Instrumented Environments

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Mon, 10-12 Uhr, Theresienstr. 39, Room E 46

Topics Today

- Wearable Computing
  - Input
  - Output
  - Platforms
  - Steve Mann
  - MIThrill
  - Wearcam
- Tangible User Interfaces
  - General frameworks

Wearable Computing

- Small and wearable computer
- wearable -> hands free
- Sensors onboard
  - Cameras, temperature sensors, microphones, GPS
- Are able to attract attention
- “Always on”
  - Sense the environment and observe user actions

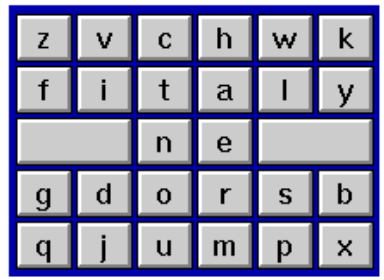
Goals of Wearable Computing

- Personal assistant
  - Internet access
  - Remind of dates and tasks
  - Handle large Databases (lexicon access, document management)
- Specialized device
  - Museum guide
  - City and Campus guides
  - Maintenance and surveillance tasks

Wearable Input: Keyboards

(images from left to right)

- Twiddler (www.handykey.com/)
- WearClam (www.robots.ox.ac.uk/~wmayol/WearClam/)
- WristPC Keyboards (L3 Systems)
- Fitaly keyboard (1-finger System)



Wearable Input: Voice Recognition

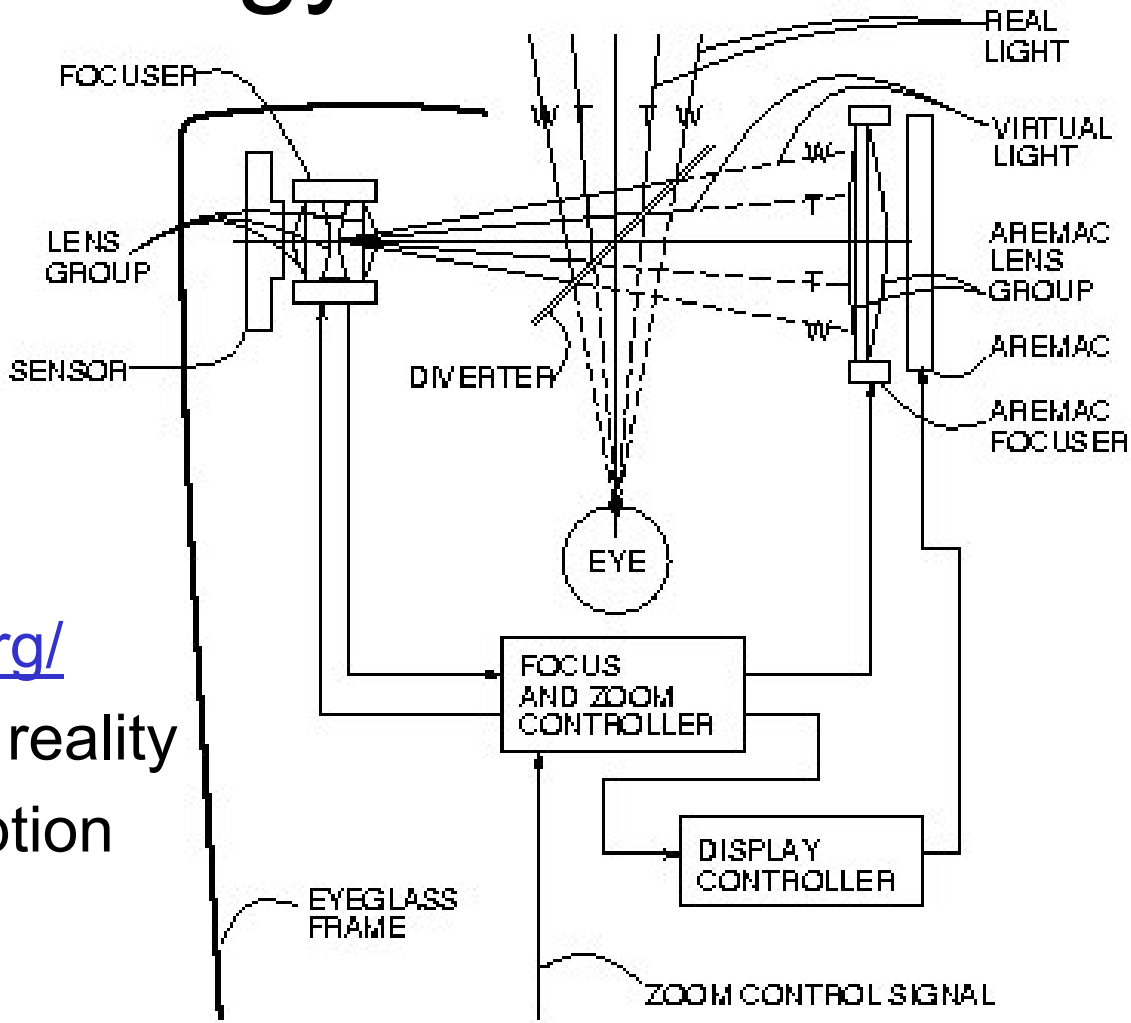
- IBM Voice Systems (Voice XML)
  - Embedded Via Voice
- Dragon Systems NaturallySpeaking
- L&H Speech Products
- Philips Speech Products (Voice Control)

