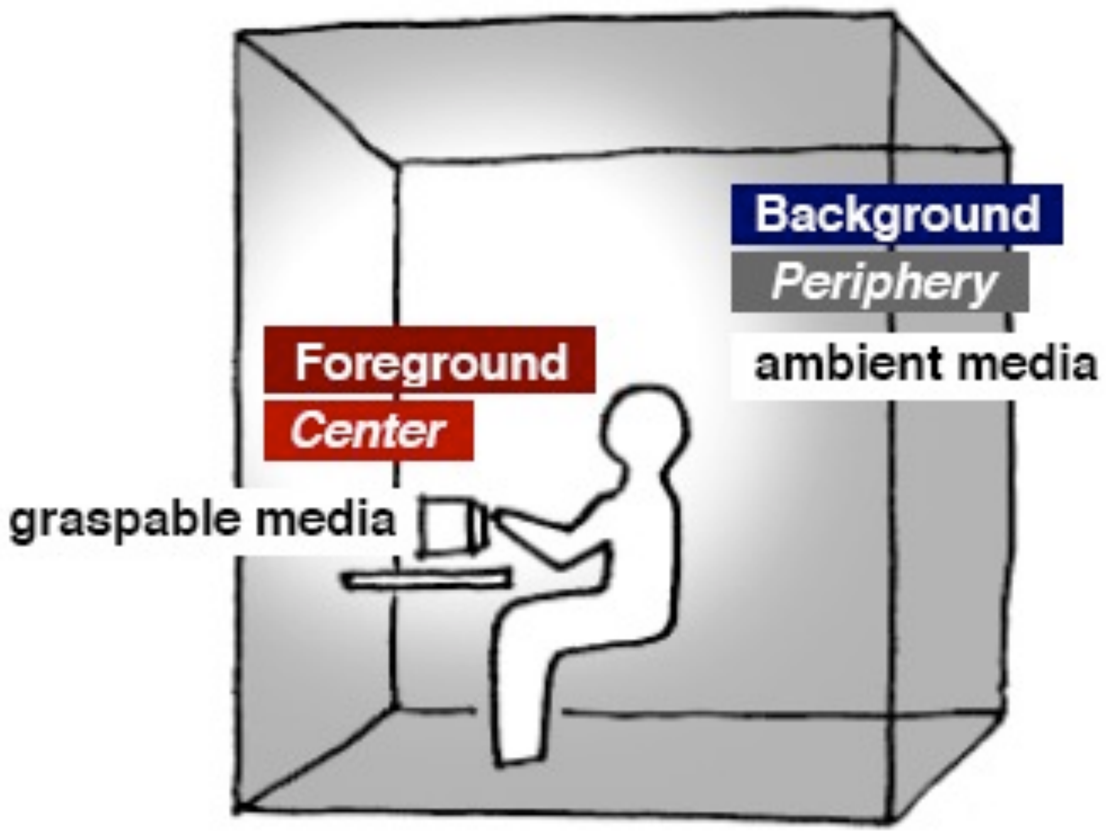
Tangible interfaces

- Type of sensor-based interaction, where physical objects, e.g., bricks, are coupled with digital representations
- When a person manipulates the physical object/s it causes a digital effect to occur, e.g. an animation
- Digital effects can take place in a number of media and places or can be embedded in the physical object

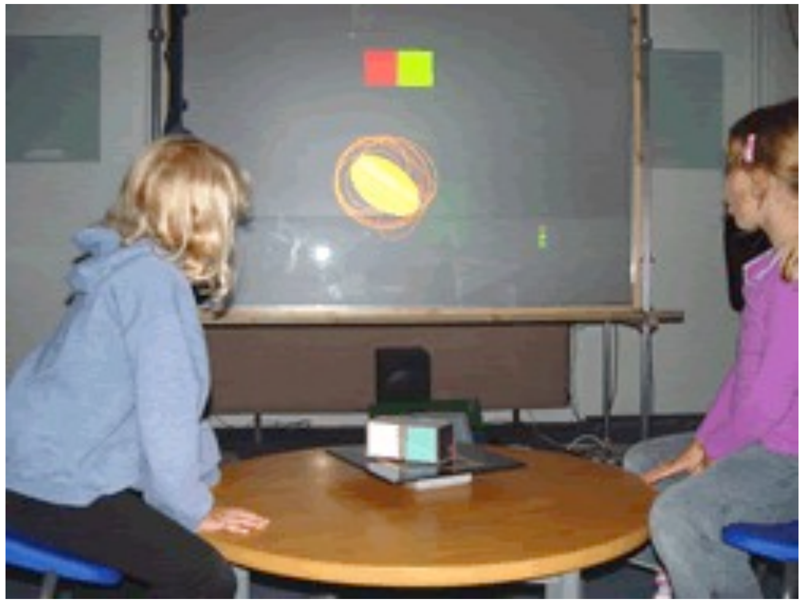
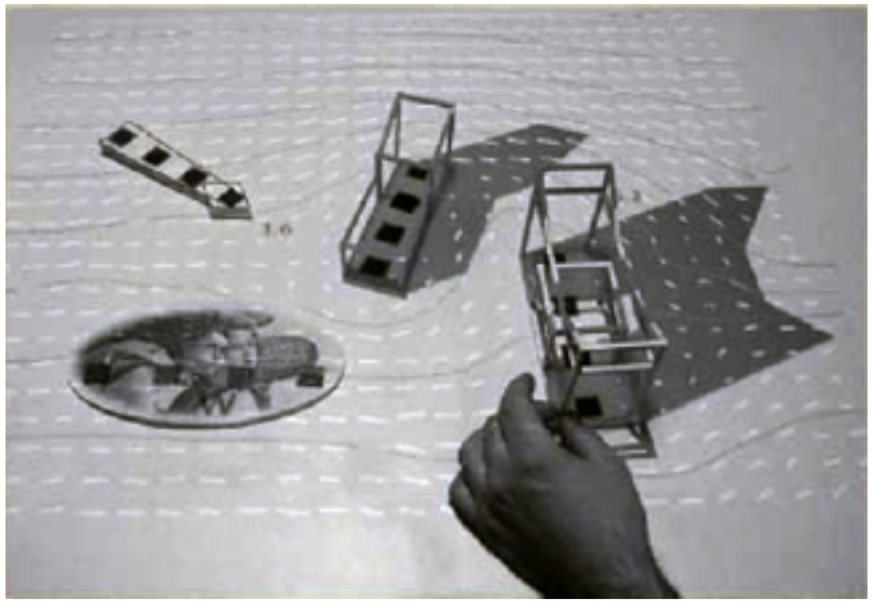
Tangible User Interfaces - Key Paper [Ishii & Ullmer, CHI 97]

- „Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms“
- Interactive surfaces
- Coupling of bits and atoms
- Ambient media



Examples

- Chromarium cubes
  - when turned over digital animations of color are mixed on an adjacent wall
  - faciliates creativity and collaborative exploration
- Flow Blocks
  - depict changing numbers and lights embedded in the blocks
  - vary depending on how they are connected together
- Urp
  - physical models of buildings moved around on tabletop
  - used in combination with tokens for wind and shadows -> digital shadows surrounding them to change over time

Benefits

- Can be held in both hands and combined and manipulated in ways not possible using other interfaces
  - allows for more than one person to explore the interface together
  - objects can be placed on top of each other, beside each other, and inside each other
  - encourages different ways of representing and exploring a problem space
- People are able to see and understand situations differently
  - can lead to greater insight, learning, and problem-solving than with other kinds of interfaces
  - can facilitate creativity and reflection

Research and design issues

- Develop new conceptual frameworks that identify novel and specific features
- The kind of coupling to use between the physical action and digital effect
  - If it is to support learning then an explicit mapping between action and effect is critical
  - If it is for entertainment then can be better to design it to be more implicit and unexpected
- What kind of physical artifact to use
  - Bricks, cubes, and other component sets are most commonly used because of flexibility and simplicity
  - Stickies and cardboard tokens can also be used for placing material onto a surface

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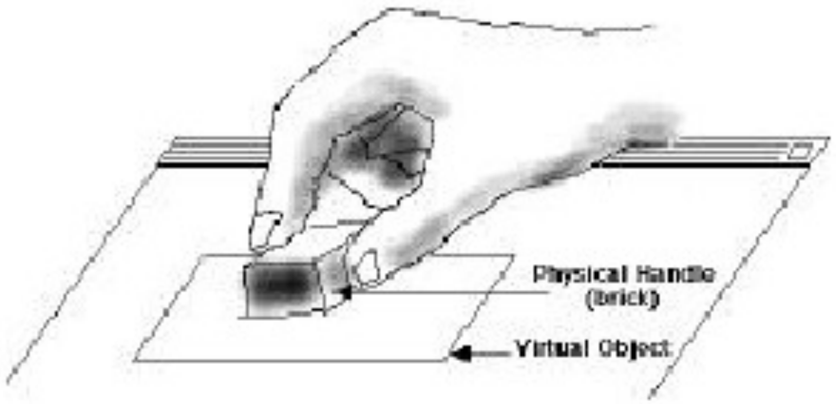
Bricks: Graspable User Interfaces
(Fitzmaurice, Ishii, Buxton, CHI 95)

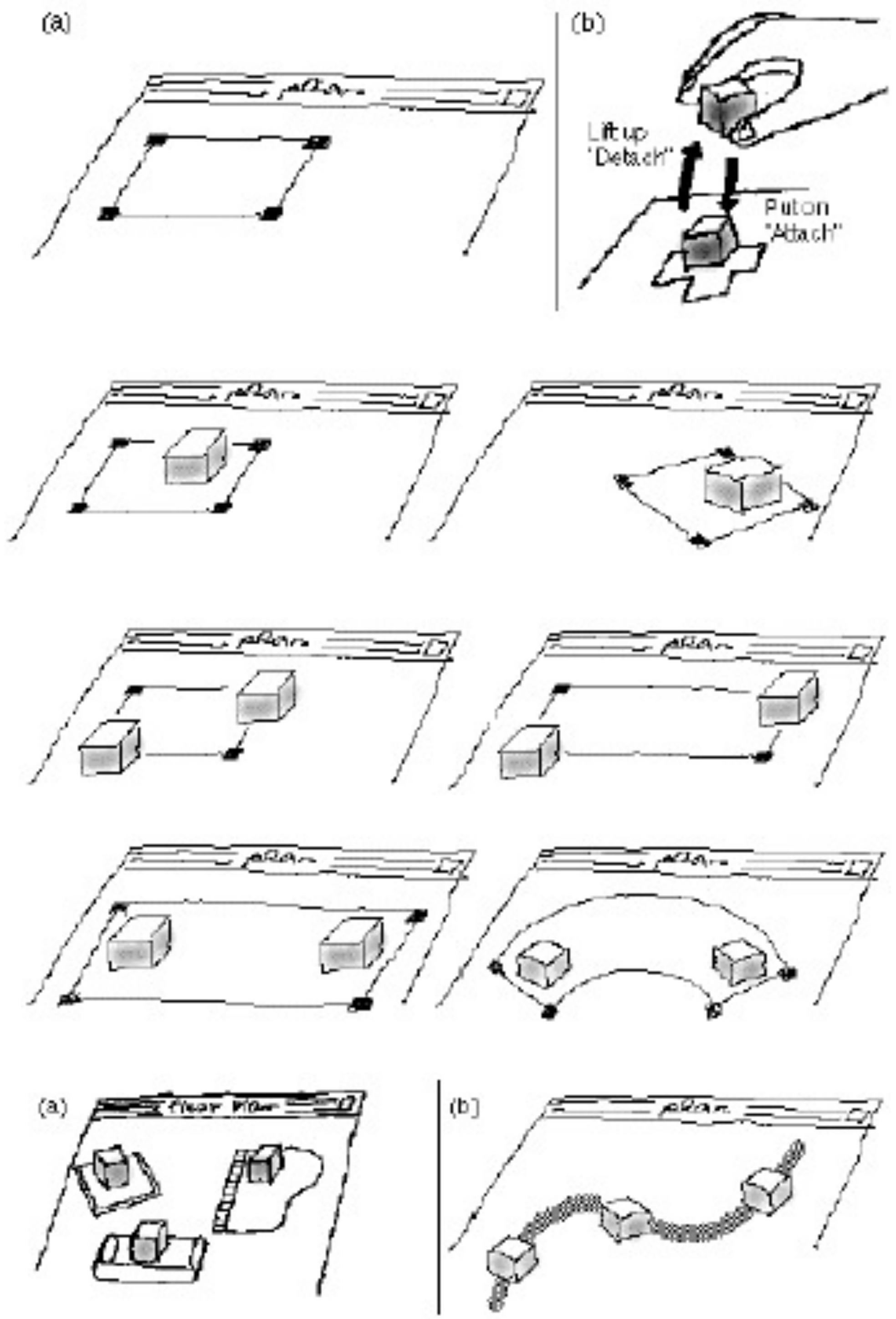
- specialized, context sensitive input devices
- interface elements more "direct" and more "manipulable" by using physical artifacts
- parallel input specification by the user
  - improving the expressiveness or the communication capacity with the computer
- encourages two handed interactions
- leverages our everyday skills of prehensile behaviors for physical object manipulations
- externalizes internal computer representations
- takes advantage of spatial reasoning skills
- affords multi-person, collaborative use



Bricks application: GraspDraw

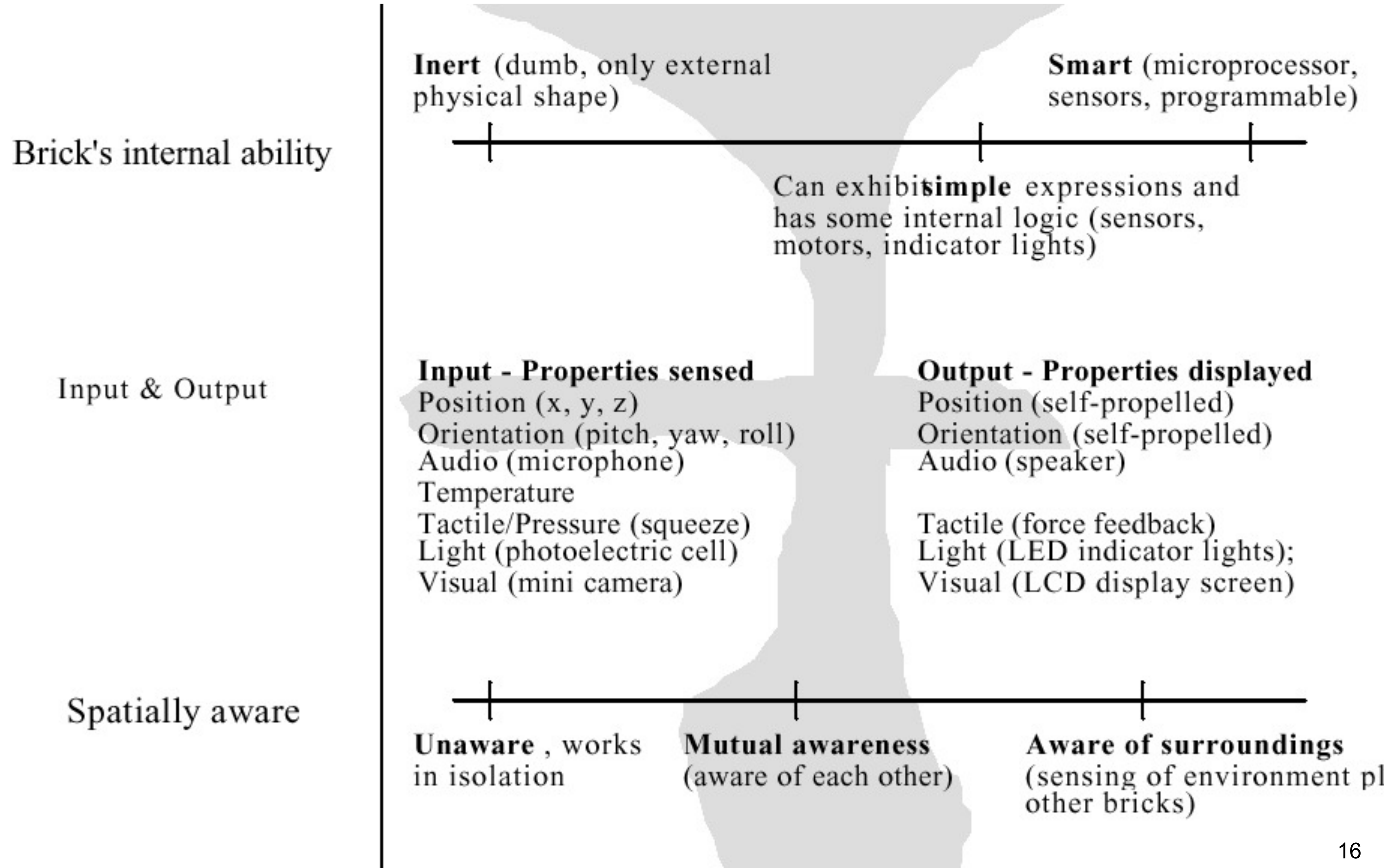
- Drawing application
- On active desk
  - Rear-projection display
  - Transparent digit. Tablet
  - Magnetic tracker for bricks
- Two bricks for input
  - „Anchor“ and „actuator“

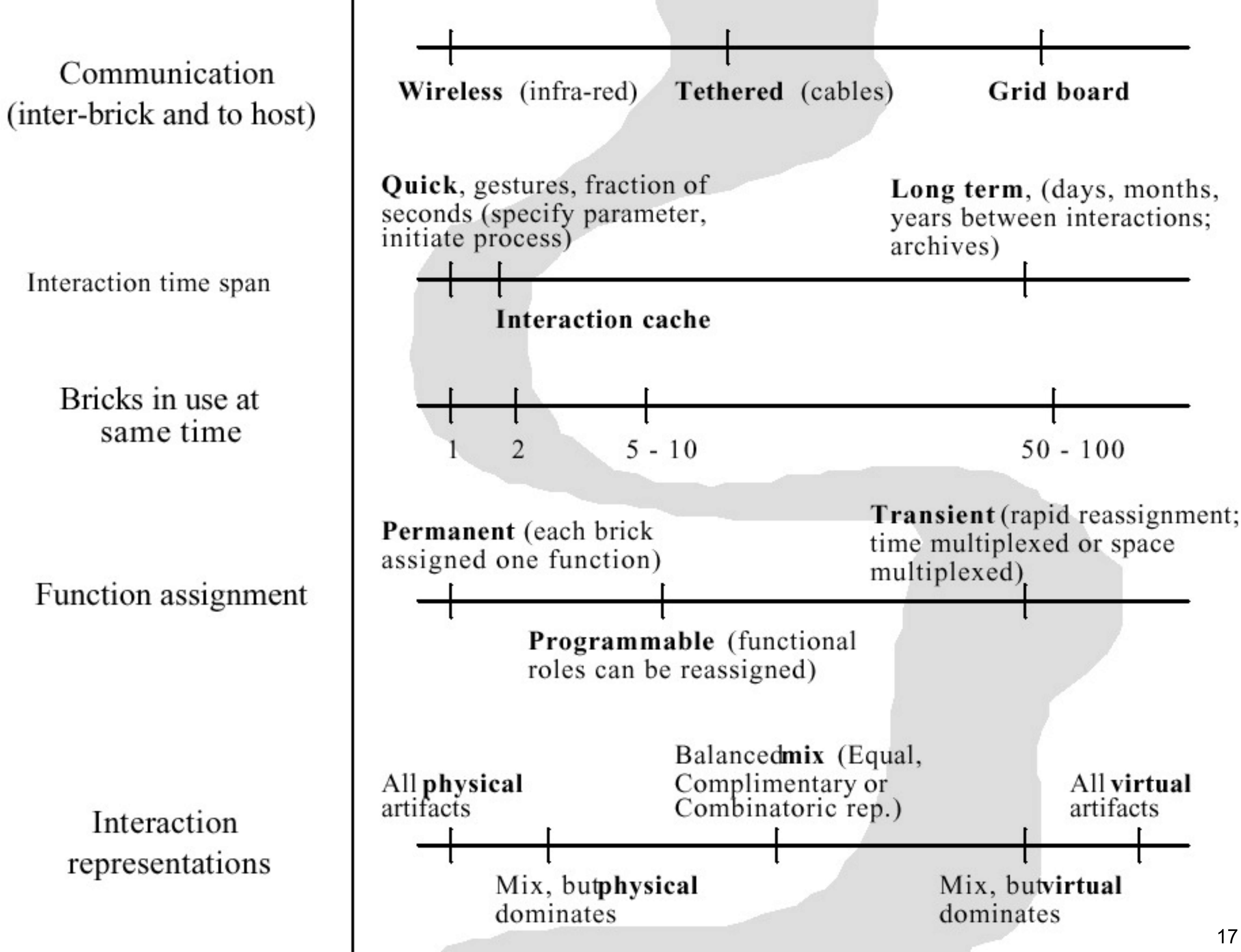
Bricks: basic operations

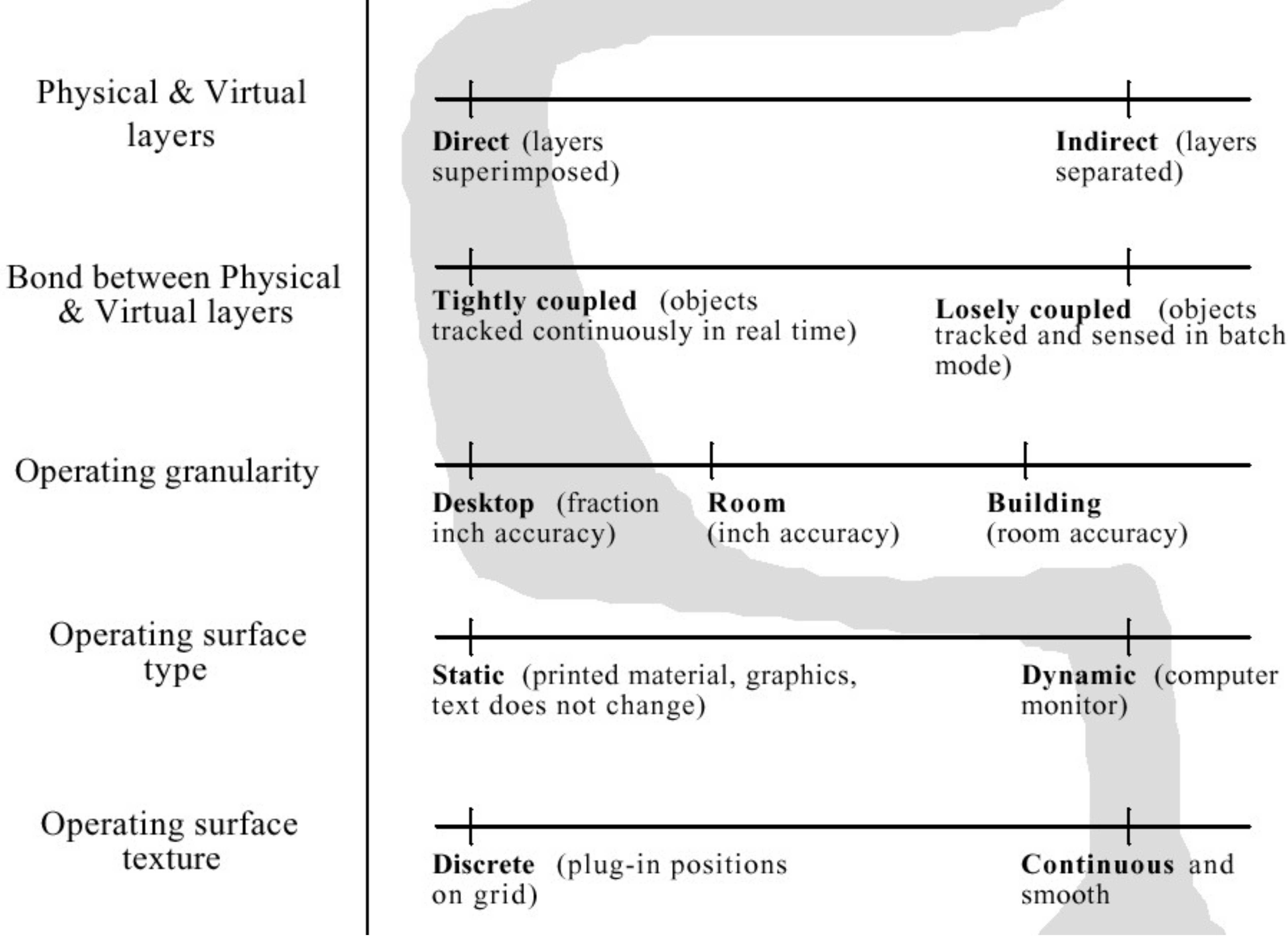


- Select an object
- Move and rotate
- Scale and stretch
- Bend and deform
- Floor planning, curve drawing

Bricks: Design Space




Communication
(inter-brick and to host)
Wireless (infra-red)
Tethered (cables)
Grid board
Interaction time span
Quick, gestures, fraction of seconds (specify parameter, initiate process)
Long term, (days, months, years between interactions; archives)
Interaction cache
Bricks in use at same time
1
2
5 - 10
50 - 100
Function assignment
Permanent (each brick assigned one function)
Transient (rapid reassignment; time multiplexed or space multiplexed)
Programmable (functional roles can be reassigned)
Interaction representations
All physical artifacts
Balanced mix (Equal, Complimentary or Combinatoric rep.)
All virtual artifacts
Mix, but physical dominates
Mix, but virtual dominates


Physical & Virtual layers
Direct (layers superimposed)
Indirect (layers separated)
Bond between Physical & Virtual layers
Tightly coupled (objects tracked continuously in real time)
Losely coupled (objects tracked and sensed in batch mode)
Operating granularity
Desktop (fraction inch accuracy)
Room (inch accuracy)
Building (room accuracy)
Operating surface type
Static (printed material, graphics, text does not change)
Dynamic (computer monitor)
Operating surface texture
Discrete (plug-in positions on grid)
Continuous and smooth

Triangles

(Gorbet, Orth, Ishii, CHI 98)

- Set of identical, flat plastic triangles
  - Each with a processor and a unique ID
  - Magnetic edge connectors
- Can be rearranged in 2D and 3D
  - Keep track of their connections
  - Transmit their configuration to a PC
- Building blocks for topographies
  - Immediate physical interaction
  - Spatial language

photo: Webb Chappell

Triangles: Example applications

Fig. 8: The *Cinderella 2000* Triangles

Non-linear storytelling

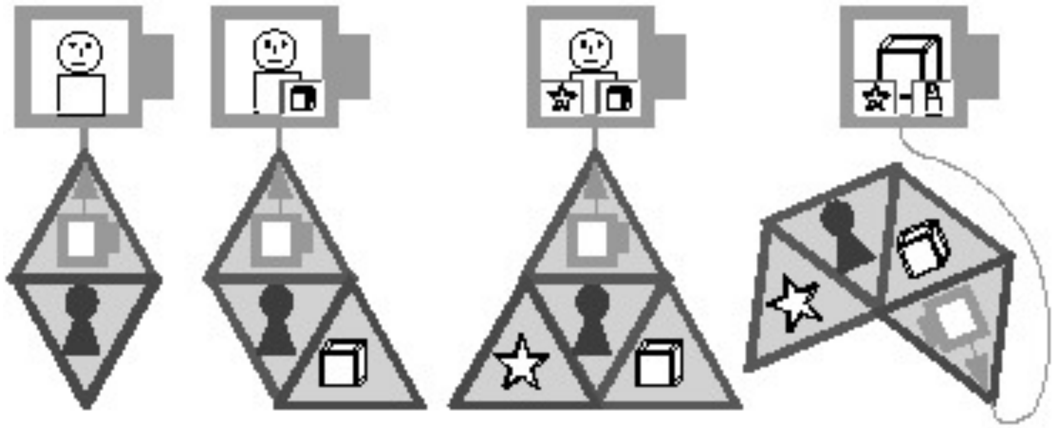


Fig. 9: *TriMediaManager*

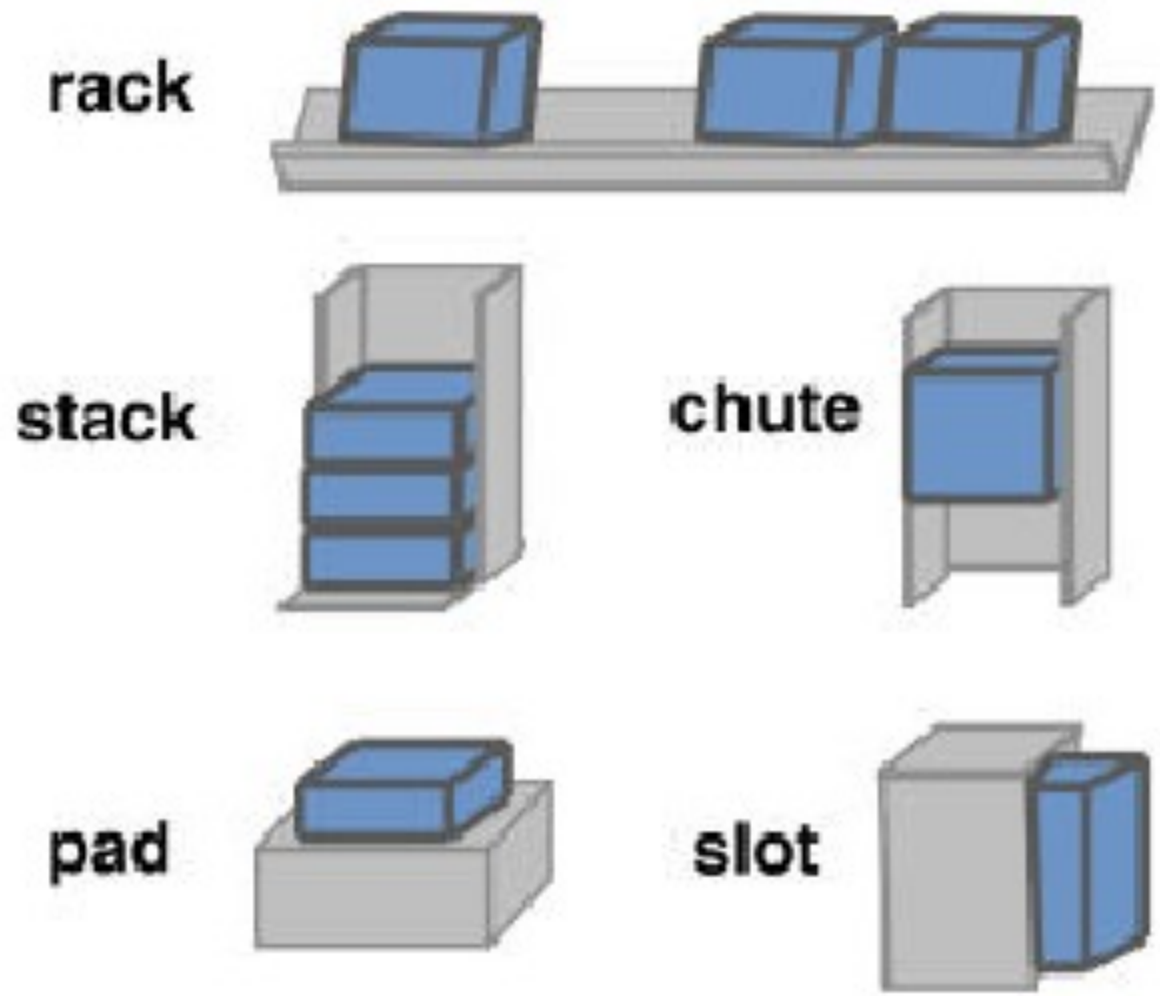
Media Management

Triangles (Cinderella) video

MediaBlocks

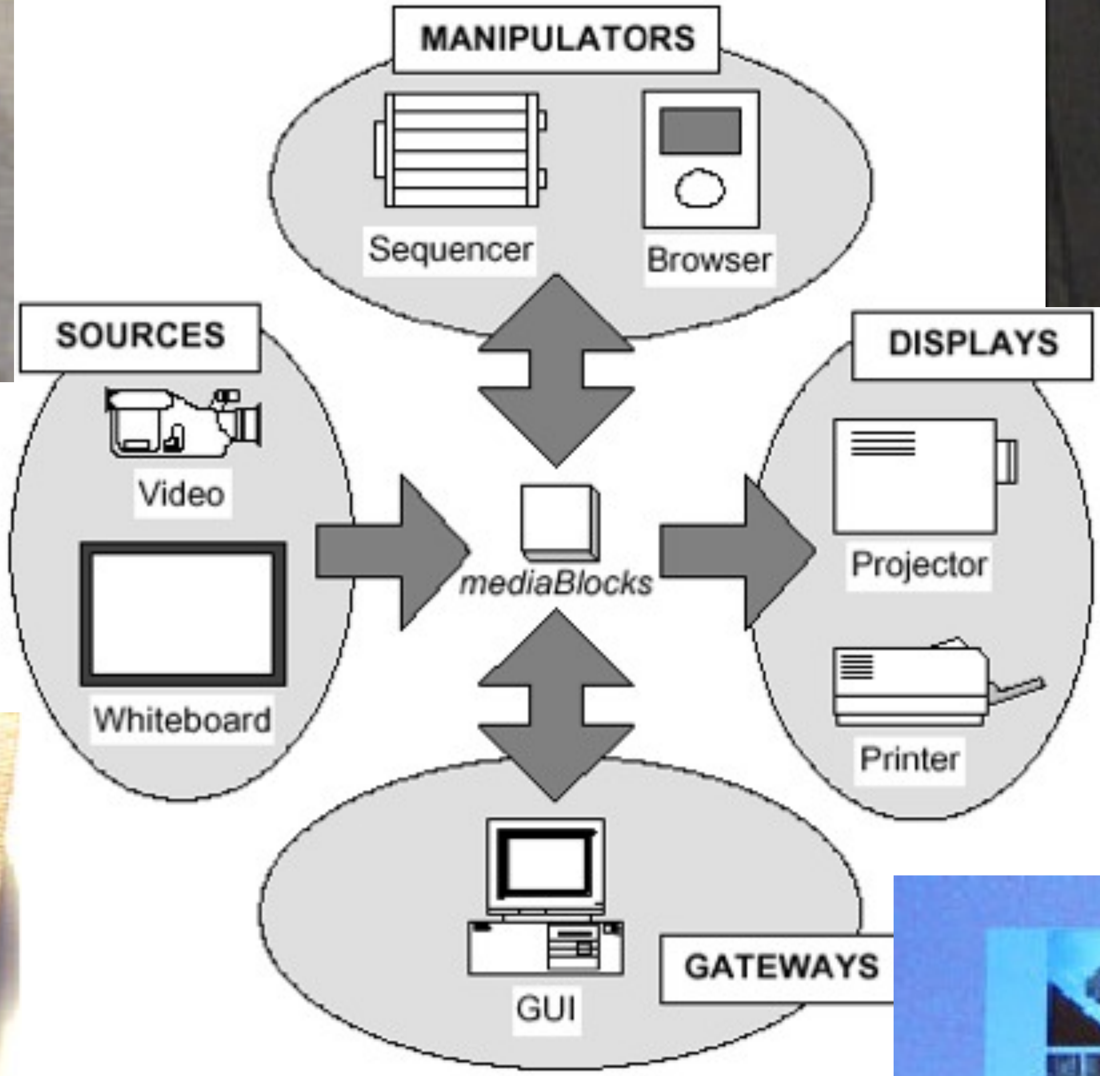
(Ullmer, Ishii, Glas, SIGGRAPH 98)

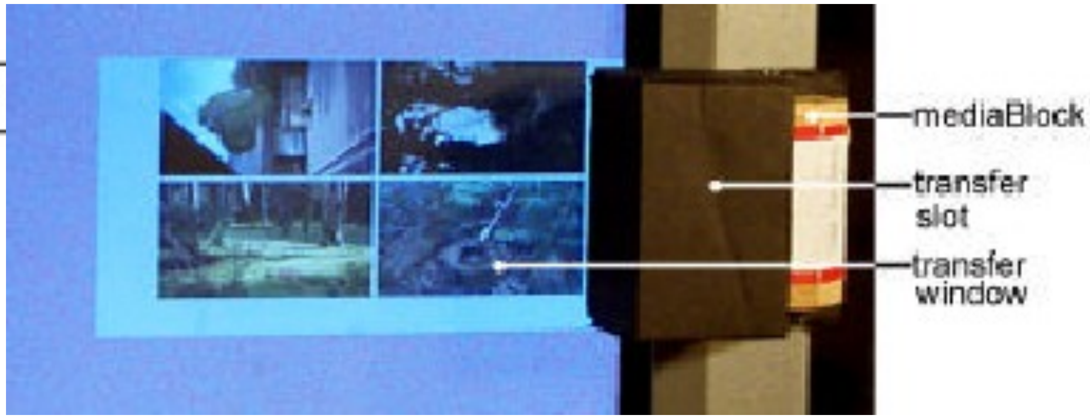
- Physical objects representing digital information: **phicons**
- No actual information stored on the blocks
- Various containers with different physical constraints



Mediablocks (Videos)

MediaBlocks (contd.)

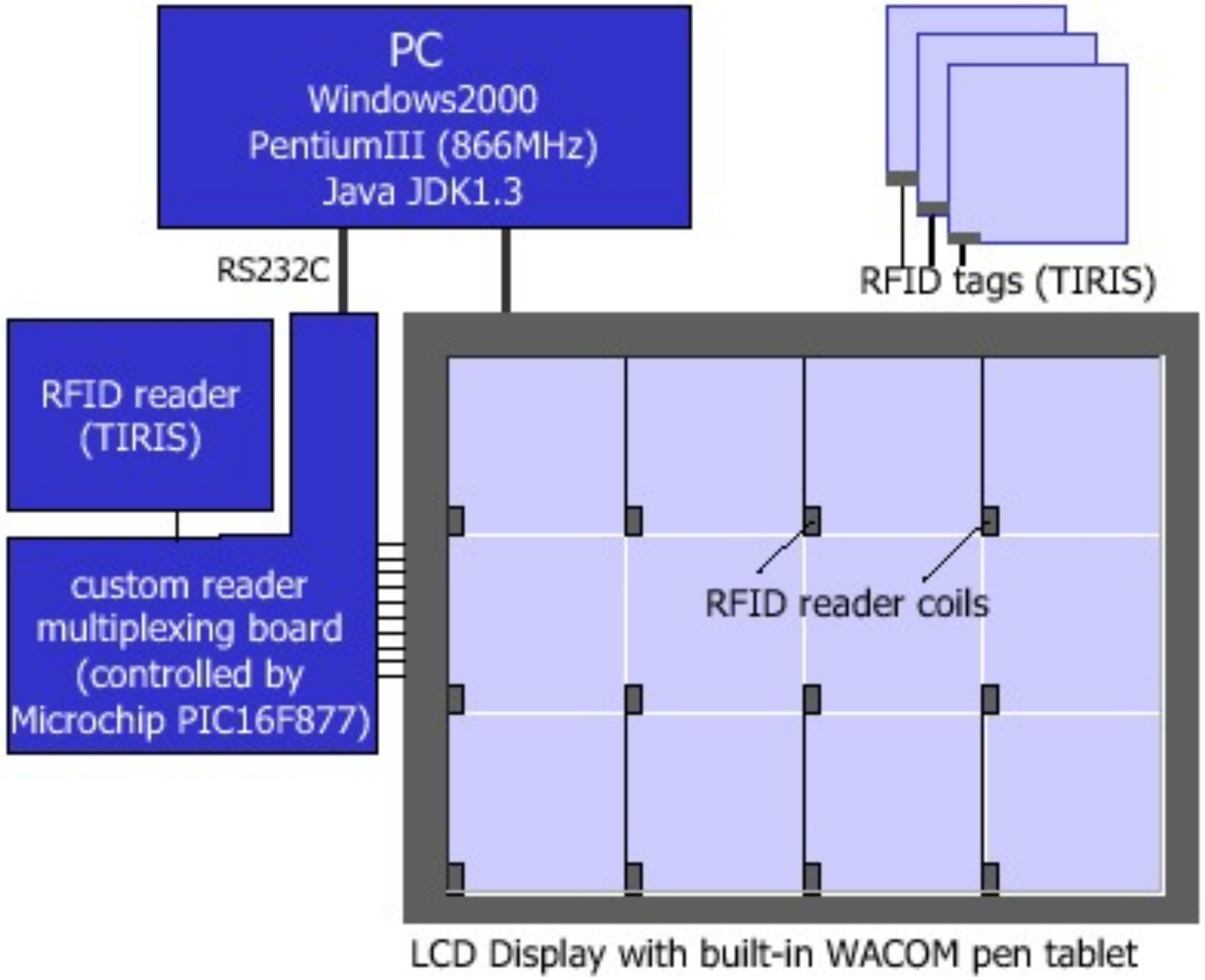


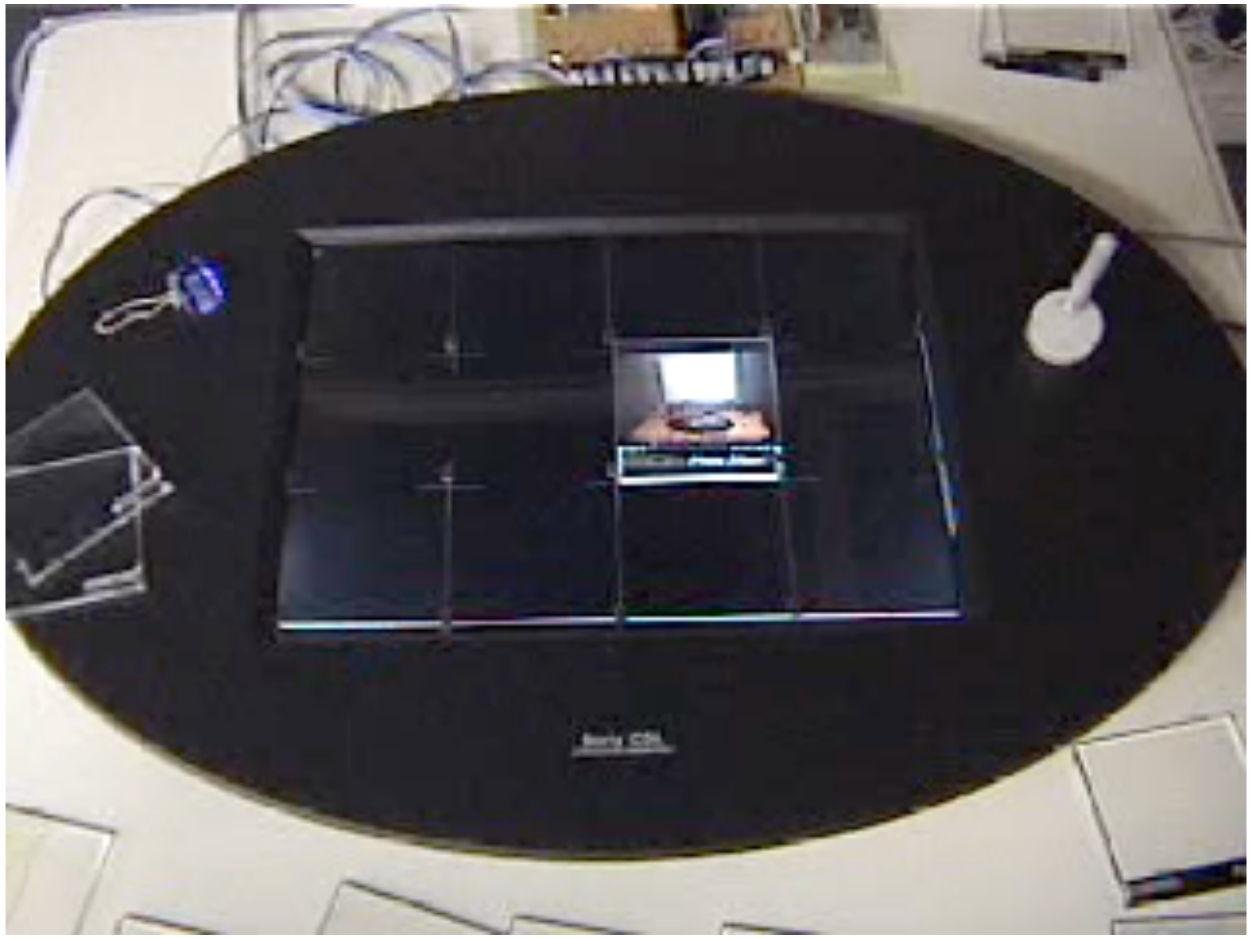


DataTiles

(Rekimoto, Ullmer, Oba, CHI 01)

- Transparent plastic tiles
  - On a flat panel screen
  - Sensed by RFID tags
  - Provide groves for pen
  - Can be spatially arranged
- Different tile types
  - Application tile
  - Container tile
  - Portal tile
  - Parameter tile





DataTiles (contd.)

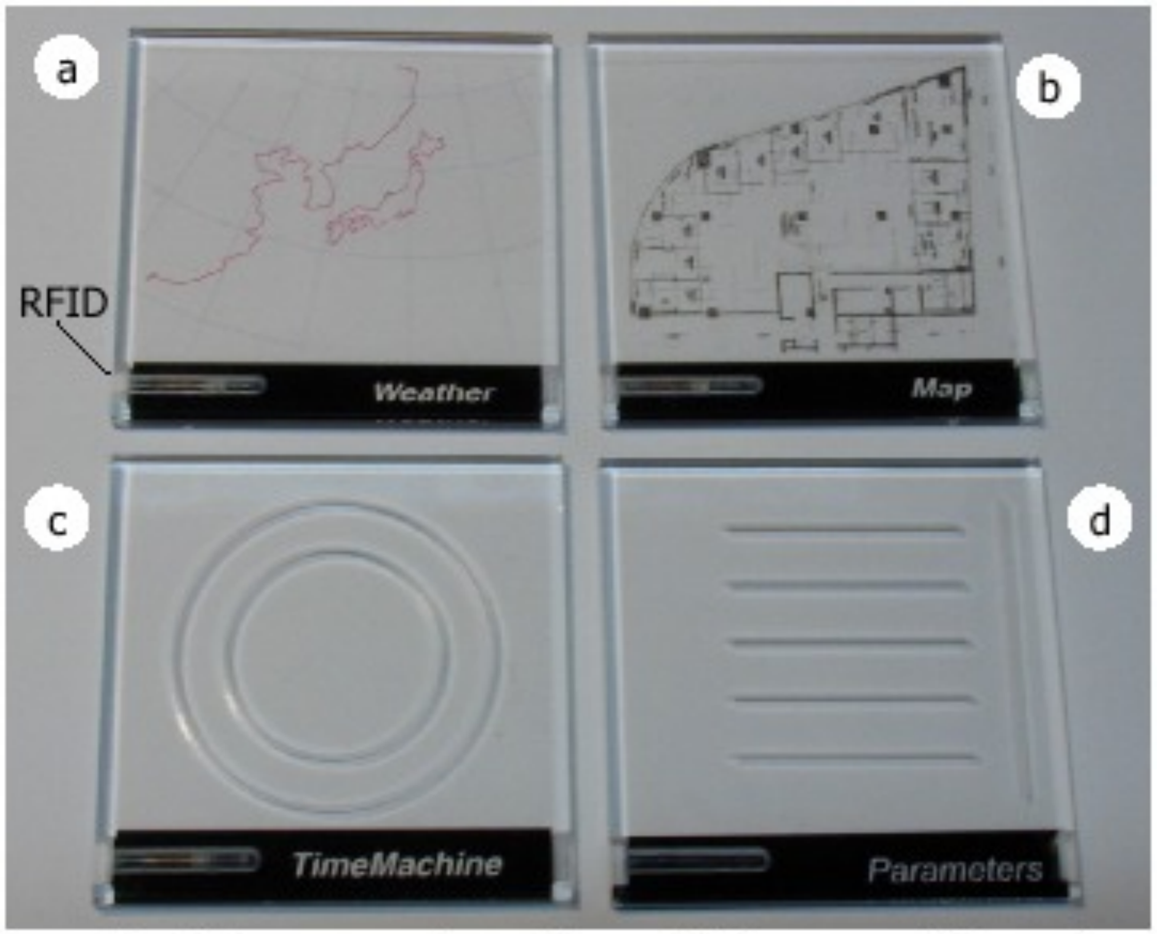


Figure 3: Tile examples. (a) and (b): partially printed tiles, (c) and (d) tiles with “grooves”.

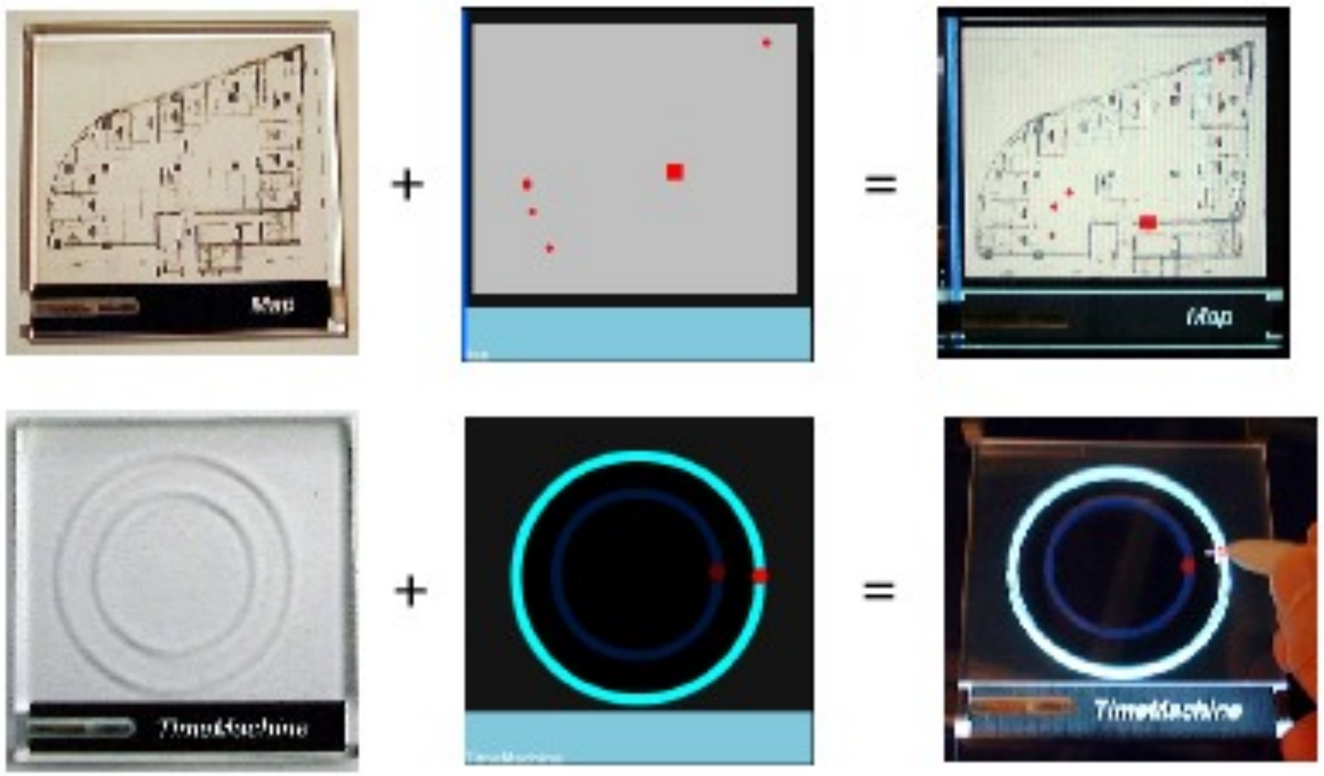


Figure 4: Combination of physical tiles and graphical information. Above: high-resolution printed information can be augmented by displayed graphics. Below: combination of physical grooves and graphical information creates a GUI widget with passive haptics.

DataTiles (contd.)

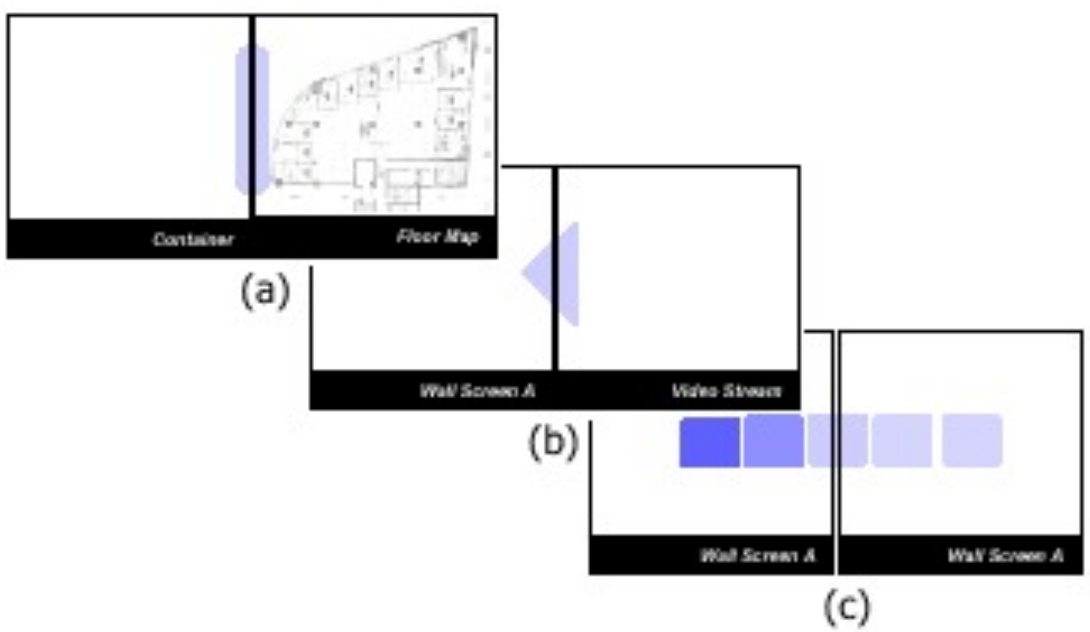


Figure 8: Several visual feedback approaches for indicating connection types. (a) one-way discrete data transmission from right to left, (b) one-way continuous data transmission, and (c) bi-directional continuous connection using animations.

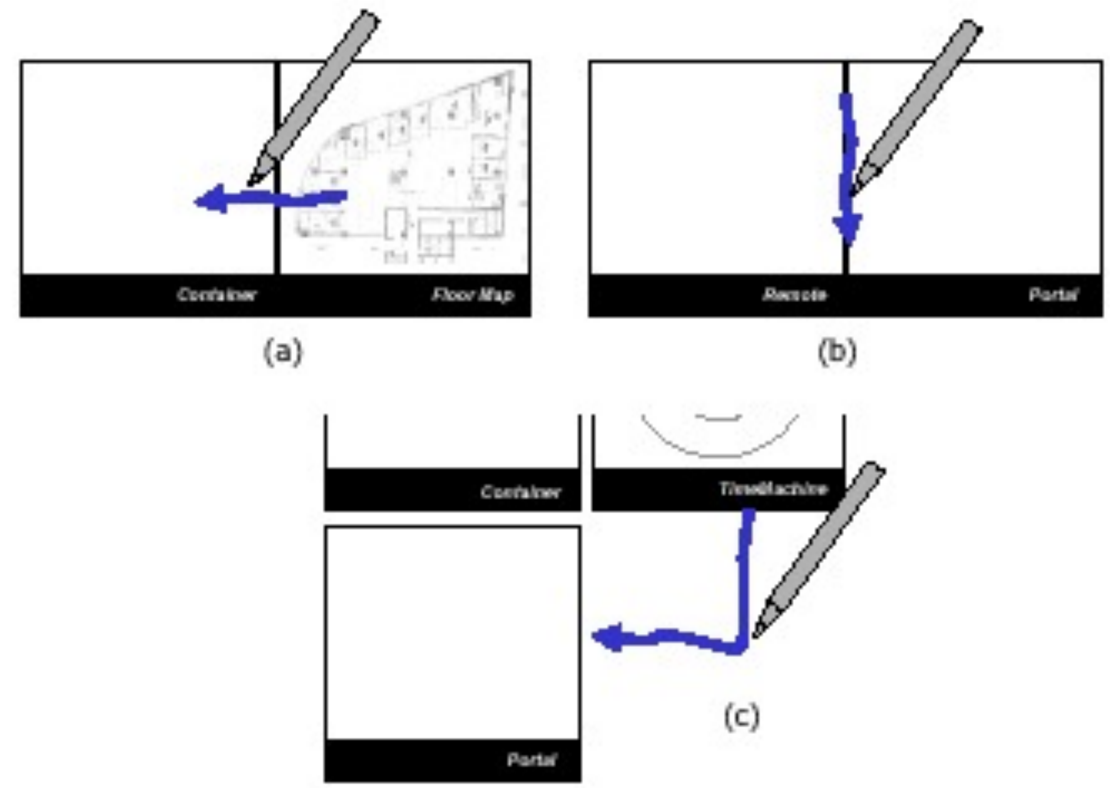


Figure 9: Inter-tile gestures by a pen to control a data connection between two adjacent tiles. (a) triggers a discrete data transmission, (b) suspends a continuous data transmission, and (c) connects two disjoint tiles. (Note: During these operations, the pen tip must be sufficiently close to the tile surfaces to be sensed, but need not touch them.)

SenseBoard

(Jacob, Ishii, Pangaro, Patten, CHI 02)

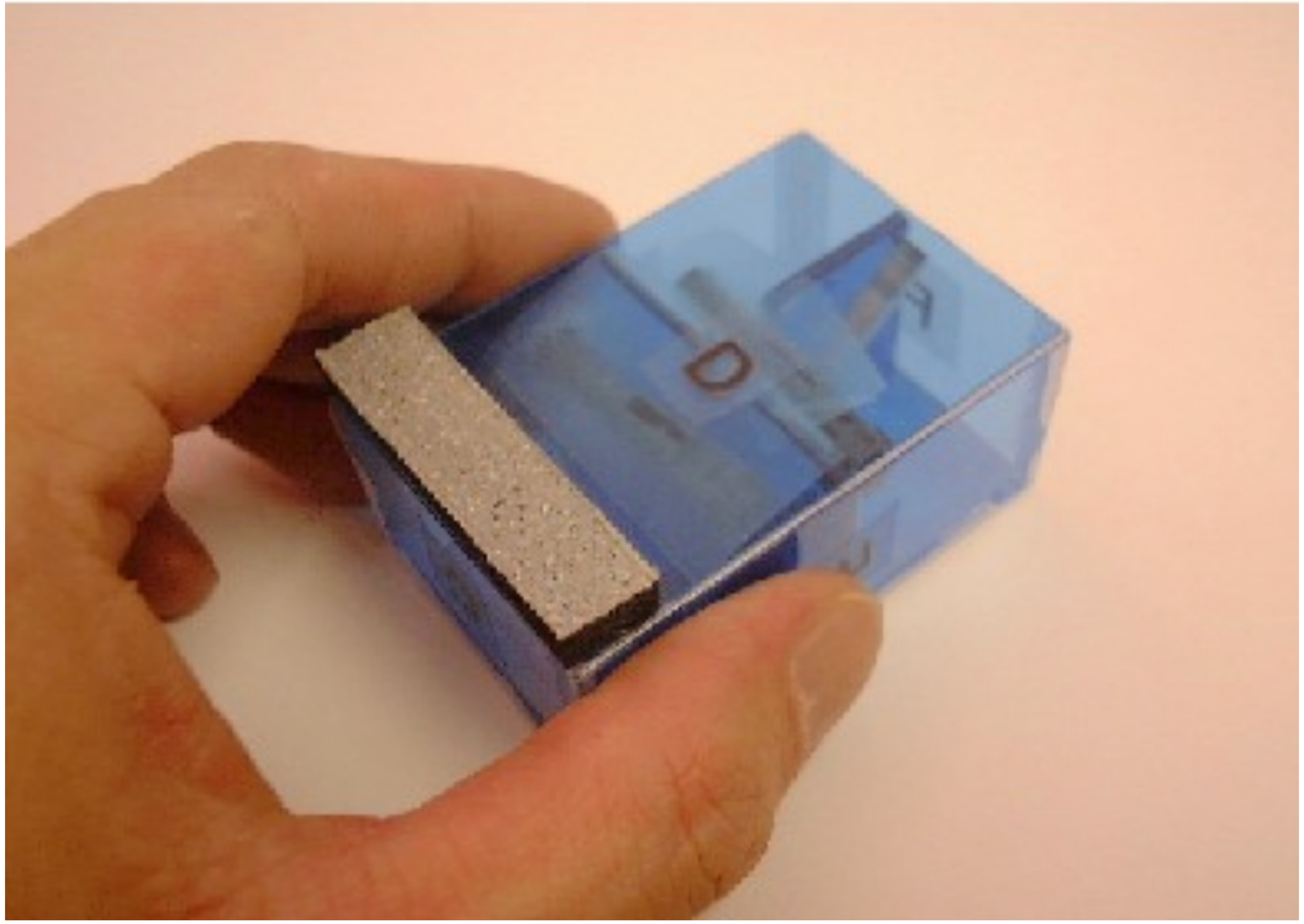
- TUI for organizing information on a grid
- Combines physical manipulation with a computer
  - Physically: arranging cards
  - Computer: arranging icons
- Get the best from both worlds

- Example: organize conference papers into sessions
- Other tasks: arrange songs in a playlist, newspaper articles, slides for a talk, ideas from a brainstorming, emails, bookmarks, notes,...

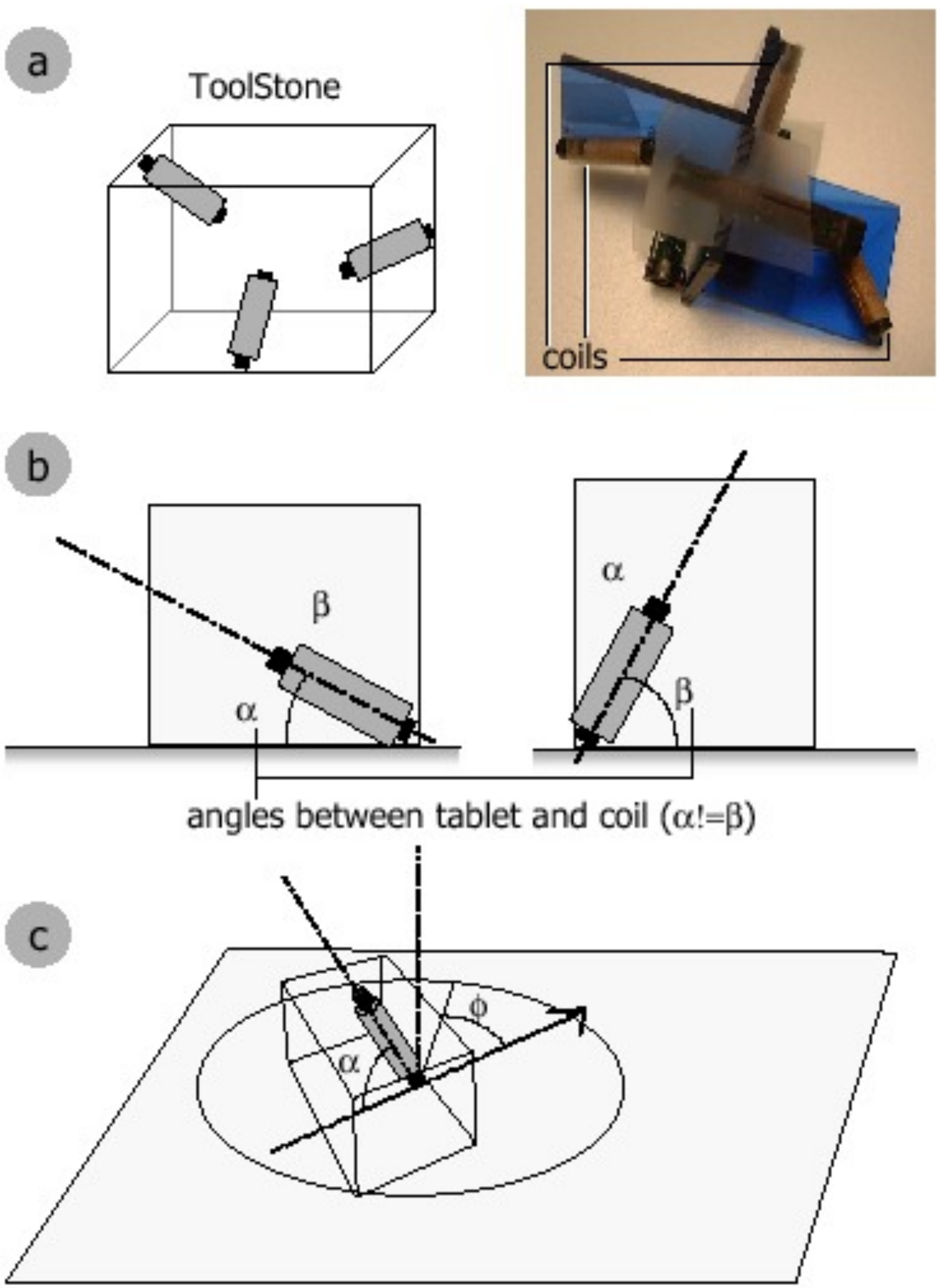
ToolStone

(Rekimoto, Sciammarella, UIST 00)

- Universal 6 DOF input device
- Works on a Wacom pen tablet
- Can be used together with pens



ToolStone working principle



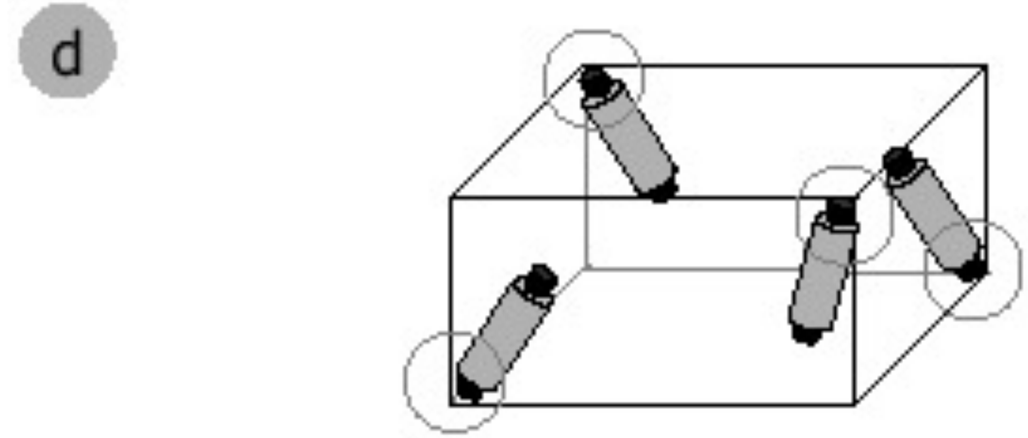


Figure 12: Detection of the touching face and orientation: (a) Inside the ToolStone: Three WACOM coils are embedded, and only one of them will be close enough to the tablet surface when the ToolStone is placed on the tablet. (b) When a coil touches the tablet, it can be identified by its unique resonance value. Two faces that share the same coil can be distinguished by comparing the tilt values (α and β). (c) Once the touching face is known, the orientation of the ToolStone can be determined from the orientation angle of the coil (ϕ). (d) An alternative sensor configuration with coils at the four corners of the device. Two of these coils are in contact with the surface when one face is placed on the tablet.

ToolStone interaction

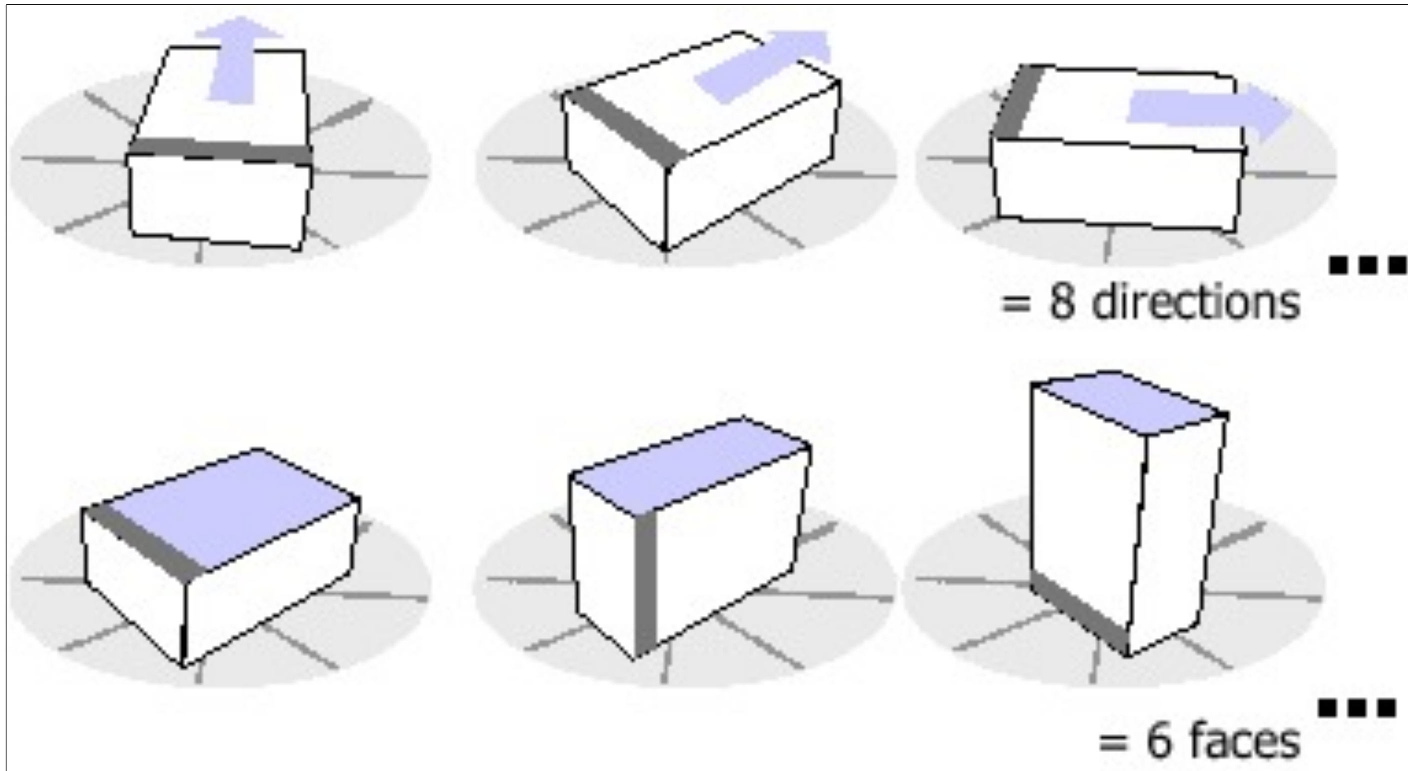


Figure 6: Selecting multiple functions by rotating and flipping the ToolStone: The combination of eight directions and six faces allows a user to quickly select 48 different functions (e.g., toolpalettes) with a single physical action.

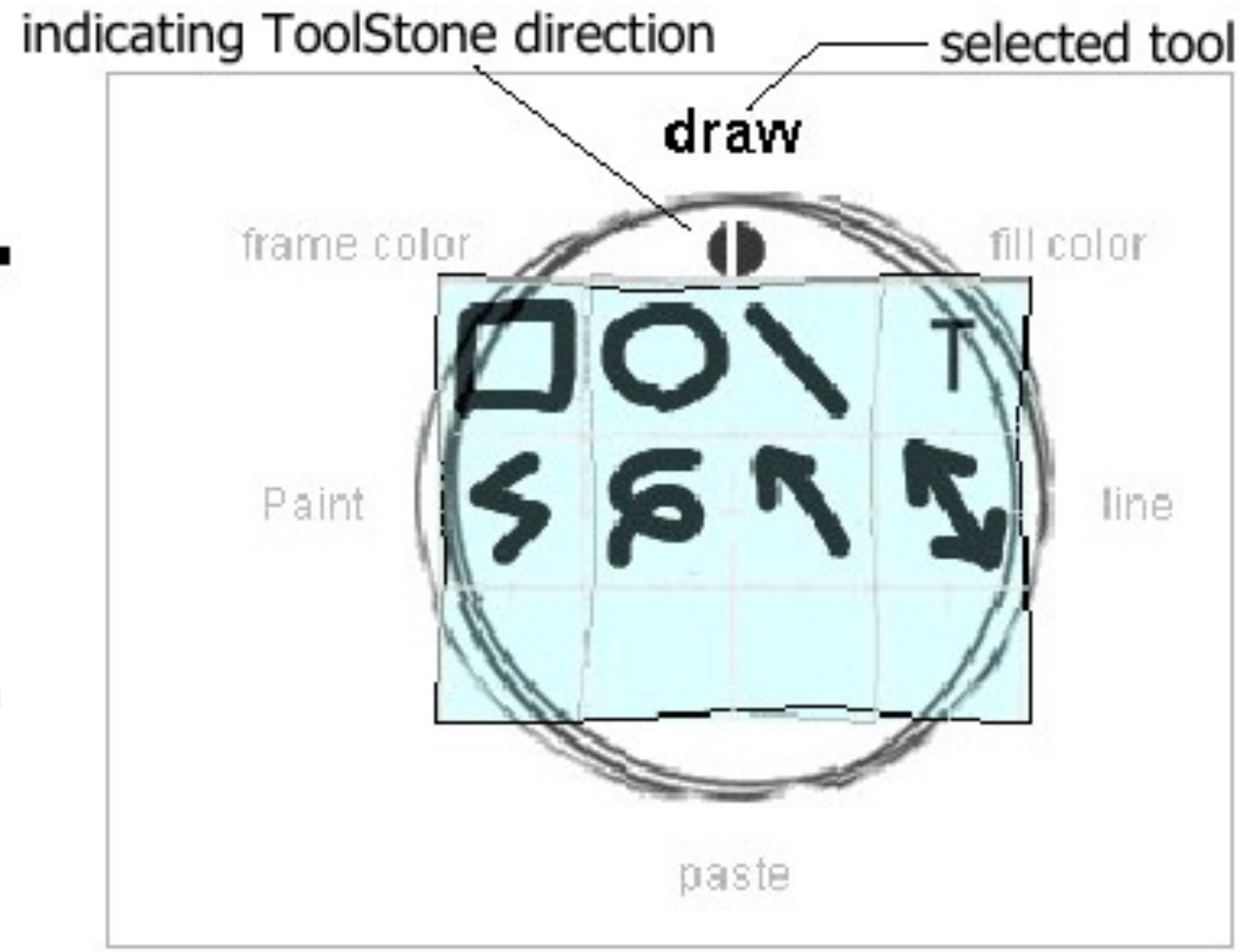


Figure 7: Example of a selected toolpalette: A dial and labels around the tool palette indicate available functionalities attached to the same face. The currently selected one is shown in bold. The selected toolpalette acts as a ToolGlass sheet.

ToolStone interaction

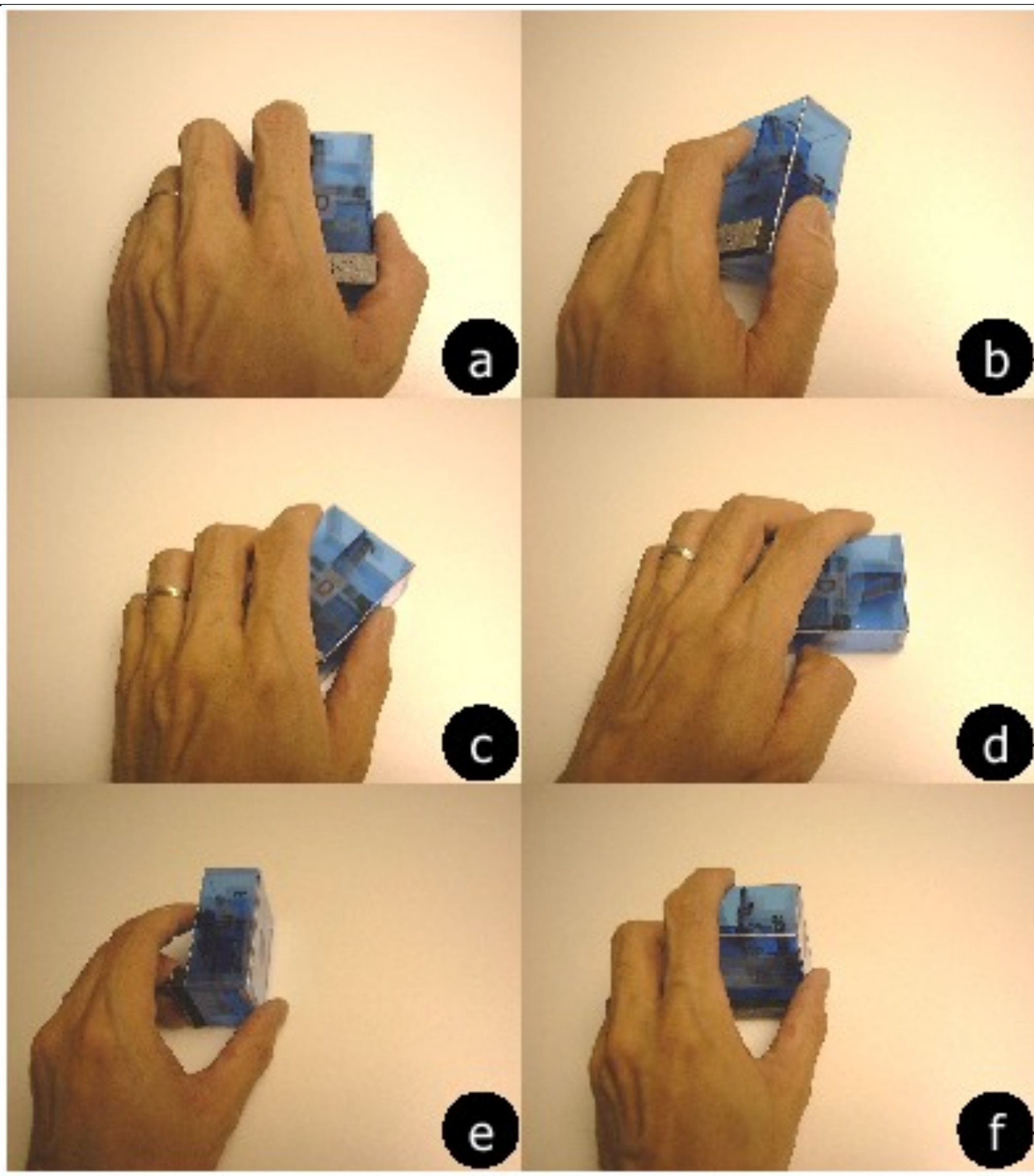


Figure 5: Several possible ways of holding the Tool-Stone: (a) Normal mode (Note: a projection attached near the lower edge of the upper face can be felt by the hand). (b) Tilting while one edge is contacting the tablet (c, d) Rotating, and (e, f) Flipping to select other faces.

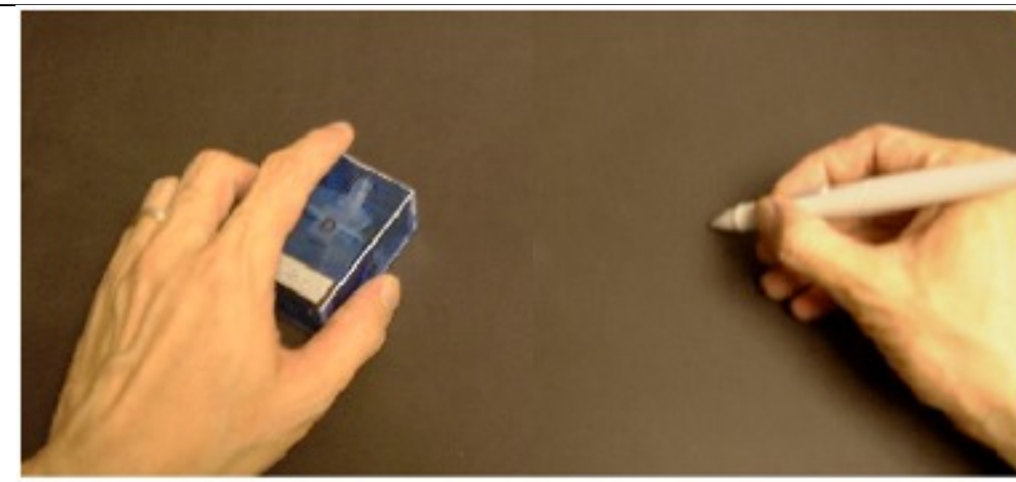


Figure 4: Bimanual interaction with the ToolStone.

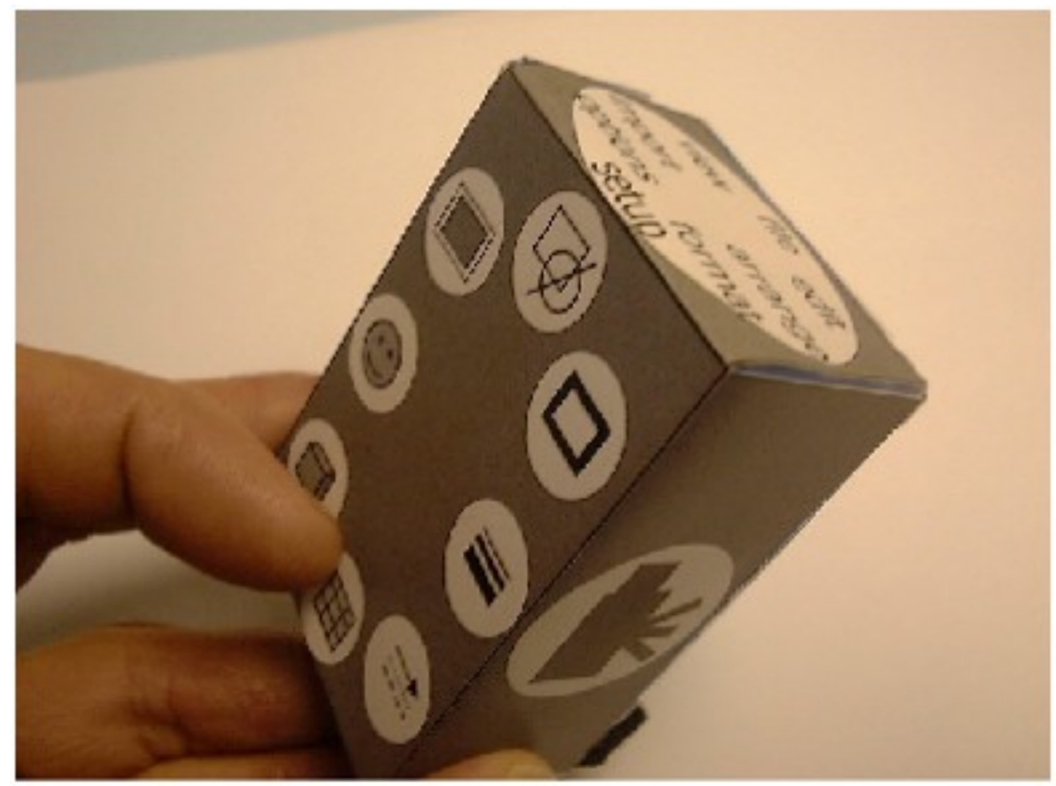


Figure 8: A ToolStone device with labels on each face. A (novice) user would be able to visually inspect available commands by physically turning the device.

ToolStone interaction

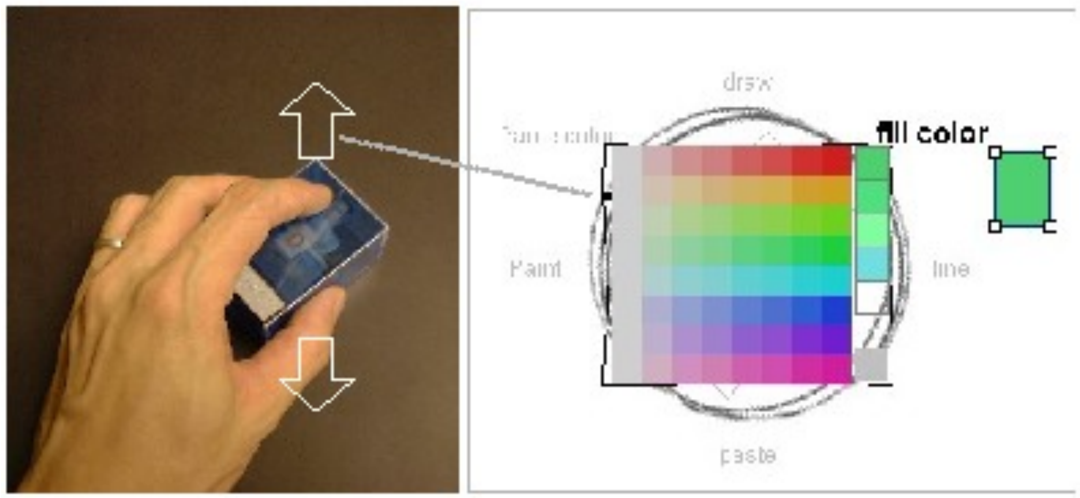


Figure 9: A color selection tool example: ToolStone's vertical motion controls the brightness parameter of the color space, while two other parameters (hue and saturation) are mapped according to the x and y axes of a 2D palette. A user can dynamically navigate though the color space before selecting a color instance. Note that the direction of the ToolStone is used to select the color selection tool.

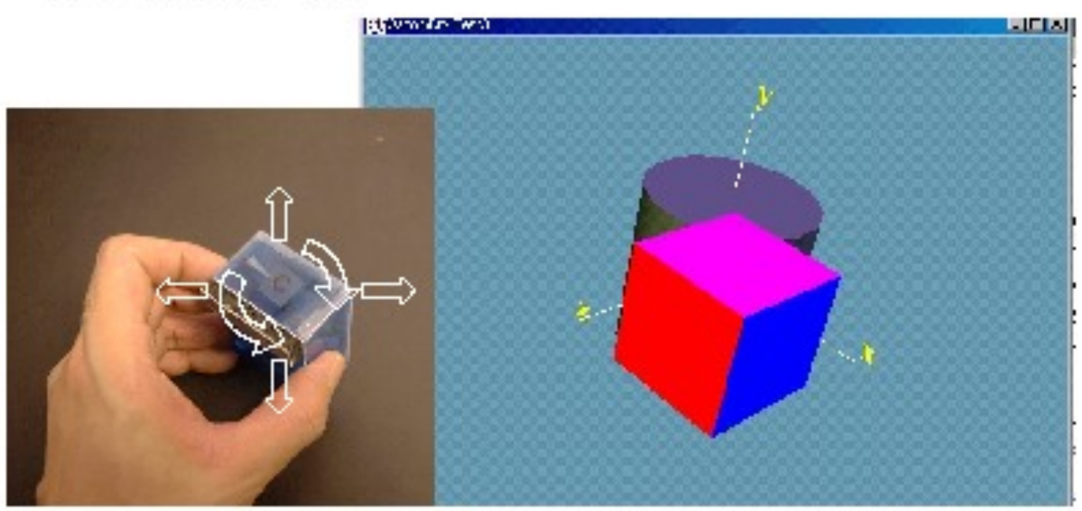


Figure 10: MDOF movement of the ToolStone can be mapped for 3D object control.

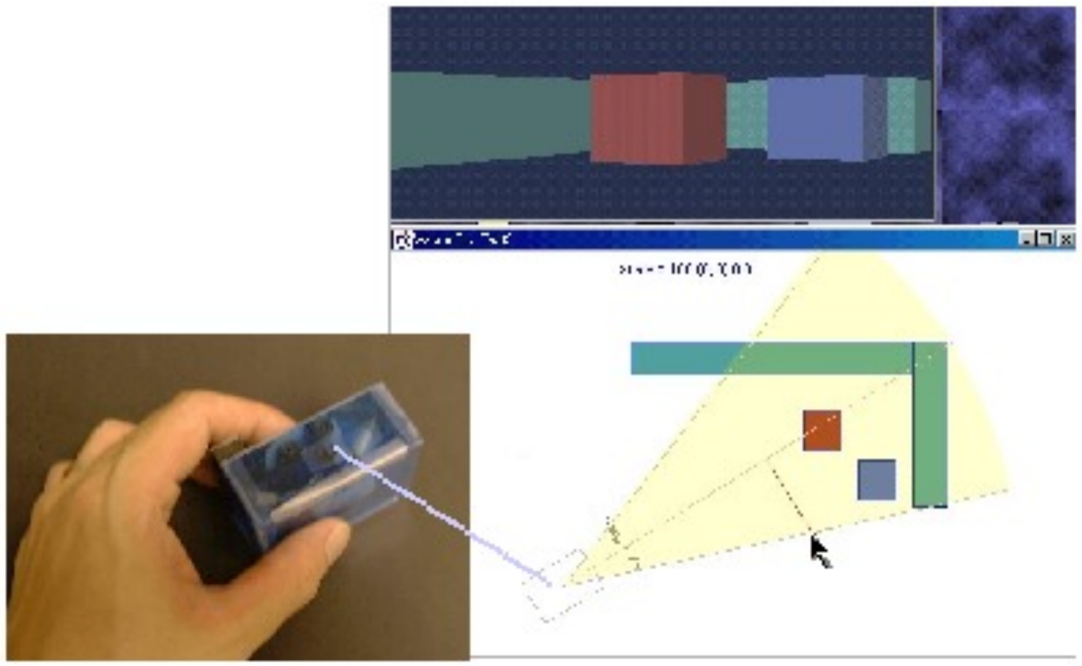
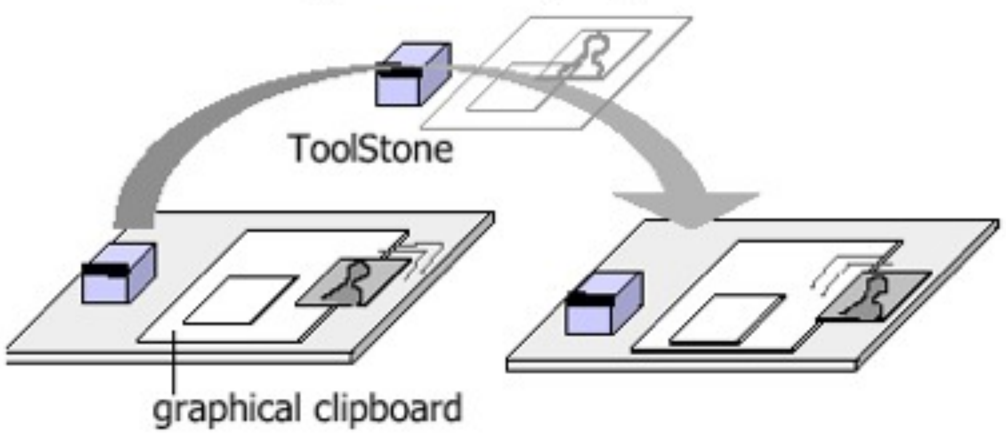
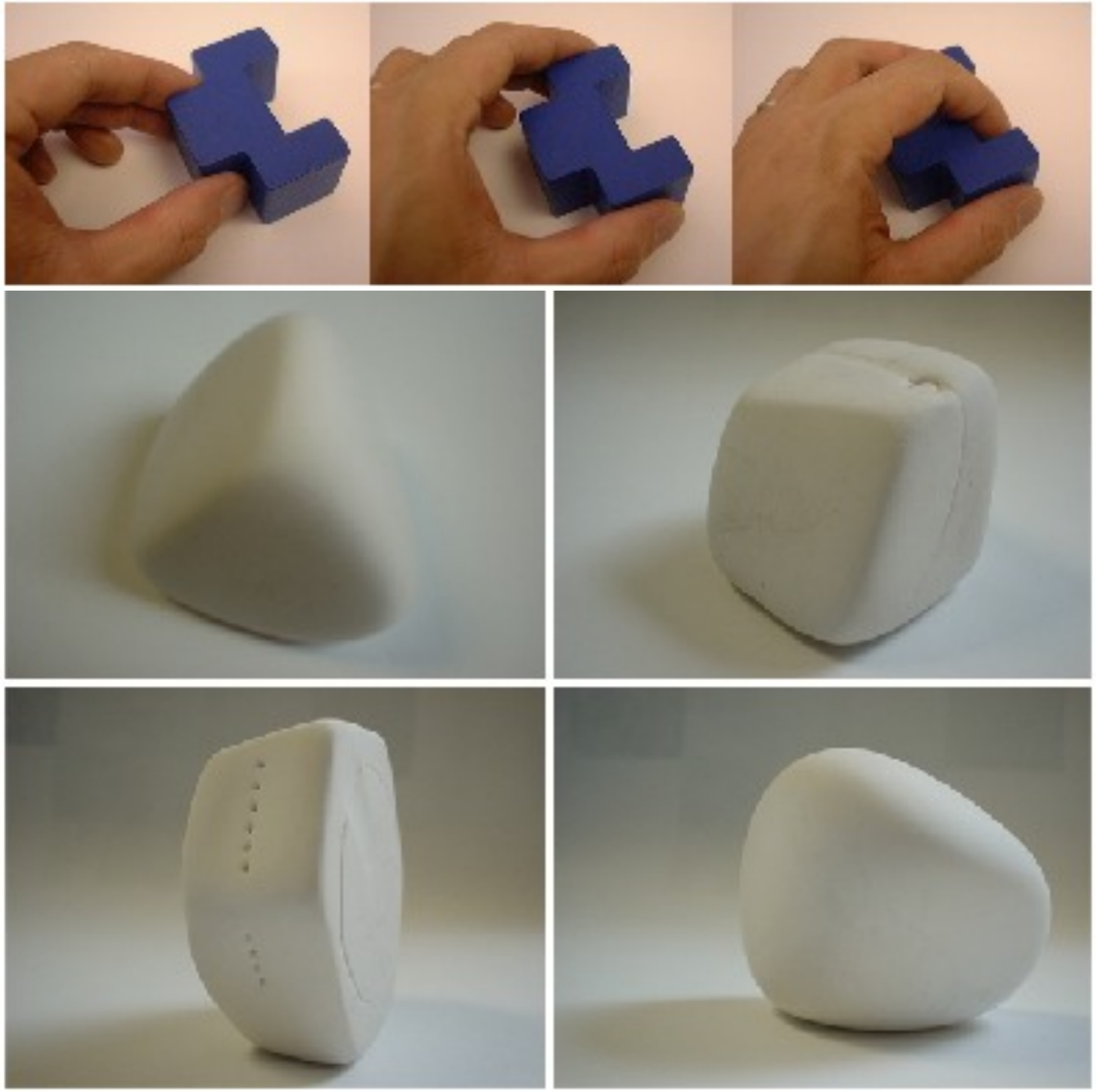


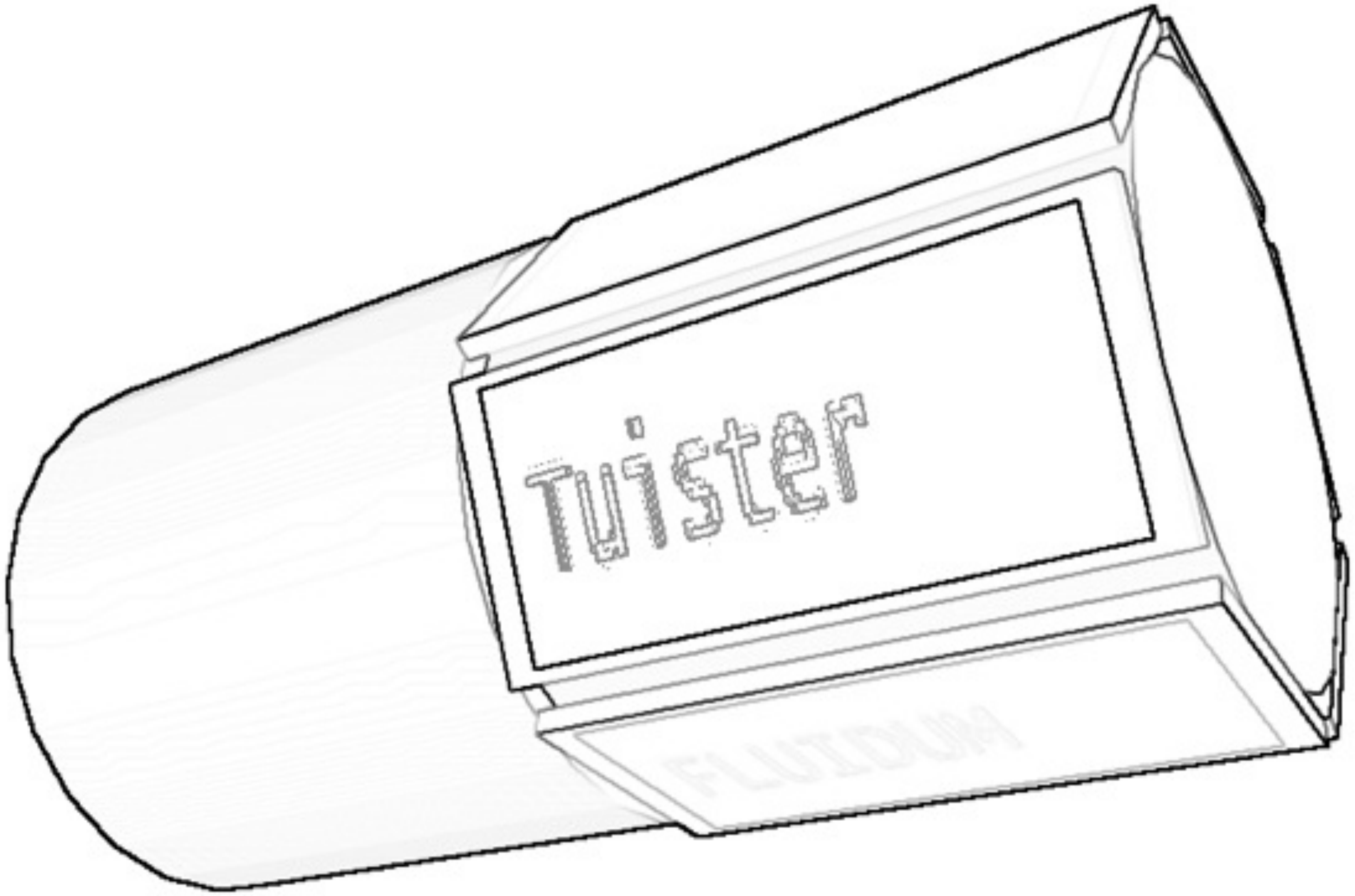
Figure 11: A user is manipulating a virtual camera of a 3D world. While the non-dominant hand is used to control the camera's position and orientation, the user can also change the field of view by dragging a viewing area (projected as a filled arc) with the dominant-hand's pointing device. Note that the pointing device is also used to change the viewing angle of the camera.

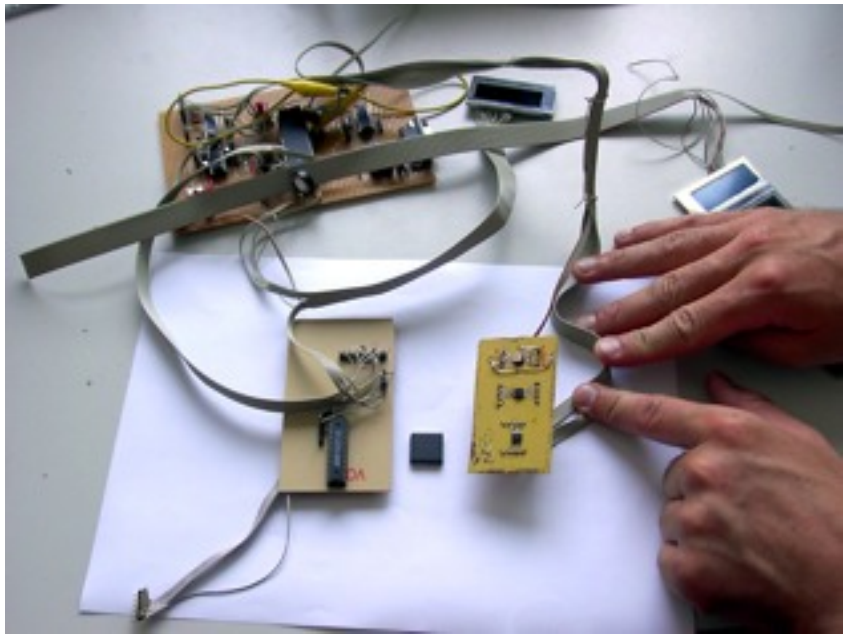


ToolStone design variations



Tuister
[Butz, Krueger, Groß, IUI 04]



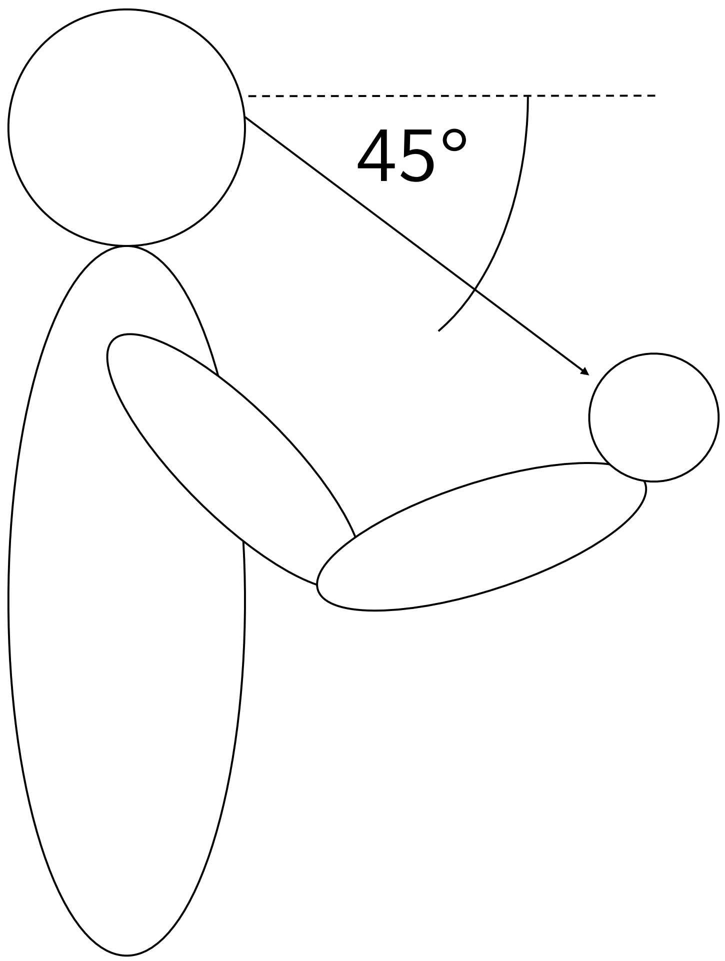


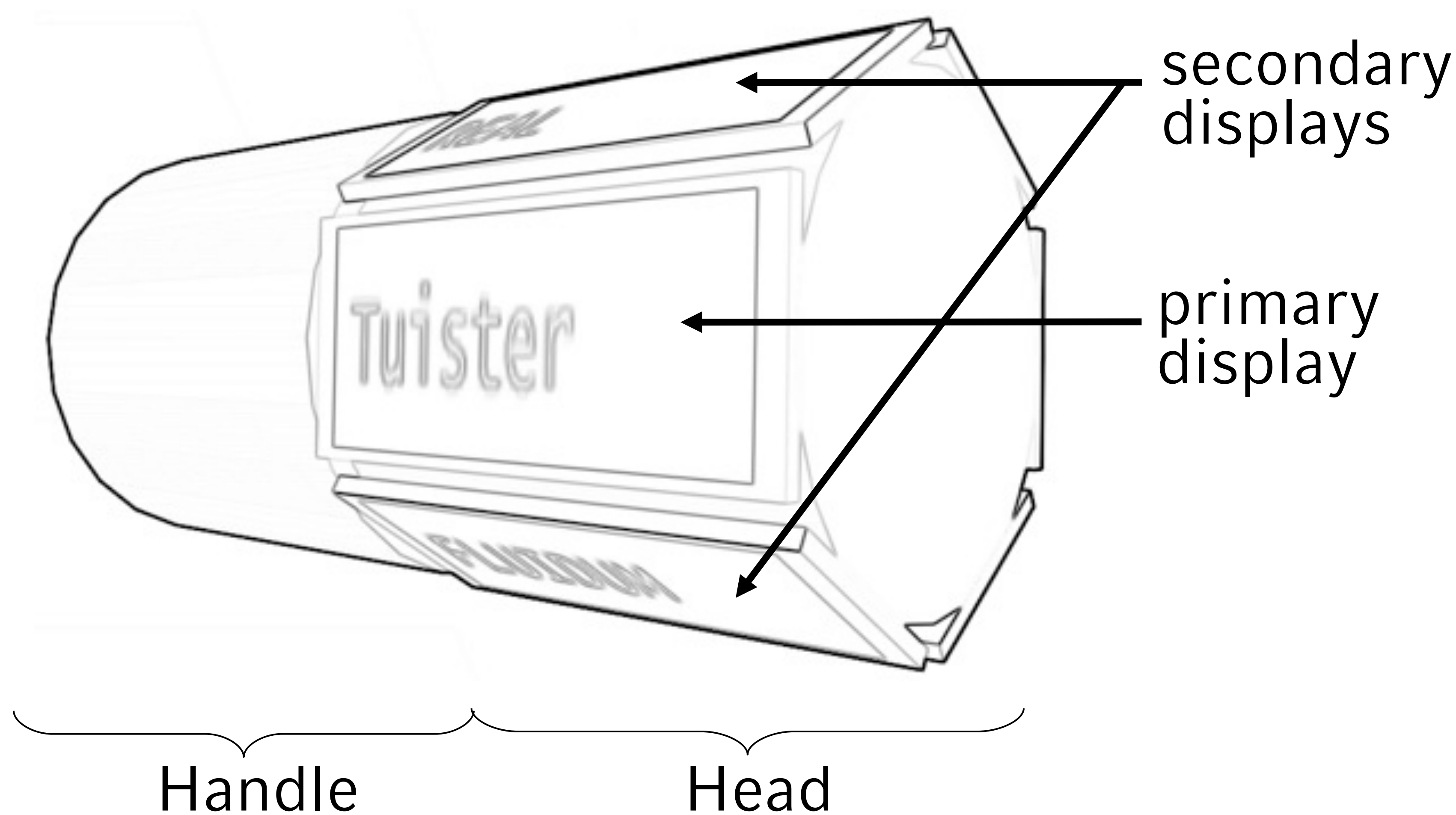
Interaction object, two-handed, 1DOF each
Gravitation, magnetic and rotation sensors
6 organic Displays
Serial/BT connection to the environment

Tuister: Conceptual Design

Determination of the primary display by two assumptions:
- Text must be upright
- User looks down about 45°

Sensors for orientation:
2x 2D acceleration
3x 1D magnetic
1x relative rotation





Two types of rotation

Rotating the head

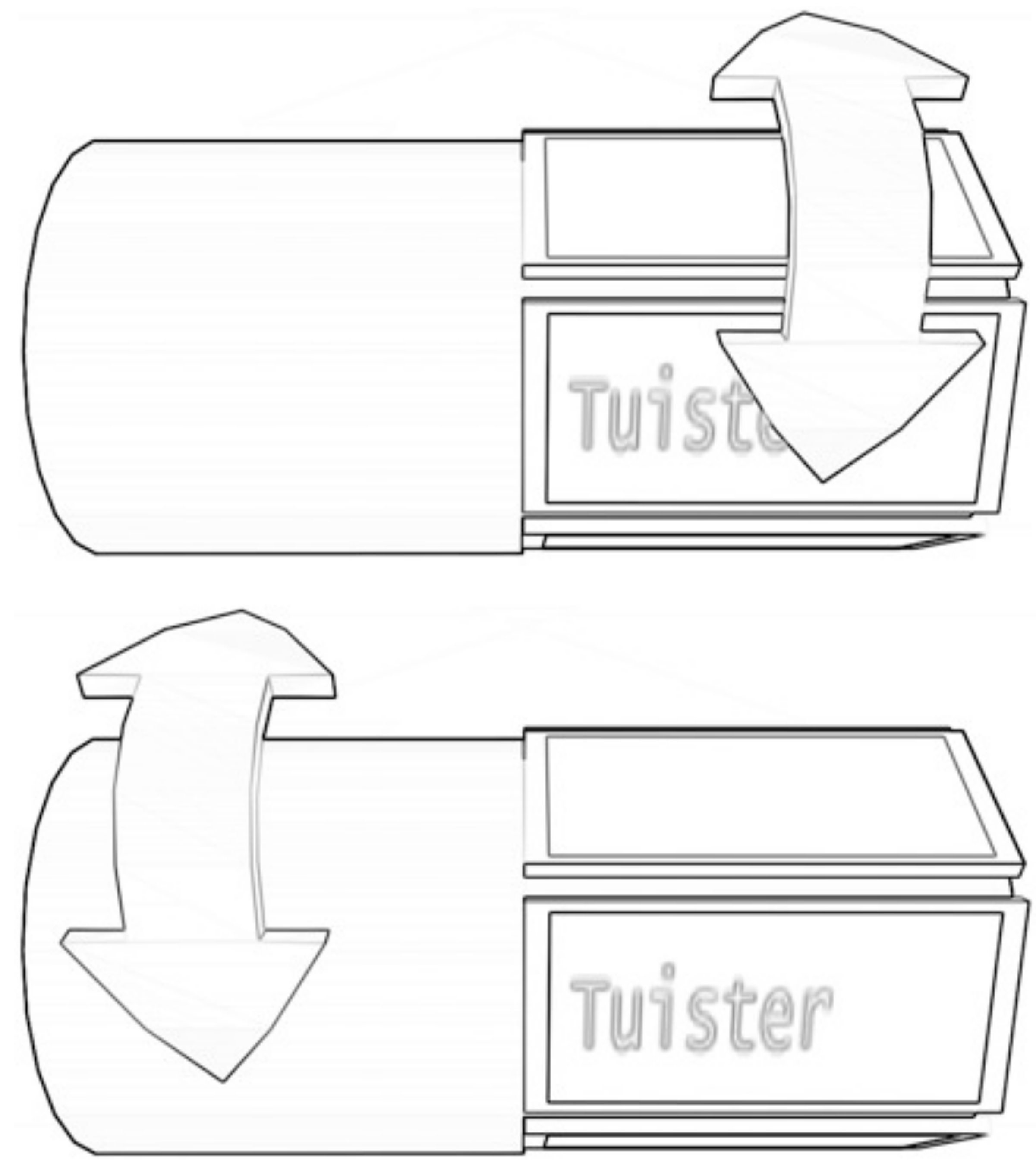
- Direct physical manipulation
- Choice within one menu level
- Context via secondary displays

Rotating the handle

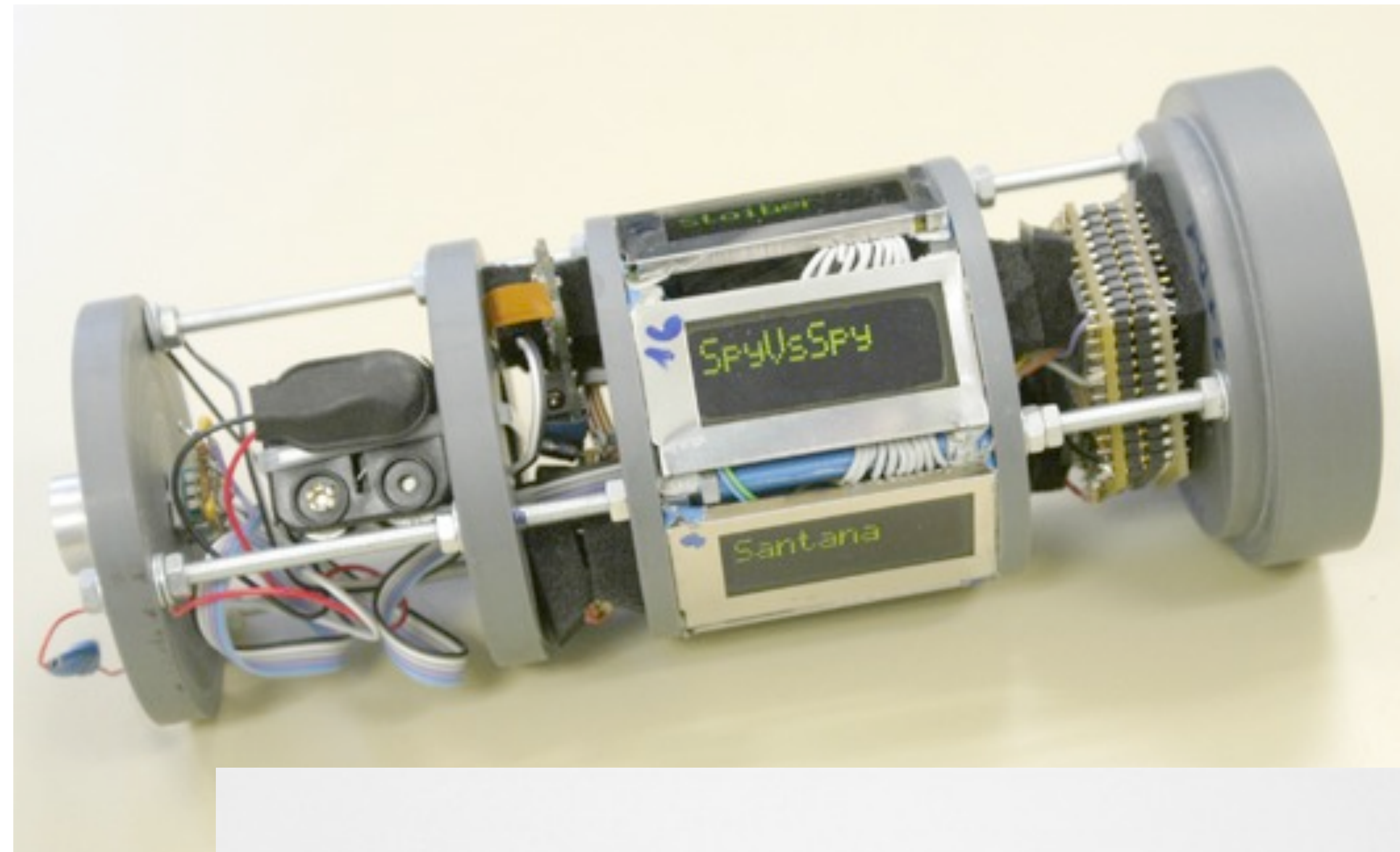
- Metaphor: (un-)fastening a screw
- Clockwise = fastening = down
- Counterclockwise = up
- Choice of the menu level

Rotation by hand: few entries

Free spin: for long menus



Tuister: Prototypes



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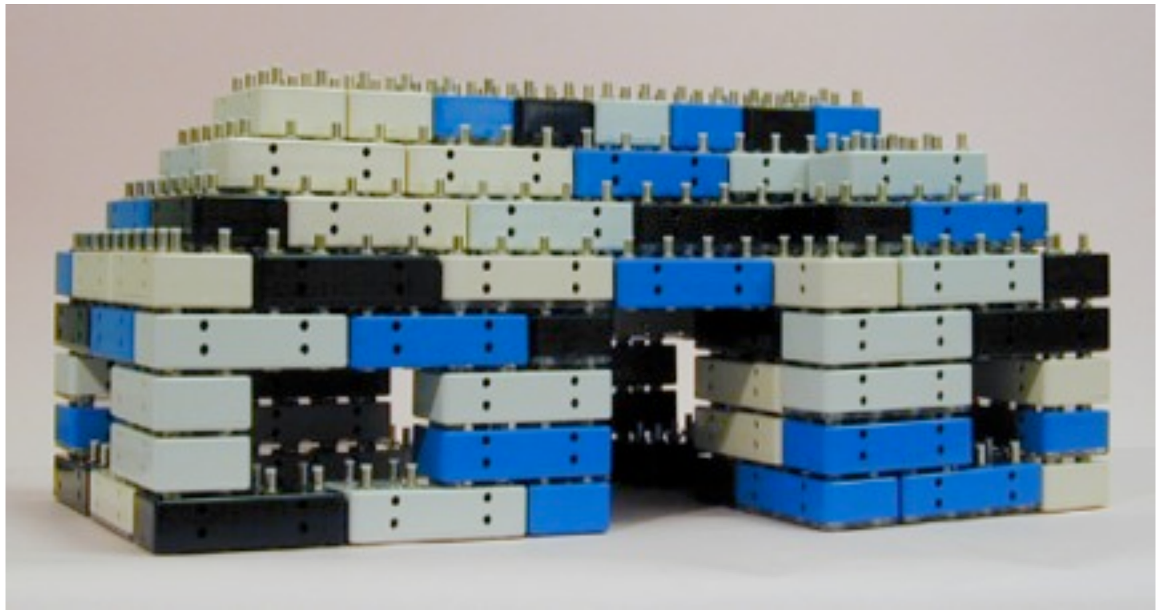
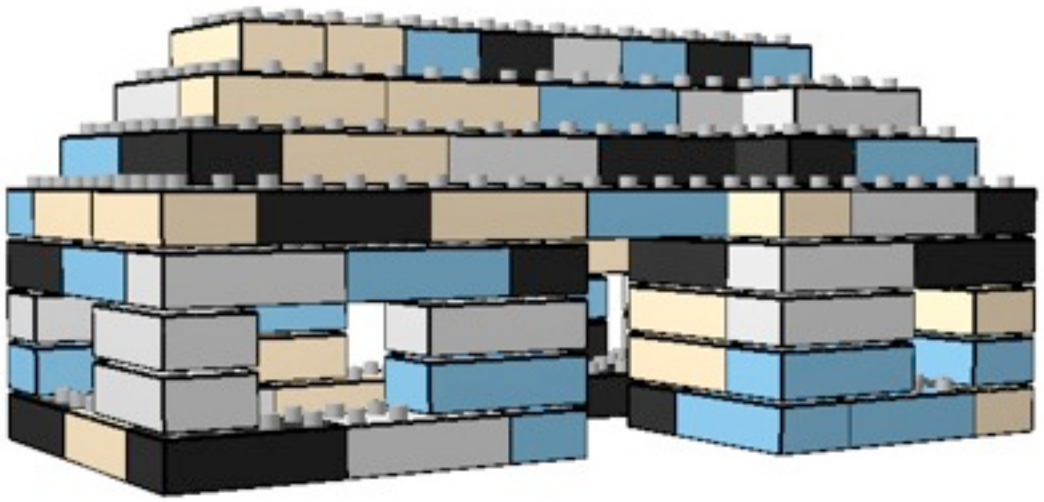
3D modeling with LEGO

(Anderson et al., SIGGRAPH 00)

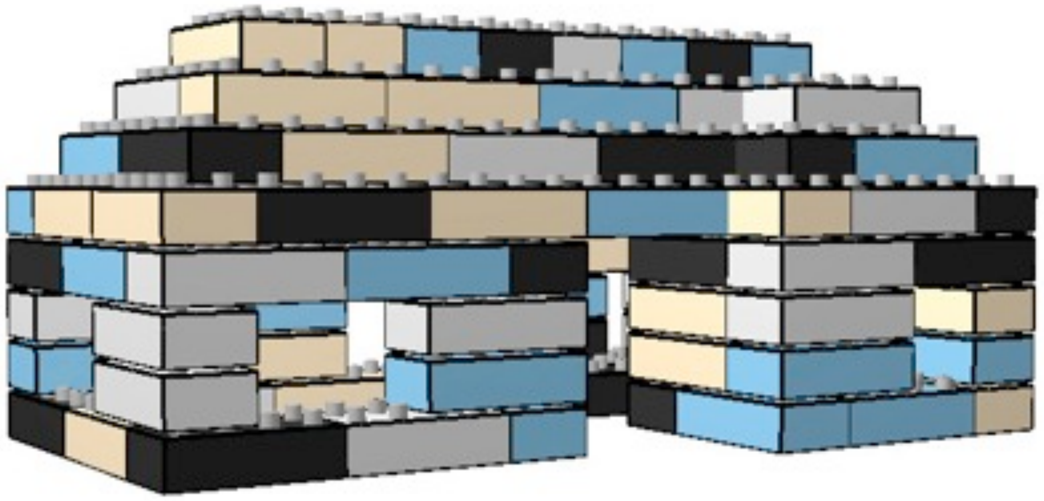
- LEGO blocks with connectors and CPU
  - Keep track of their spatial configuration
  - Describe a voxel („volume pixel“) model
- Reconstruction in the host computer
- Interpretation acc. to prototypes



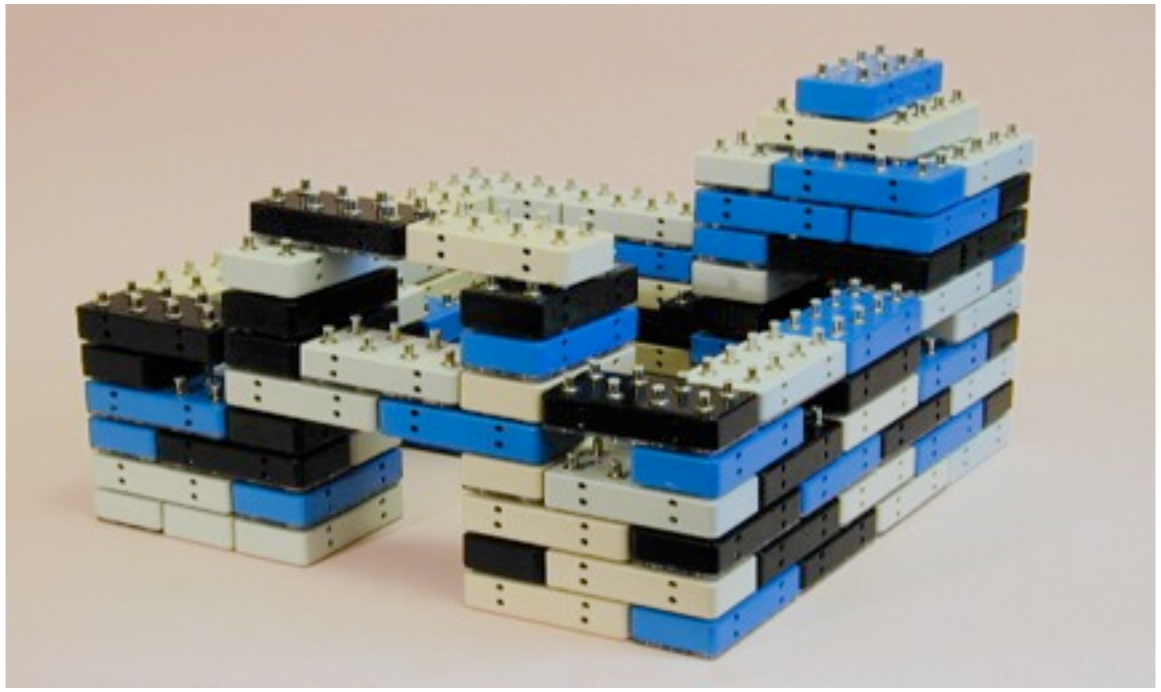


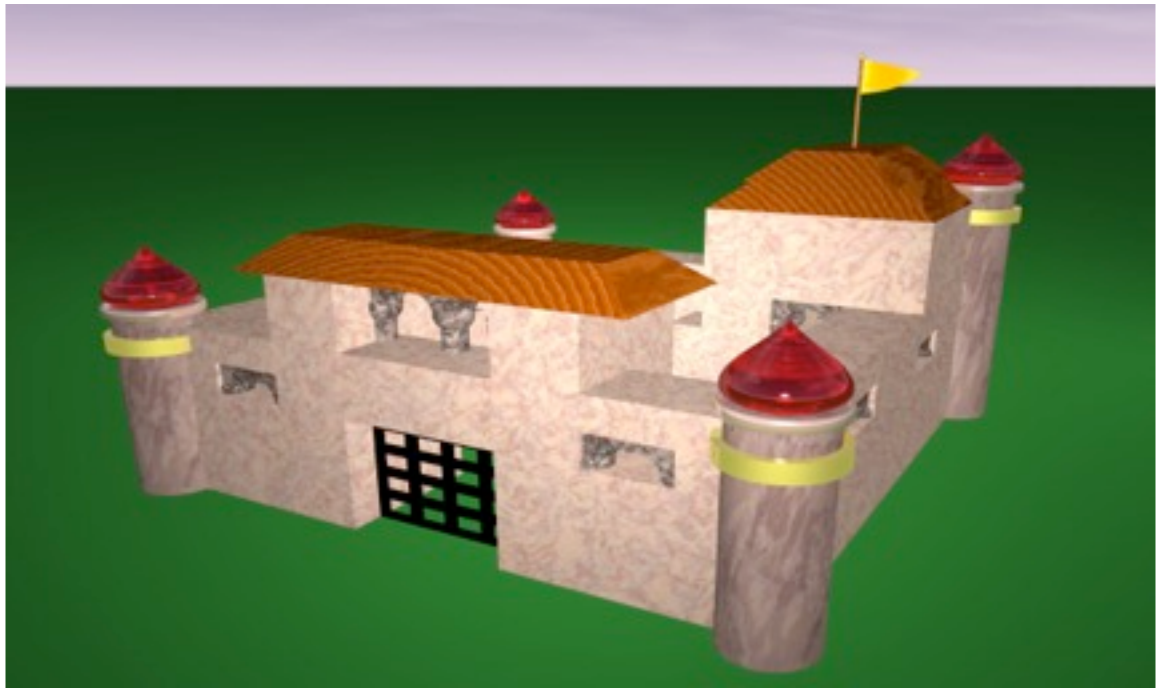
3D modeling with LEGO

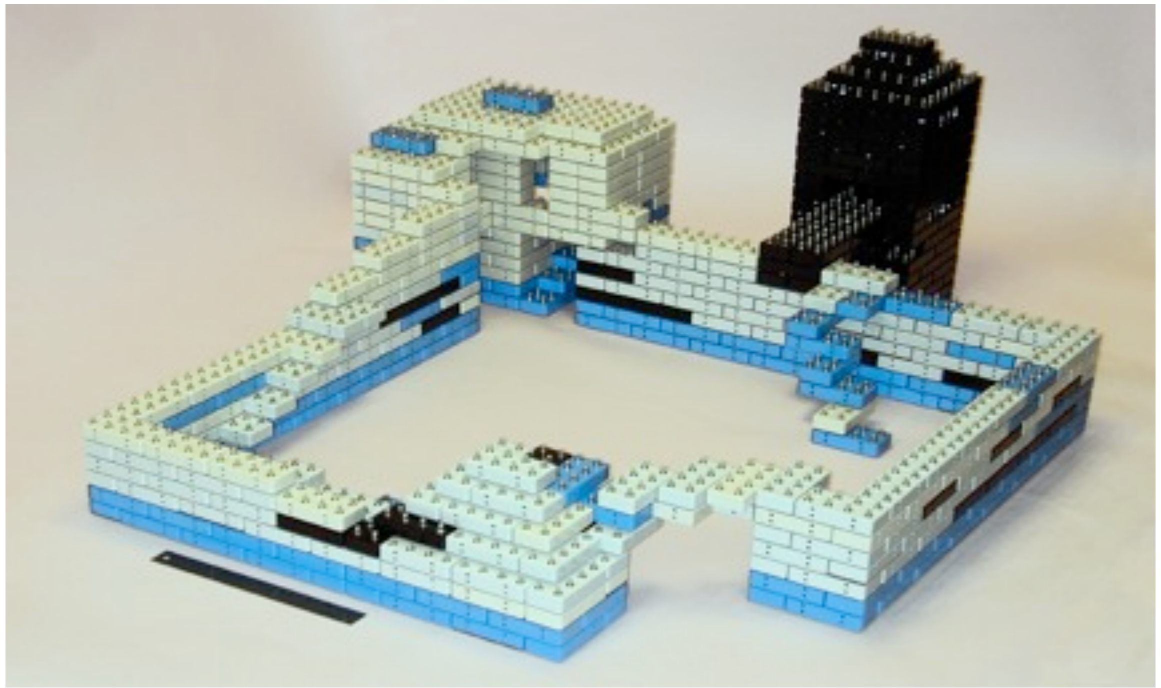
- Interpretation of structure:
  - Transform structure into a set of logical propositions
  - Define rules what is a wall, roof, window…
  - Determine from structure and rules, what block has which function
  - Construct 3D model accordingly

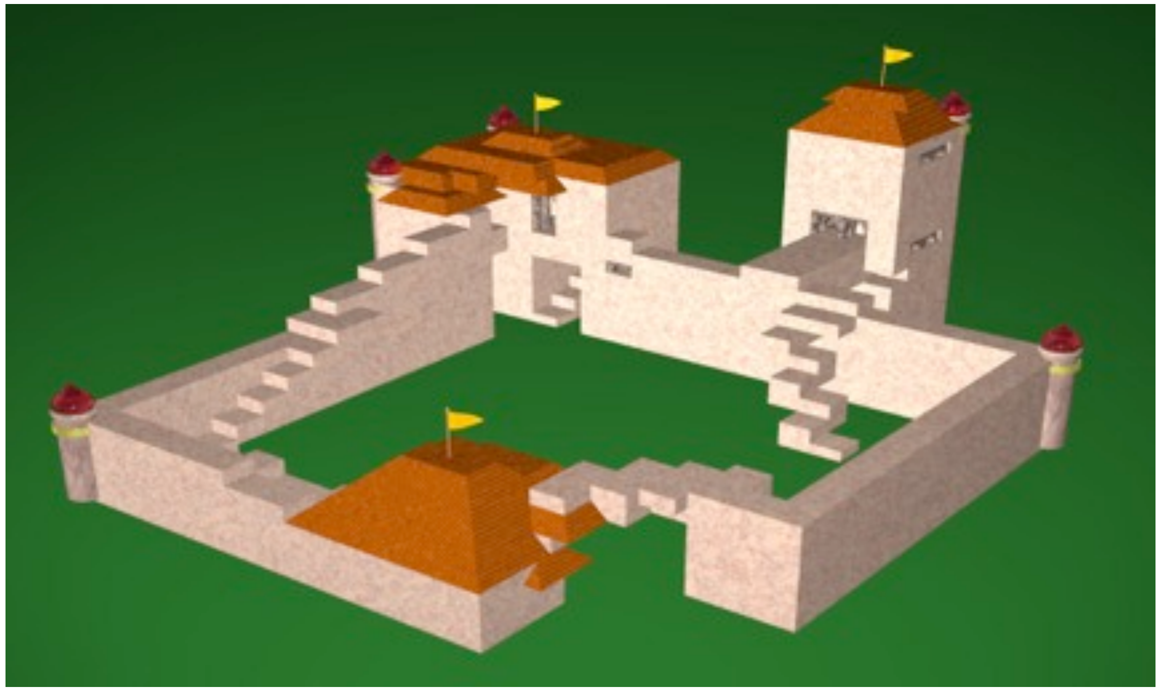


LEGO (contd.)





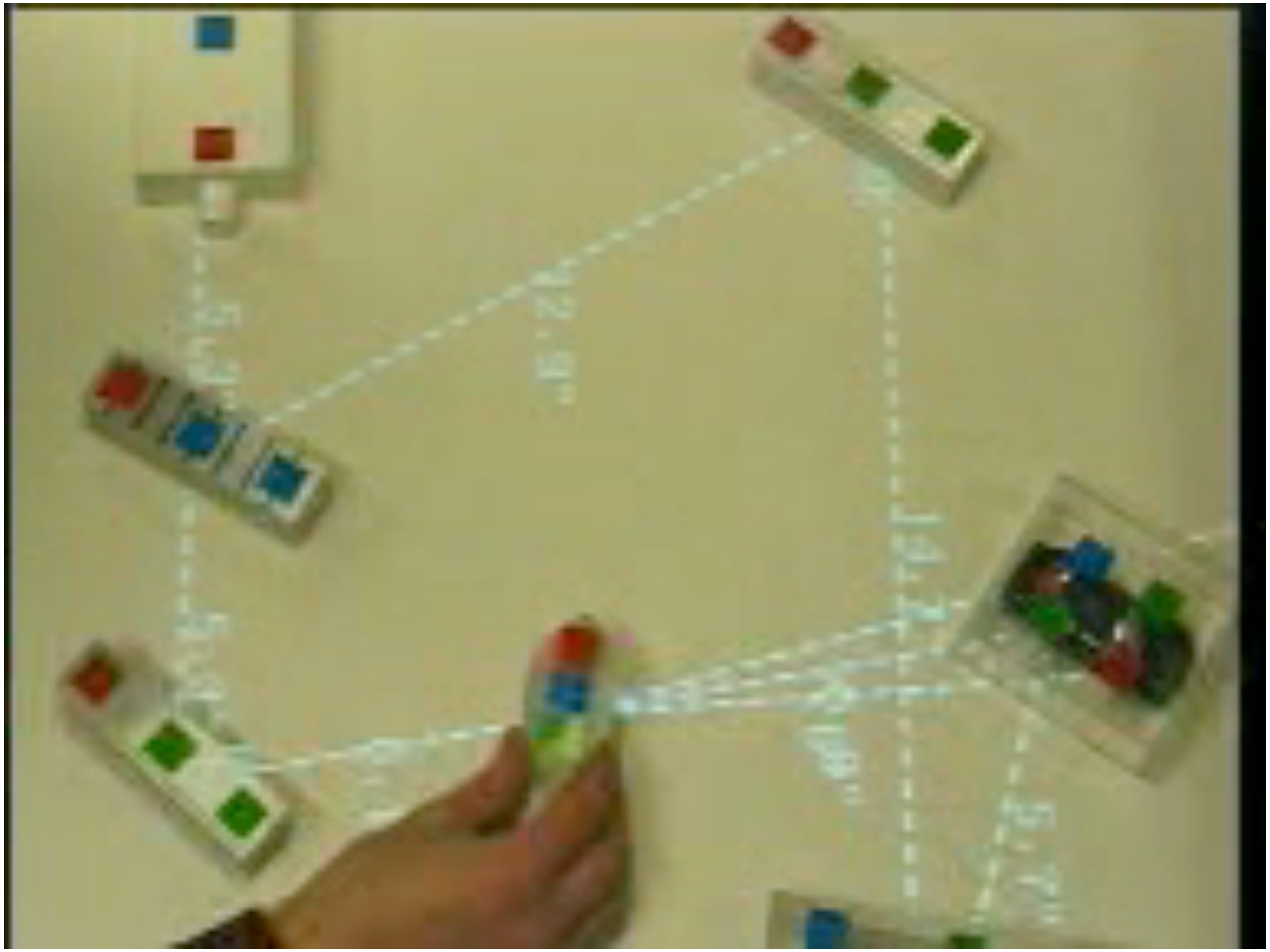


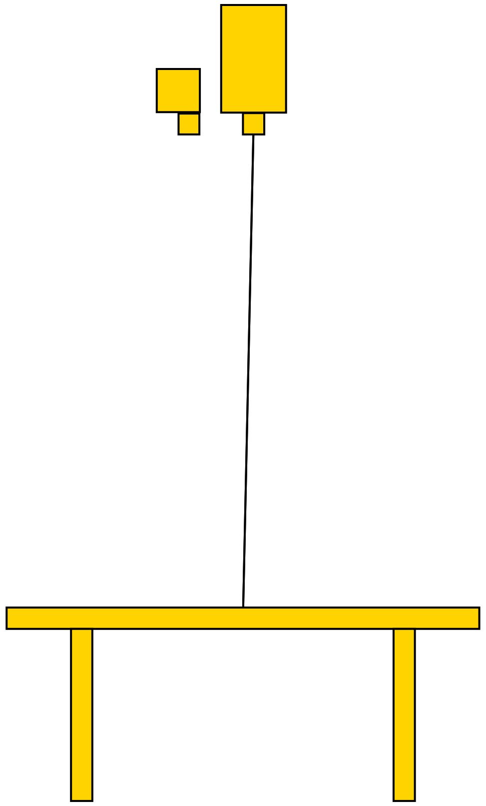


Luminous room: Illuminating Light

(John Underkoffler, Hiroshi Ishii, CHI 98)

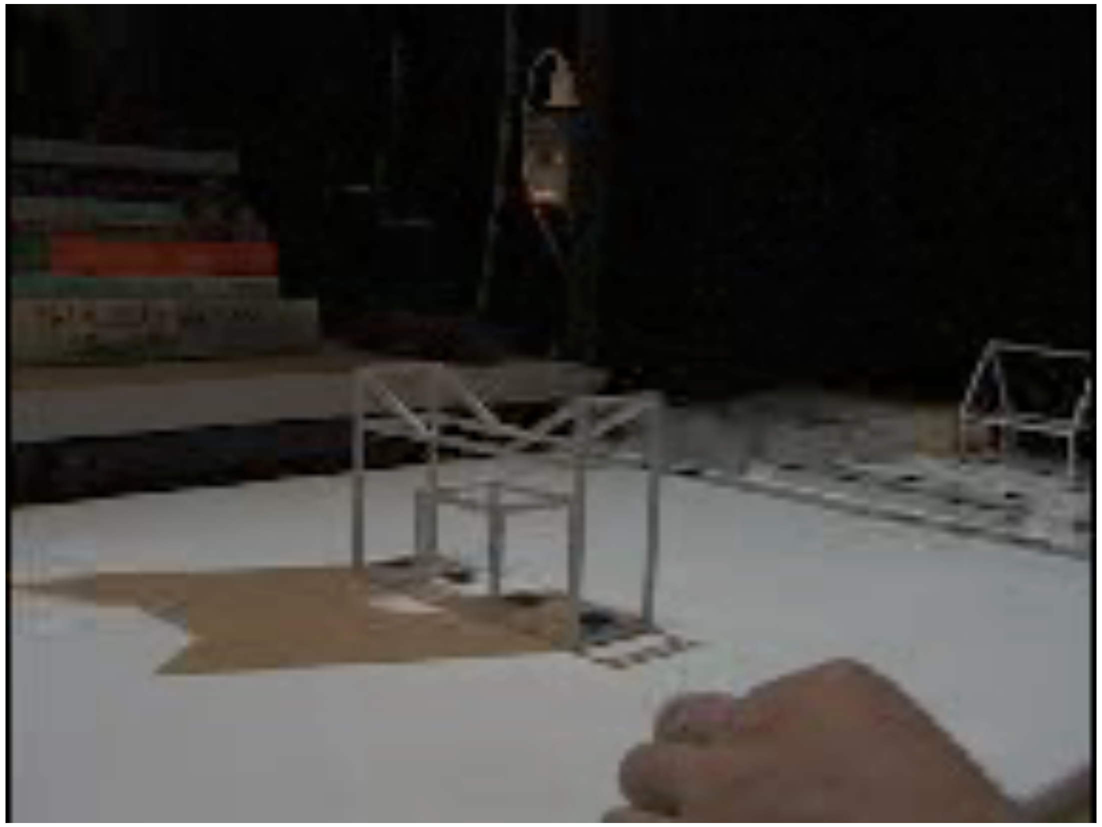
- Simulation of optical/holographic setups
- Phys. objects represent optical elements
- Top projection of resulting laser beam

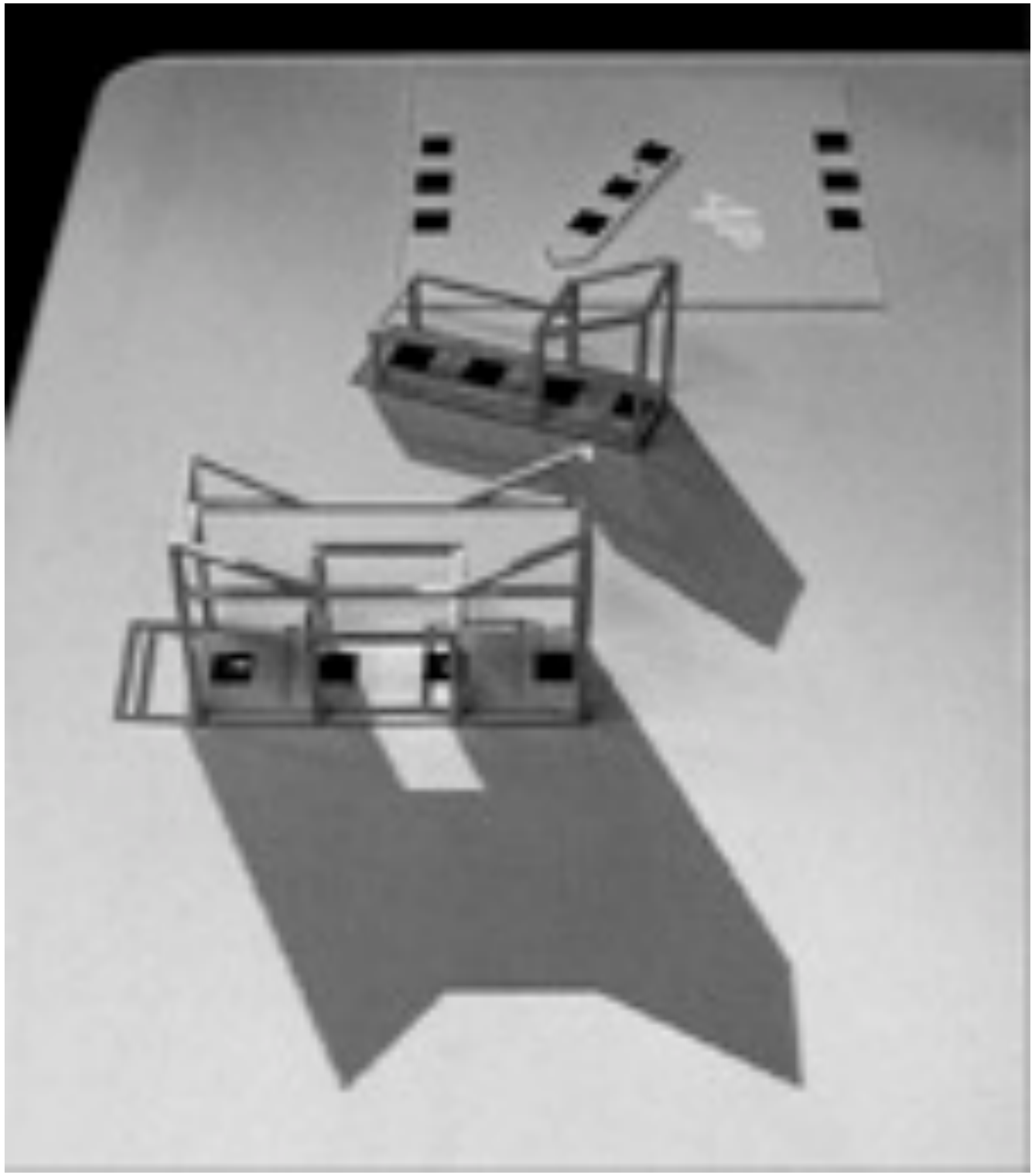




Luminous room: Urban Planning (URP)
(John Underkoffler, Hiroshi Ishii, CHI 99)

- Move physical models of houses on a desk surface
- Simulate in the computer:
  - Shadows
  - Window reflections
  - Air flow and wind

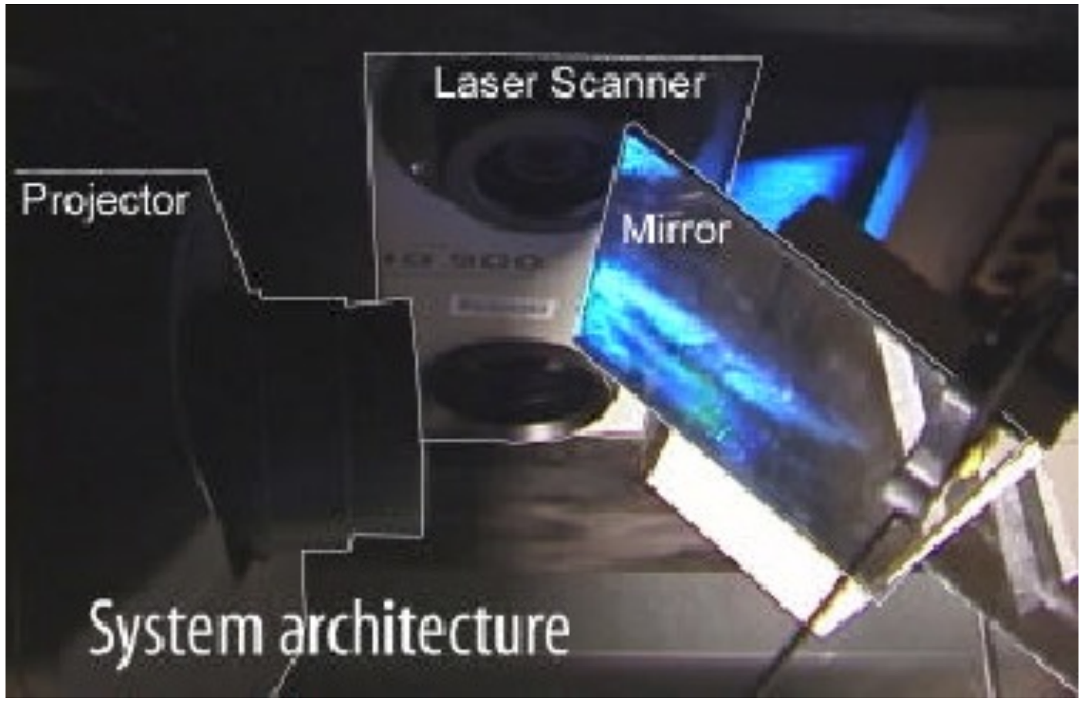


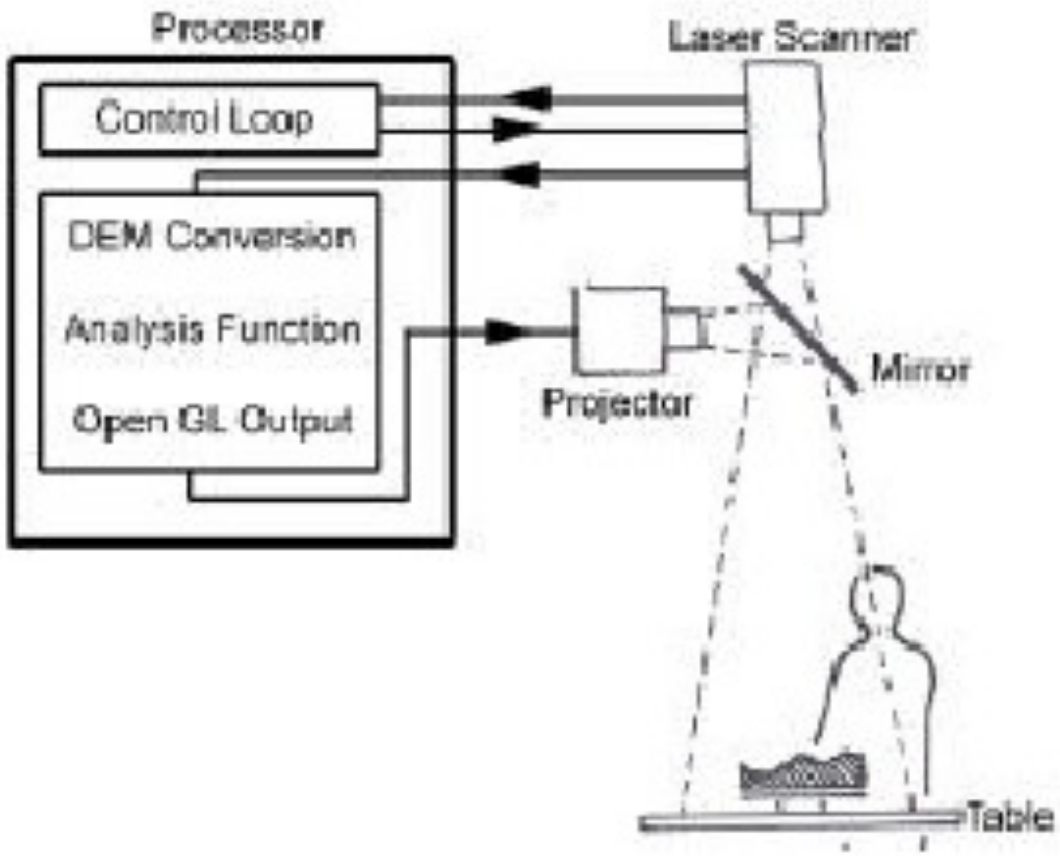


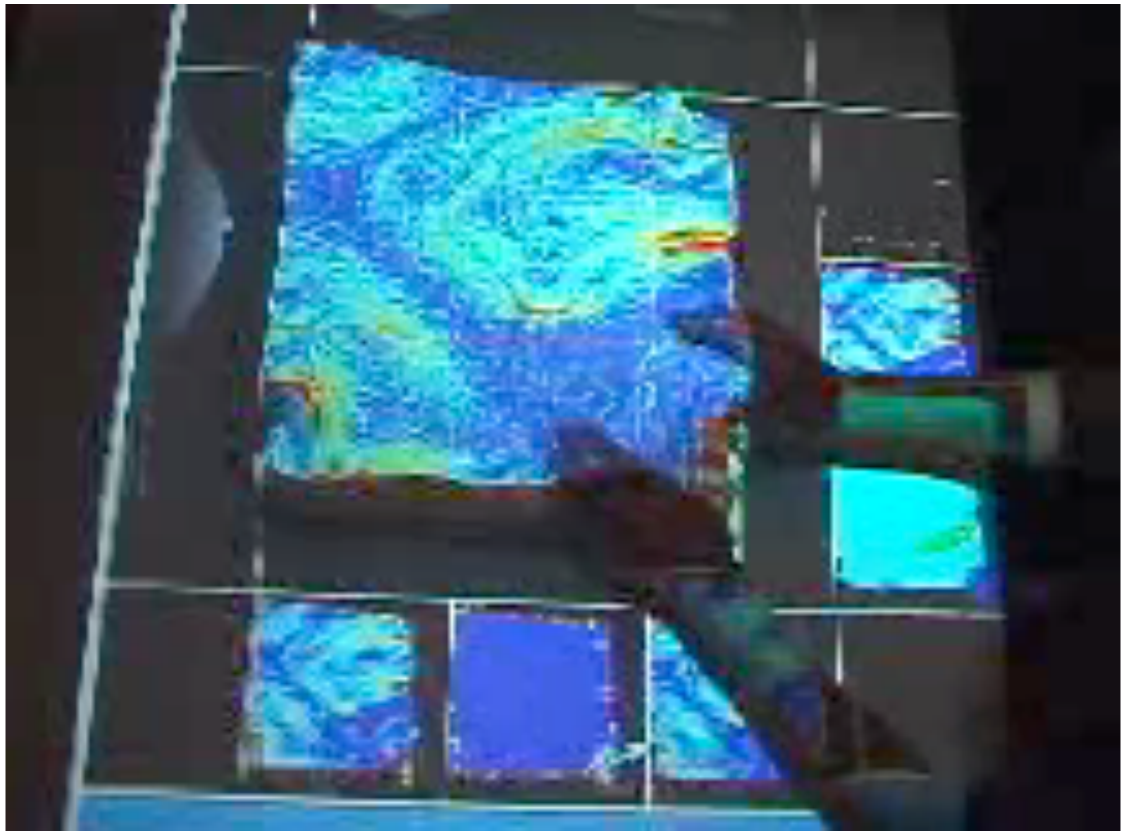
Illuminating Clay

(Piper, Ratti, Ishii, Chi 02)

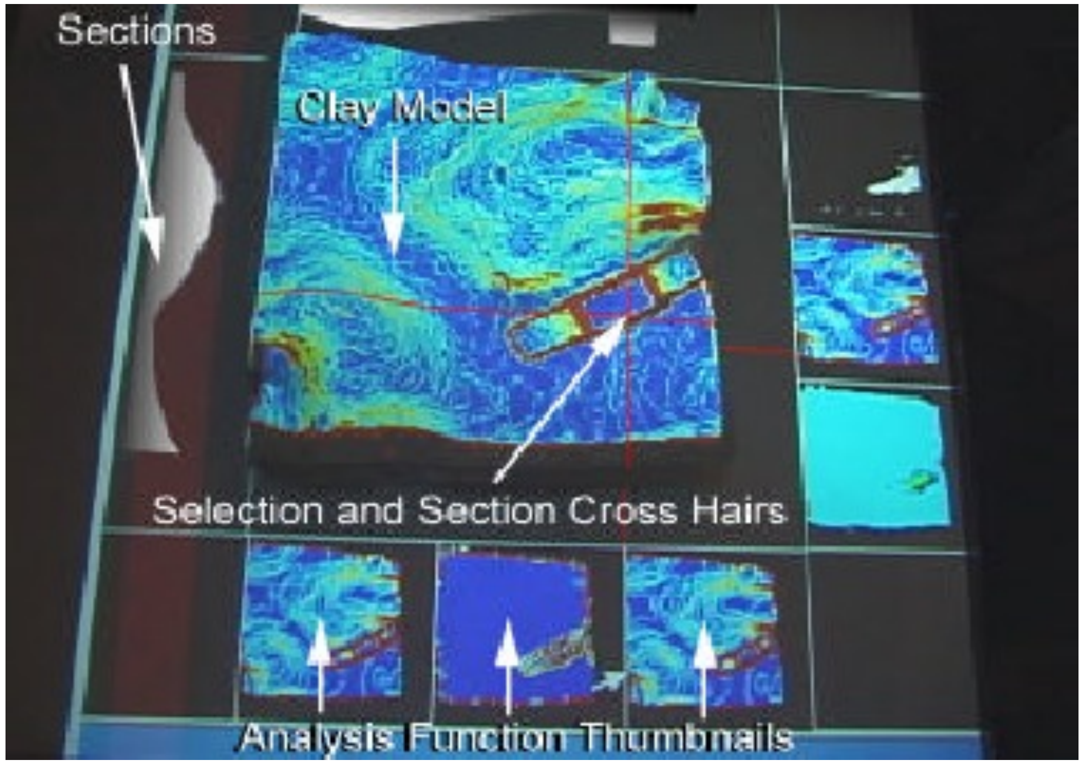
- Clay model on desk surface
- Top projection = output
- 3D laser scanner = input
- Used for landscape design



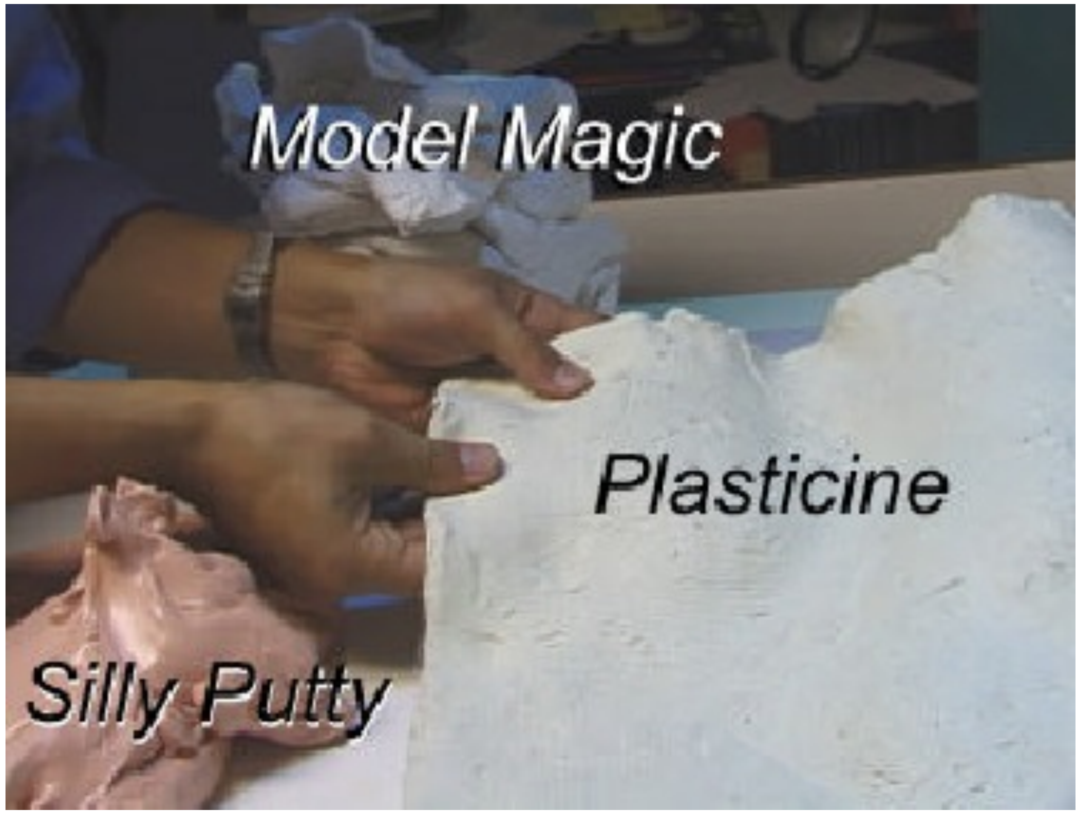


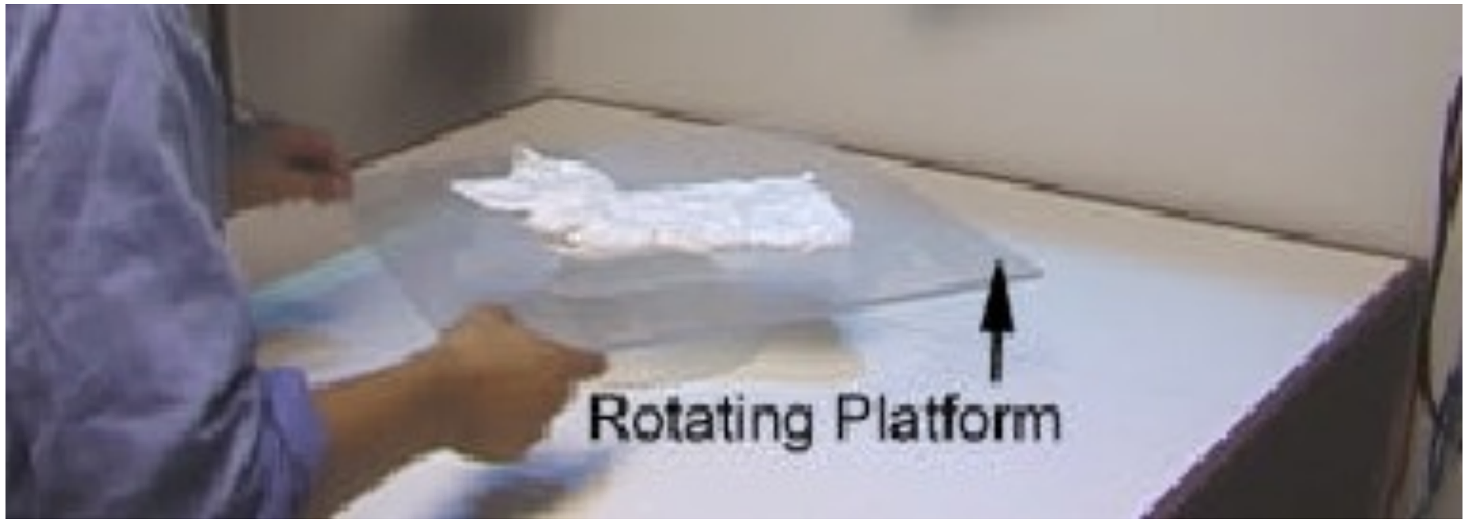


Illuminating Clay UI elements



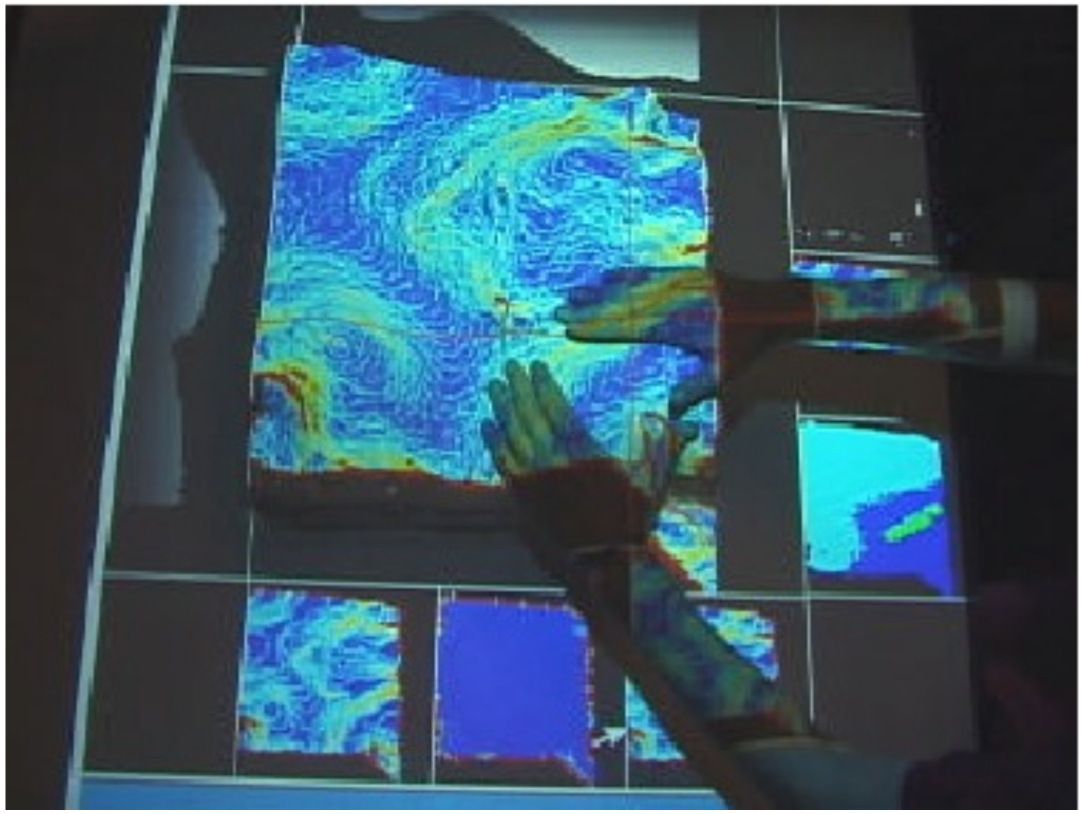
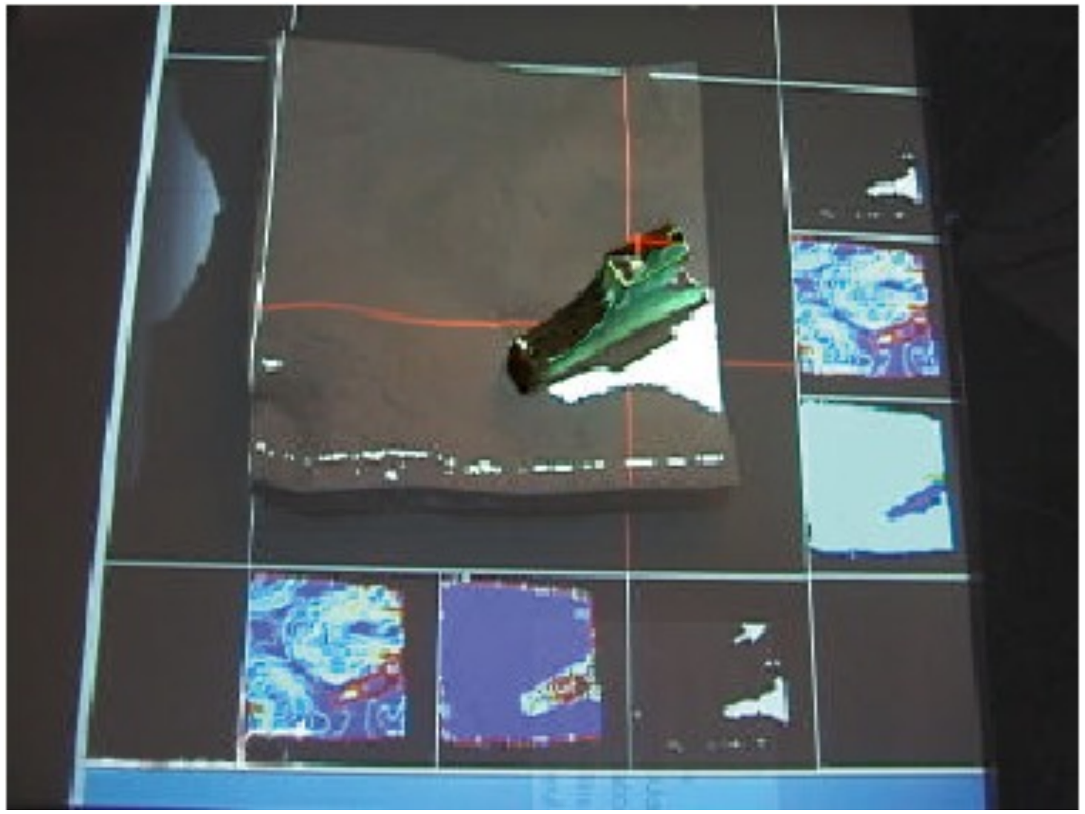
- Deformable clay model
- UI elements for section and analysis functions
- Interaction with terrain





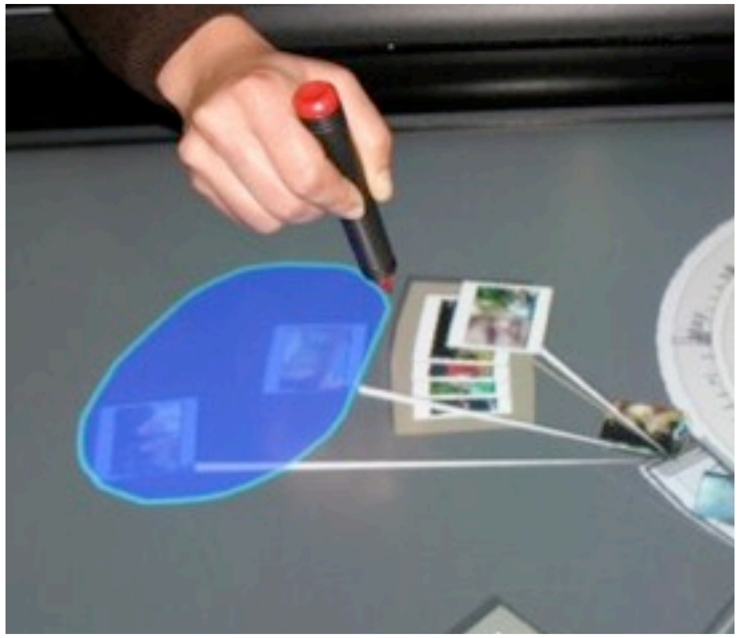
Illuminating Clay applications

- Slope variation with color feedback
- Solar radiation, shadows

PhotoHelix

[Hilliges, Baur, Butz, IEEE Tabletop 2007]



- Idea: Hybrid widget, i.e., mix btw. Physical & virtual.

Physical Interaction, Tangible and Ambient UI

- Shareable Interfaces
- Tangible UI
  - General purpose TUI frameworks
  - Specialized TUIs
  - TUIs in everyday objects
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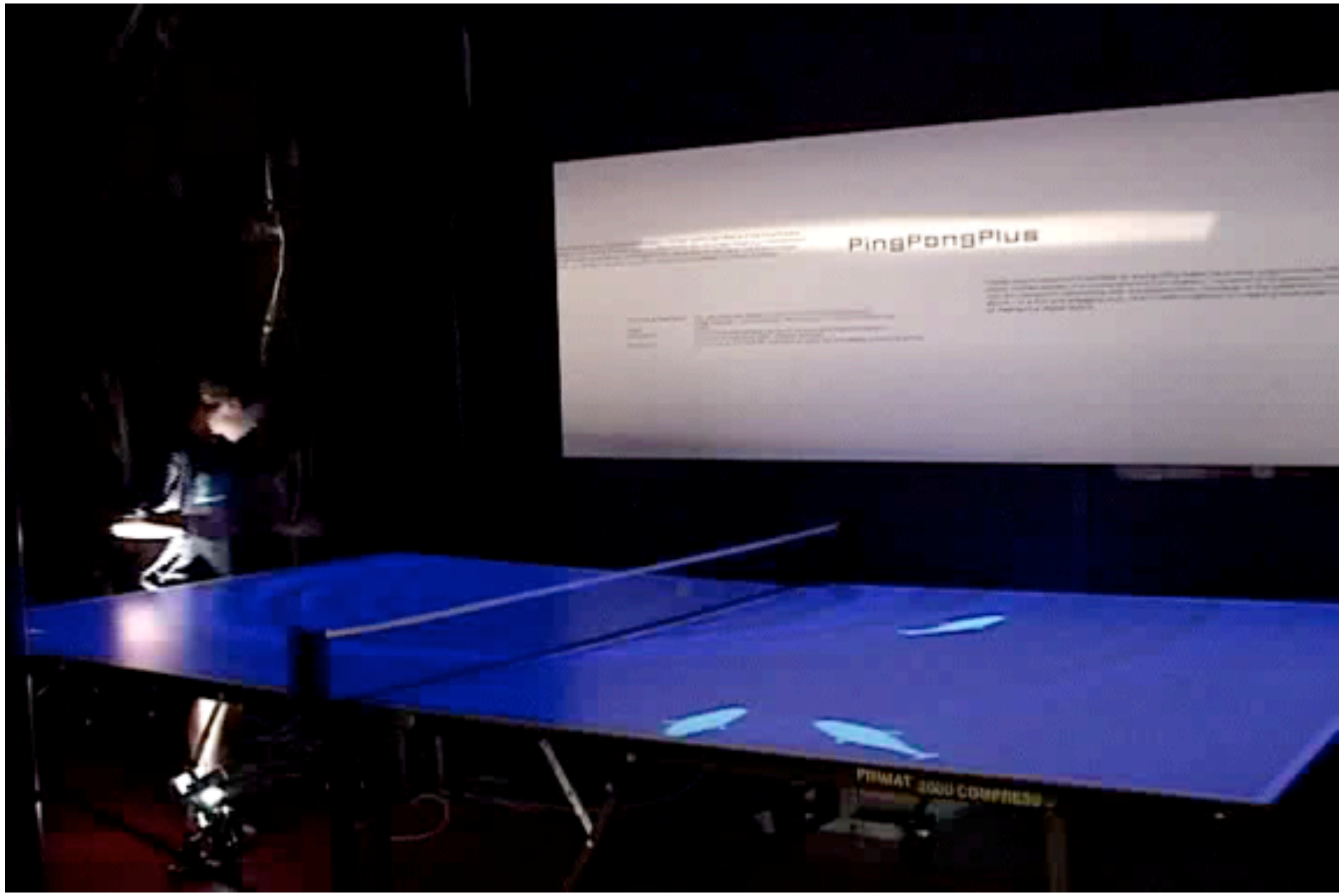
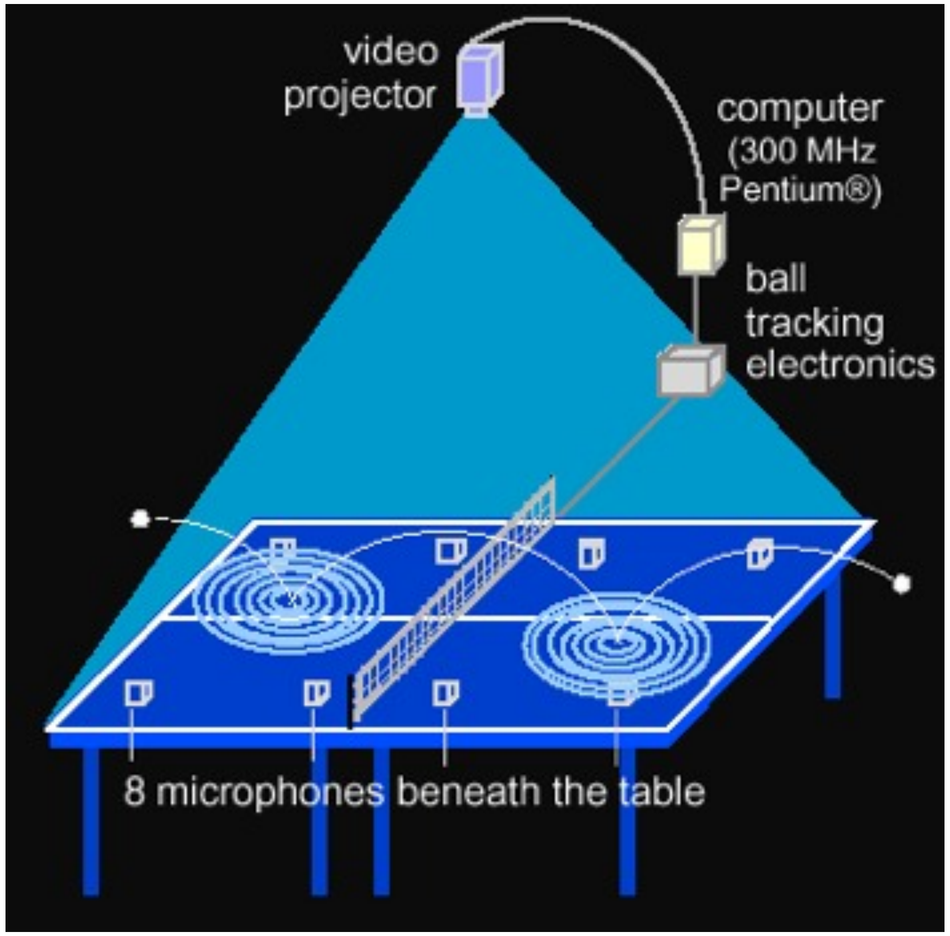
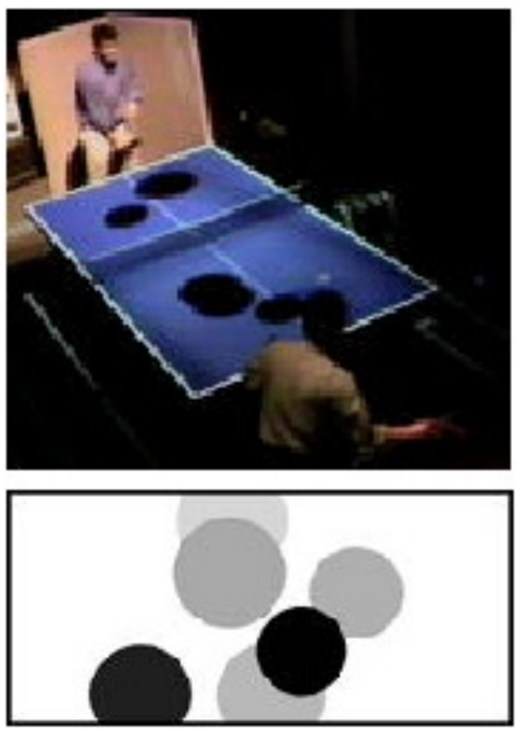
PingPongPlus
(Ishii et al. SIGGRAPH 98)

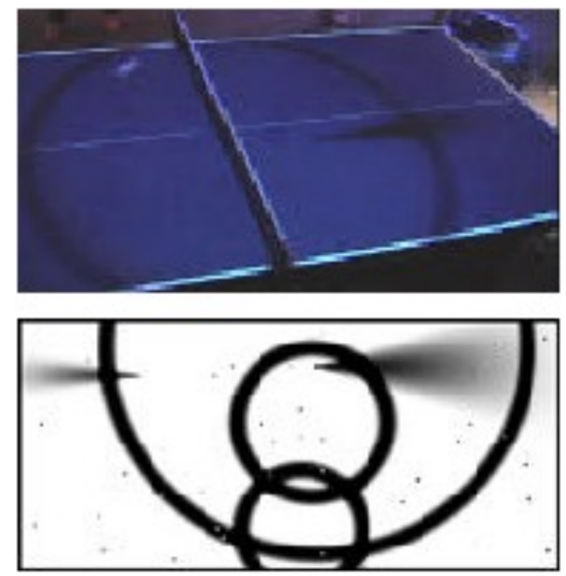
- Physical PingPong
- Virtually augmented
- Additional game functionality

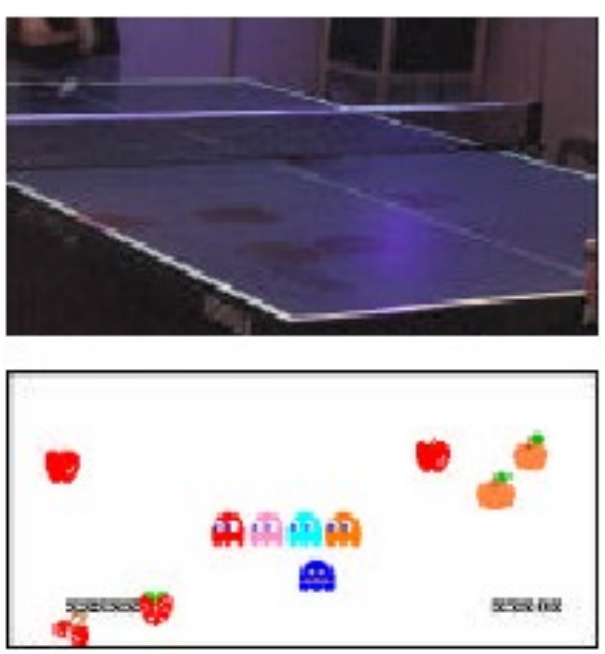


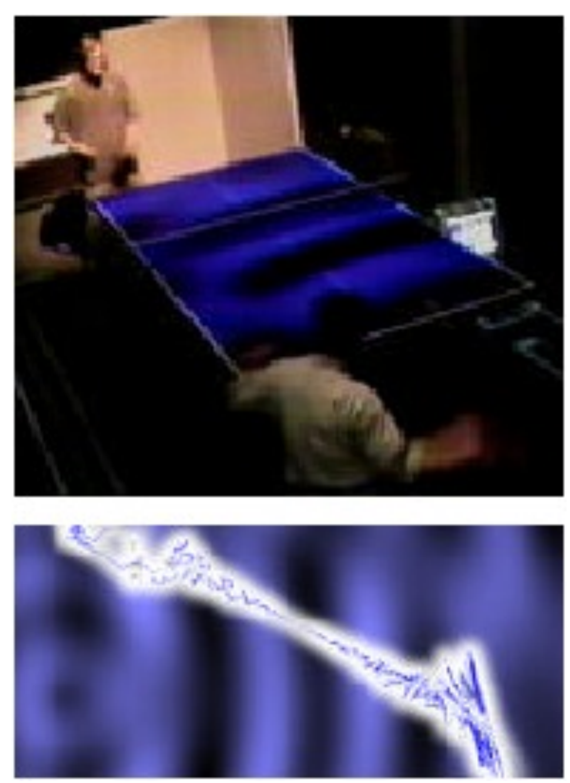


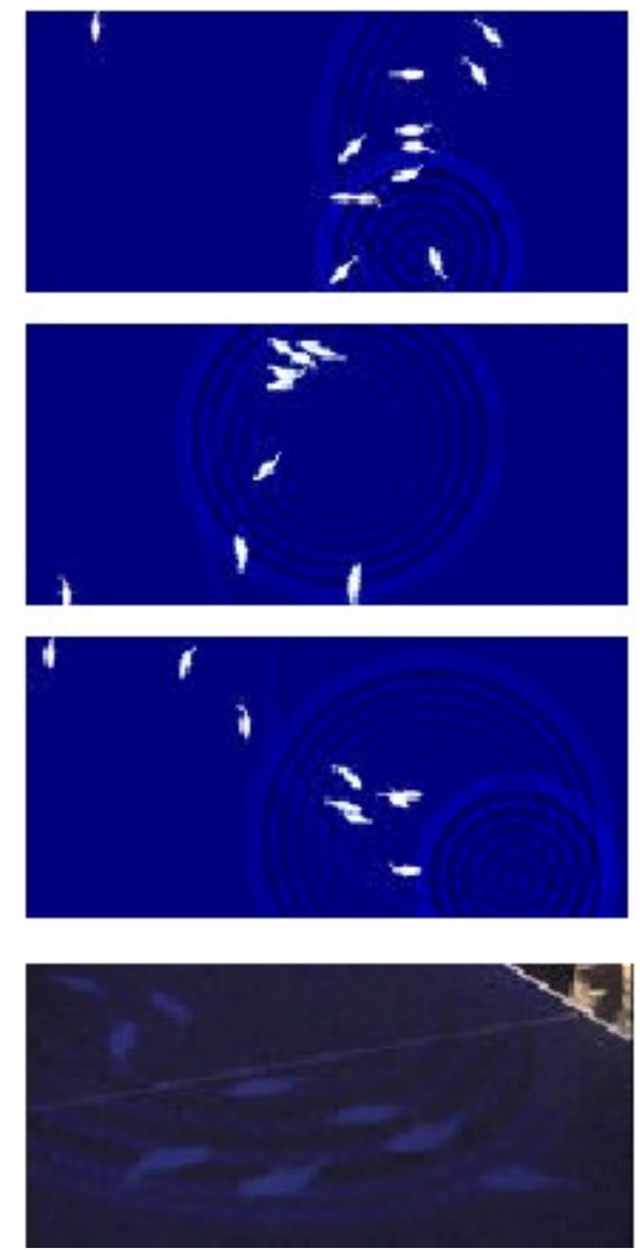
PingPongPlus variations











MusicBottles
(Ishii, Mazalek, Lee, CHI 01)

- Bottles contain music (classical, jazz, techno)
- When placed on the desk, light appears around them
- When opened, music can be heard
- Metaphor: bottles contain something, can be released when bottle is opened

Marble Answering Machine
(concept study by Gary Bishop, RCA)

- Design study and some prototypes
- Each message represented by a marble
- Placing the marble on tray plays back the message
- Placing the marble on the phone calls back


SIMON & IMOGEN'S HOUSE
© Durrell Bichop 1992

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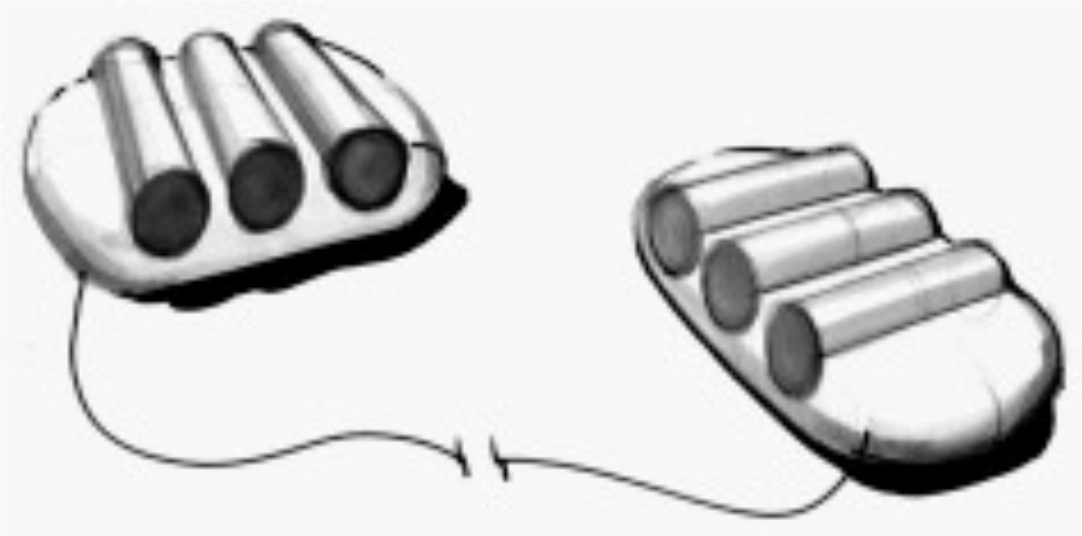
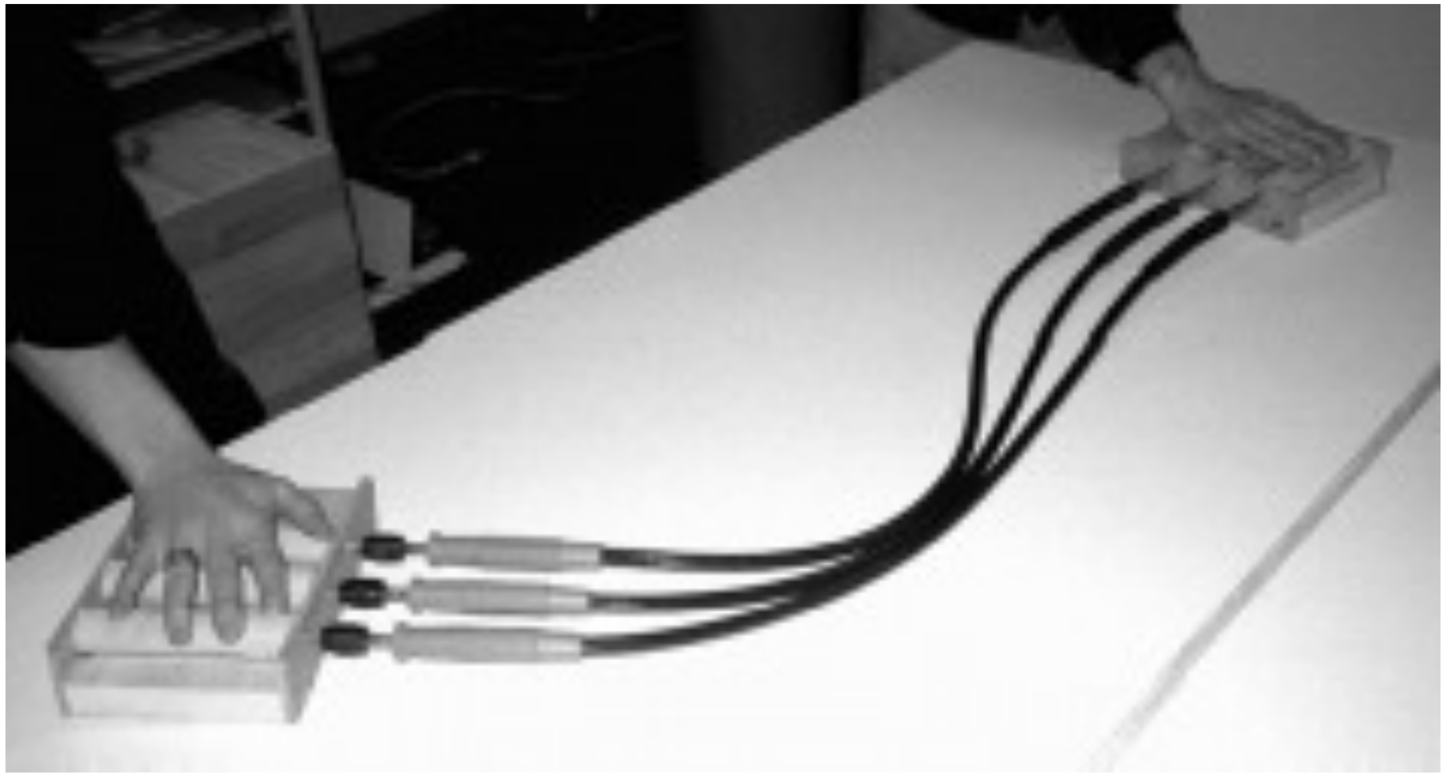
InTouch
(Brave, Ishii, Dahley, CSCW 98)

- UI for remote „awareness“
- Enhance the feeling of physical presence





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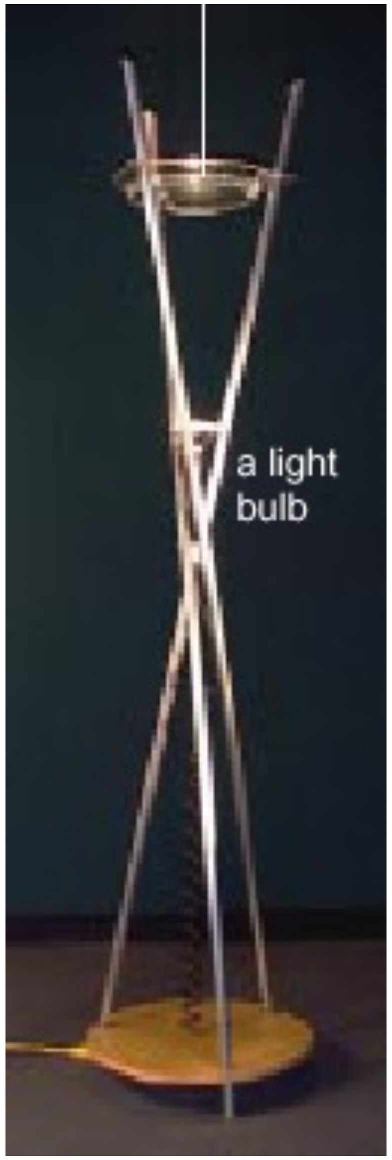
Waterlamp
(Dahley, Wisneski, Ishii, CHI 98)



- Lamp shining from below
- Water surface with 3 actuators
- Changing information creates ripples on water surface
- Result: patterns projected on the ceiling

Pinwheels

(Dahley, Wisneski, Ishii, CHI 98)

- Actual pinwheels, mounted on small DC electrical motors
- Rotation speed changes according to information flows
- Metaphor: flow of air ⇔ flow of information

The window as the interface
(Rodenstein, 99)

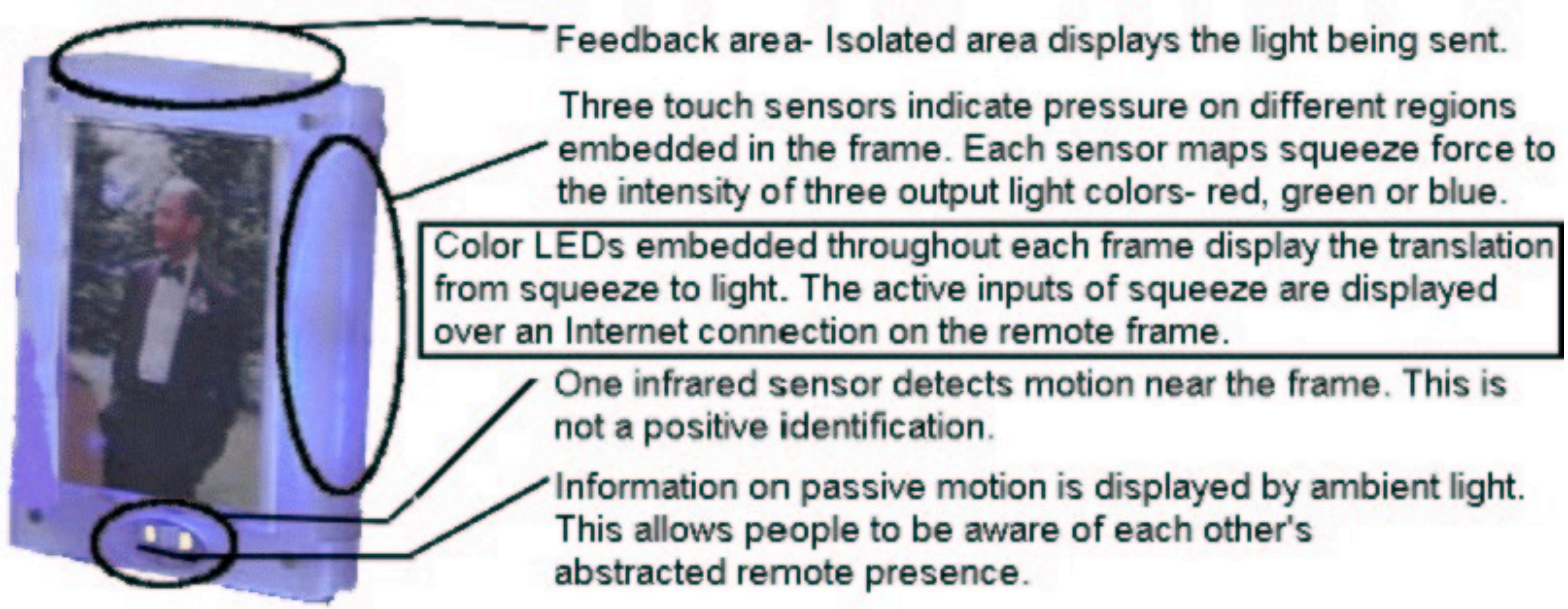
- Projection on „privacy film“ (by 3M)
- Can be made transparent or opaque by applying electricity

Figure 2: It will freeze tonight, better wear gloves.

Figure 1. It will get stormy in the next few hours.

LumiTouch
(Chang et al. CHI 01)

- Connected picture frames
  - show when other frame is squeezed
  - Create a feeling of mutual awareness

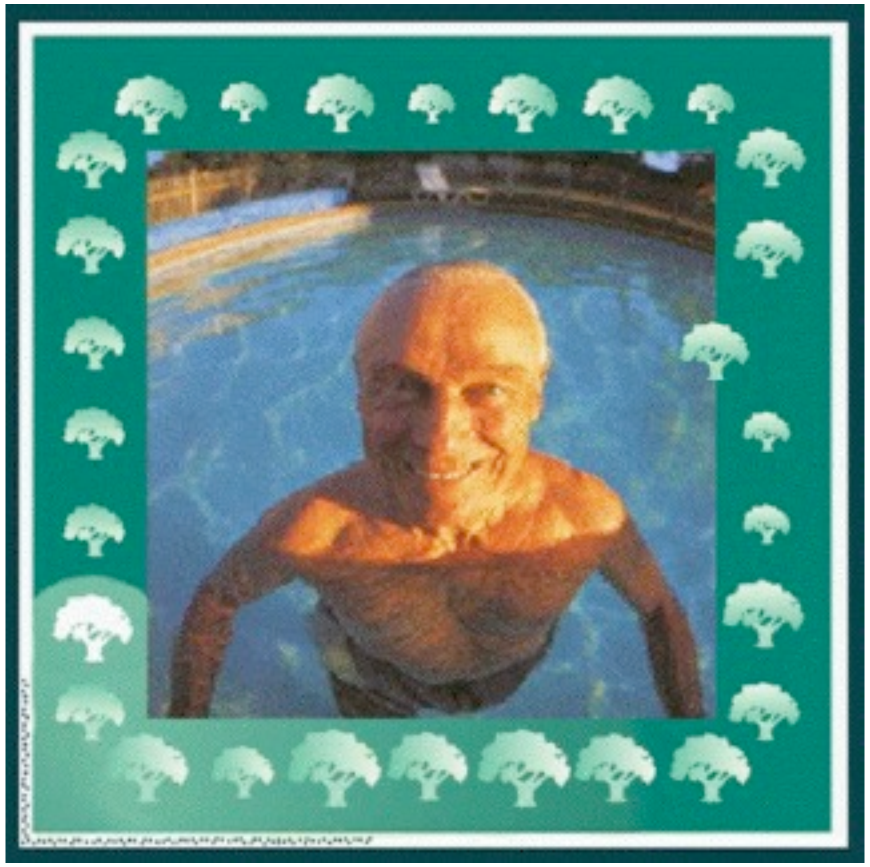


Digital Family Portrait

(Mynatt et al. CHI 01)

- In the “Aware home”
- Lets people “keep an eye” on others
- Balance btw. privacy and contact

- Icons around the frame indicate health, activity or relationships
- 28 icons on 4 sides = 4 weeks
- Position and size carry a meaning



Hello.Wall
[Prante et al., Ubicomp 03]

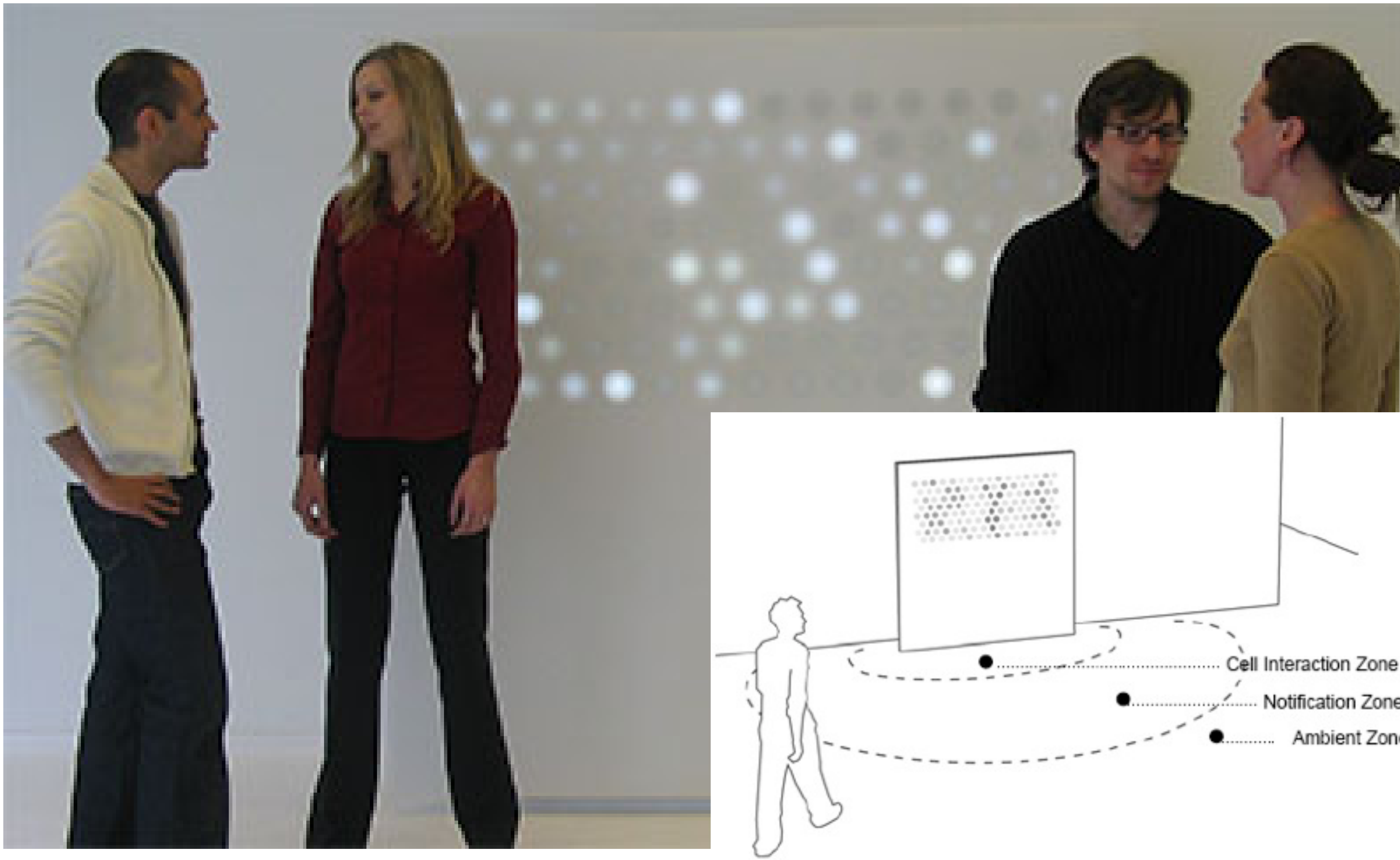


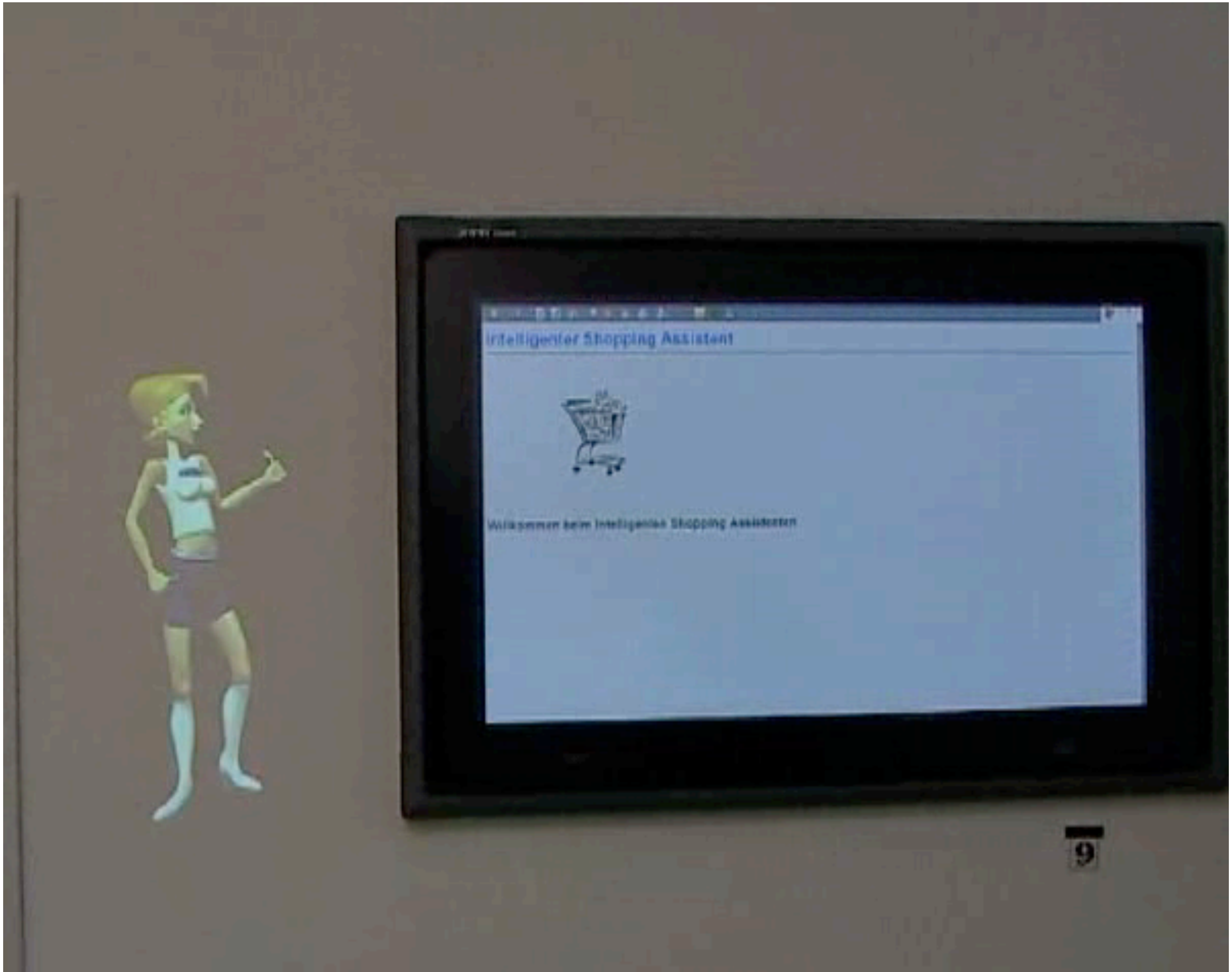
Figure 2. Three zones of interaction

The Drift Table

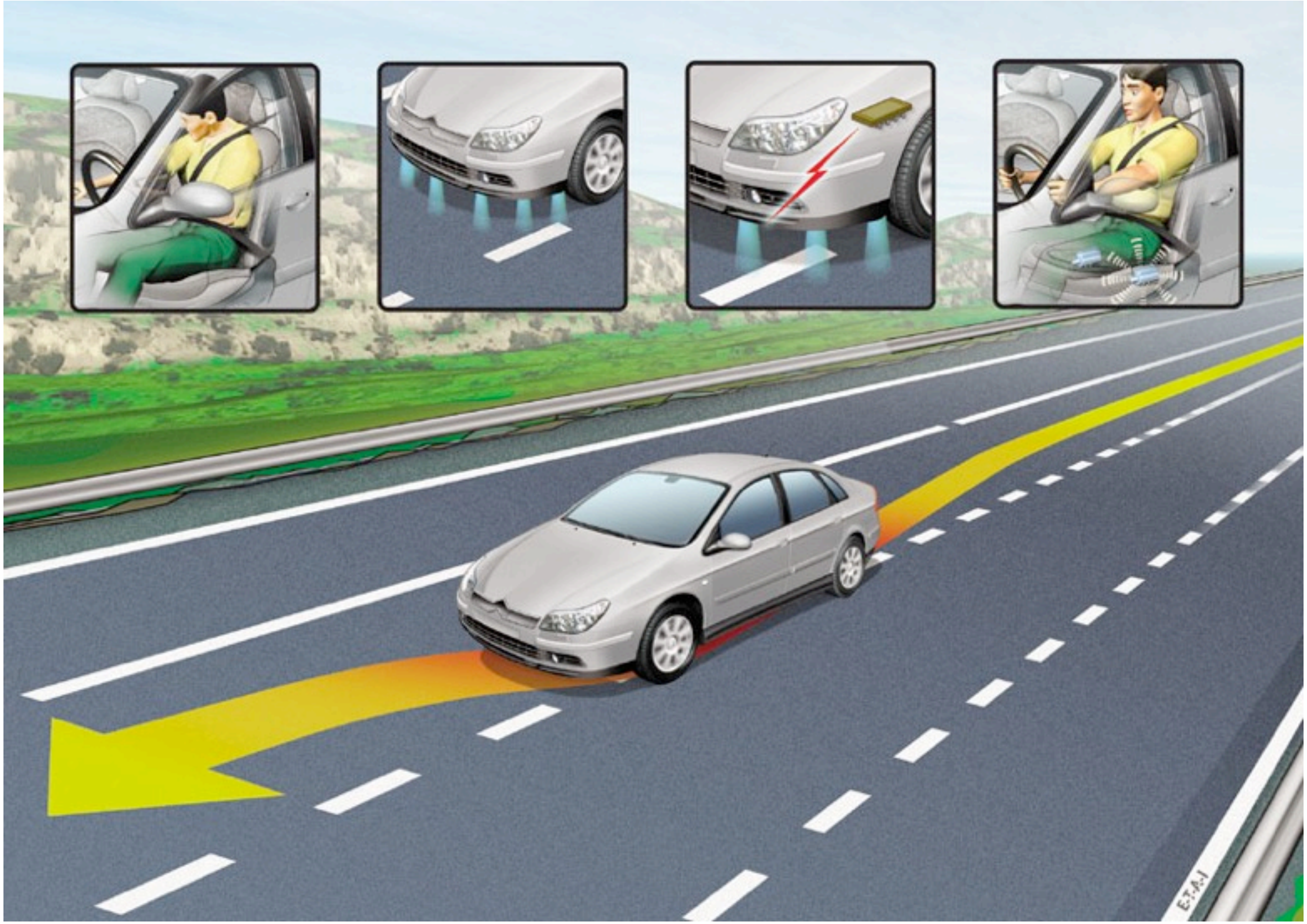
The Virtual Room Inhabitant (VRI)

[Kruppa et al. AI05]

VRI Video



(Ambient ?) Tactile UI: Citroen LDWS



http://www.piecescitroensport.citroen.com/CWW/en-US/TECHNOLOGIES/SECURITY/AFIL/

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Steve Mann - pioneer of wearables

- http://www.eecg.toronto.edu/~mann/

Research and design issues

- Comfort
  - needs to be light, small, not get in the way, fashionable, and preferably hidden in the clothing
- Hygiene
  - is it possible to wash or clean the clothing once worn?
- Ease of wear
  - how easy is it to remove the electronic gadgetry and replace it?
- Usability
  - how does the user control the devices that are embedded in the clothing?

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Robotic interfaces

- Four types
  - remote robots used in hazardous settings
  - domestic robots helping around the house
  - pet robots as human companions
  - sociable robots that work collaboratively with humans, and communicate and socialize with them – as if they were our peers

Advantages

- Pet robots have therapeutic qualities, being able to reduce stress and loneliness
- Remote robots can be controlled to investigate bombs and other dangerous materials

Research and design issues

- How do humans react to physical robots designed to exhibit behaviors (e.g., making facial expressions) compared with virtual ones?
- Should robots be designed to be human-like or look like and behave like robots that serve a clearly defined purpose?
- Should the interaction be designed to enable people to interact with the robot as if it was another human being or more human-computer-like (e.g., pressing buttons to issue commands)?

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Which interface?

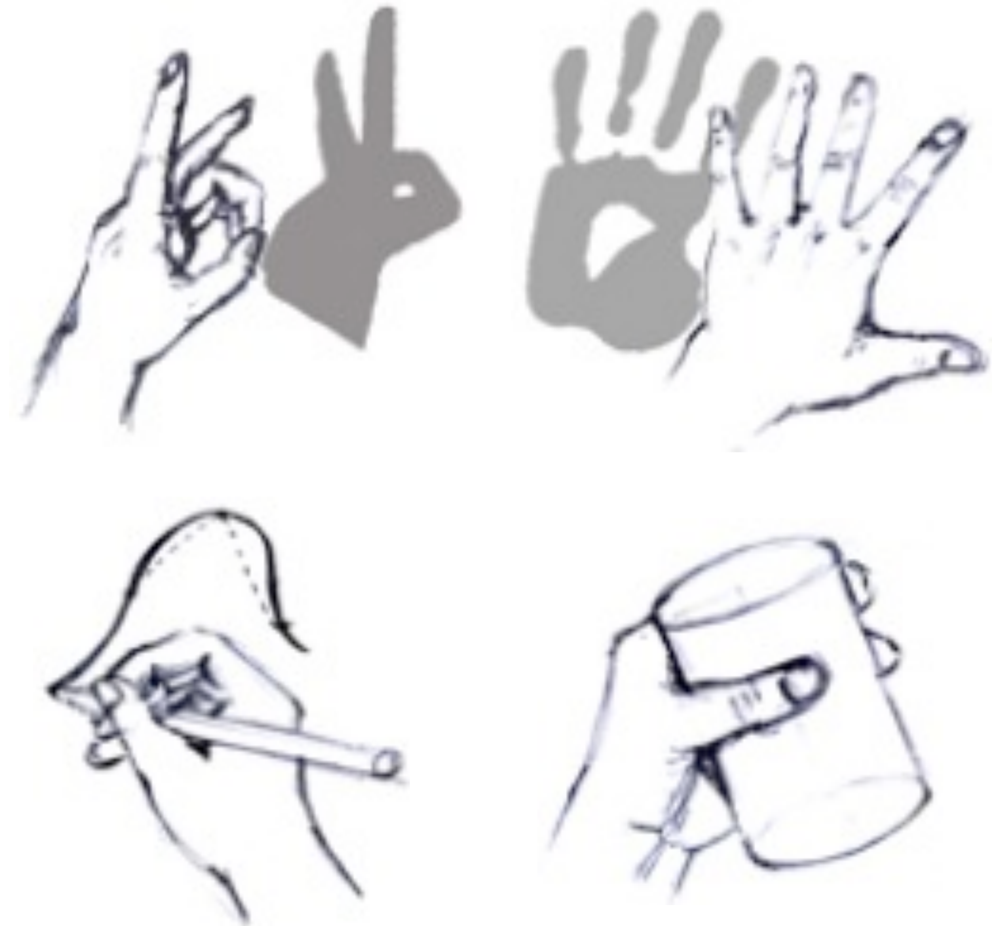
- Is multimedia better than tangible interfaces for learning?
- Is speech as effective as a command-based interface?
- Is a multimodal interface more effective than a monomodal interface?
- Will wearable interfaces be better than mobile interfaces for helping people find information in foreign cities?
- Are virtual environments the ultimate interface for playing games?
- Will shareable interfaces be better at supporting communication and collaboration compared with using networked desktop PCs?

Which interface?

- Will depend on task, users, context, cost, robustness, etc.
- Much system development will continue for the PC platform, using advanced GUIs, in the form of multimedia, web-based interfaces, and virtual 3D environments
  - Mobile interfaces have come of age
  - Increasing number of applications and software toolkits available
  - Speech interfaces also being used much more for a variety of commercial services
  - Appliance and vehicle interfaces becoming more important
  - Shareable and tangible interfaces entering our homes, schools, public places, and workplaces

Qualities of physical manipulation [PhD Lucia Terrenghi]

- Metaphorical representation
- Directness
- Continuity of action
- 3D space of manipulation
- Physical constraints
- Multimodal feedback
- Two-handed cooperative work



Summary

- Many innovative interfaces have emerged post the WIMP/GUI era, including speech, wearable, mobile, and tangible
- Many new design and research questions need to be considered to decide which one to use
- Web interfaces are becoming more like multimedia-based interfaces
- An important concern that underlies the design of any kind of interface is how information is represented to the user so they can carry out ongoing activity or task