- Possible today: speaker-dependent command input (limited grammar and dictionary)

Output (Examples)

- Clip-on glasses (Micro Optical Corp.)
- Retinal Scanning devices
- See TekGear for more
- www.tekgear.com

Eyetap Technology



- http://www.eyetap.org/
- Computer mediated reality
- modify visual perception
  - Augment
  - Diminish
  - Alter

Hardware and OS Platforms

- Chips and embedded platforms
  - Pict Processors
  - Transmeta Crusoe Processor
  - TINI board (www.ibutton.com/TINI/)
  - ZF Linux Devices (www.zflinux.com/)
    - Motherboard on a chip with Linux OS
- PDAs: Palm, Sony, HP/Compaq, Sharp
- Tiqit Computers (www.tiqit.com/)
- Subnotebooks, Webpads

CharmIT (www.charmed.com)

- Complete „wearable“ system bundle
  - PC class hardware
    - Transmeta Crusoe processor
    - 20GB hard disk
    - 8hrs battery life (differing info)
  - Linux operating system
  - Clip-on display
  - Finger mouse
  - Carrying bag

Some Research Projects

- MIT (MIThril, startle cam)
- CMU (VUMAN, Navigator)
  - www.wearablegroup.org
- Stanford University, (matchbox computer)
- Univ. of Bristol (Cyberjacket)
  - wearables.cs.bris.ac.uk
- ETH Zürich (WearArm together with MIT)
  - www.wearable.ethz.ch
- Saarland University: IRREAL + ARREAL

ARREAL (Saarland University)

Navigation on campus

- Instructions in clip-on display
- Adaptive to walking speed
- Adaptive to positioning quality

Exploration of environment

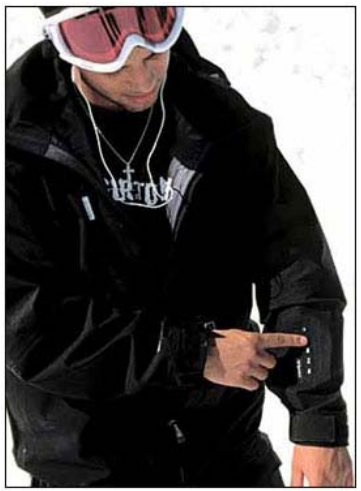
- Pointing gestures with hand-held compass
- Body-stabilized information presentation

Commercial Research

- Compaq Itsy
- IBM wearables
- I-wear (http://www.i-wear.com/)
  - Siemens, Philips, Samsonite, adidas, starlab.org
  - Intelligent Clothing
  - Antennas integrated into clothing
- Xybernaut
- Matsucom onHandPC
- IBM Linux wrist watch

(COURTESY XYBERNAUT)

Some „Wearable“ Products

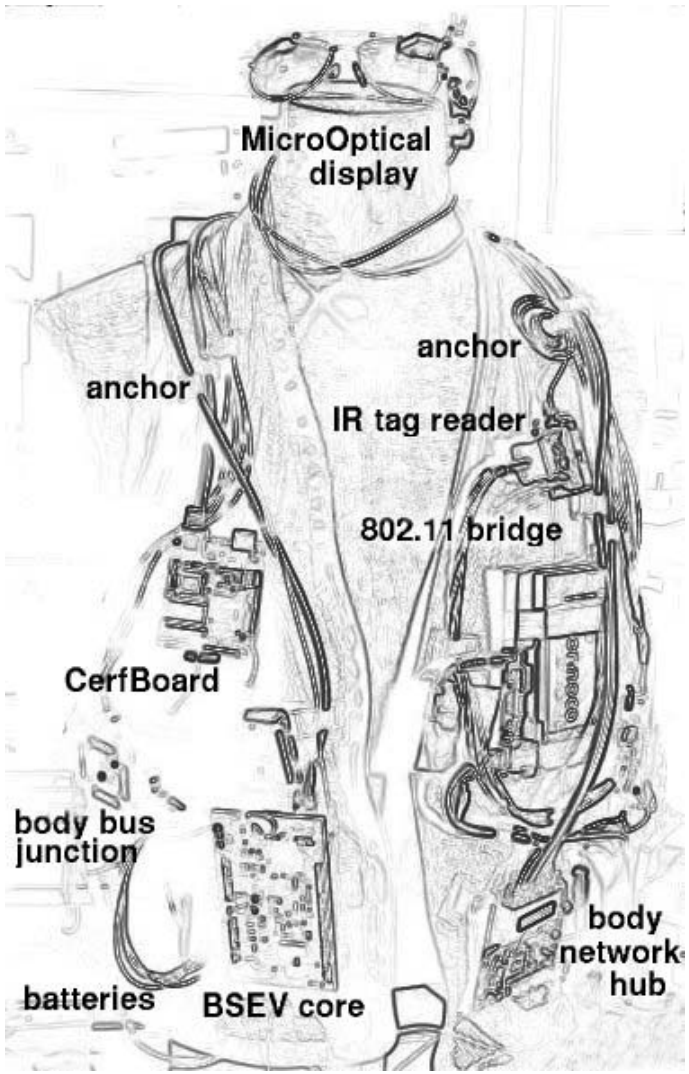


- Apple & Burton „Amp Jacket“ (2003)
  - Includes Apple iPod MP3 player
  - Player control keys integrated in sleeve
  - $500 without iPod

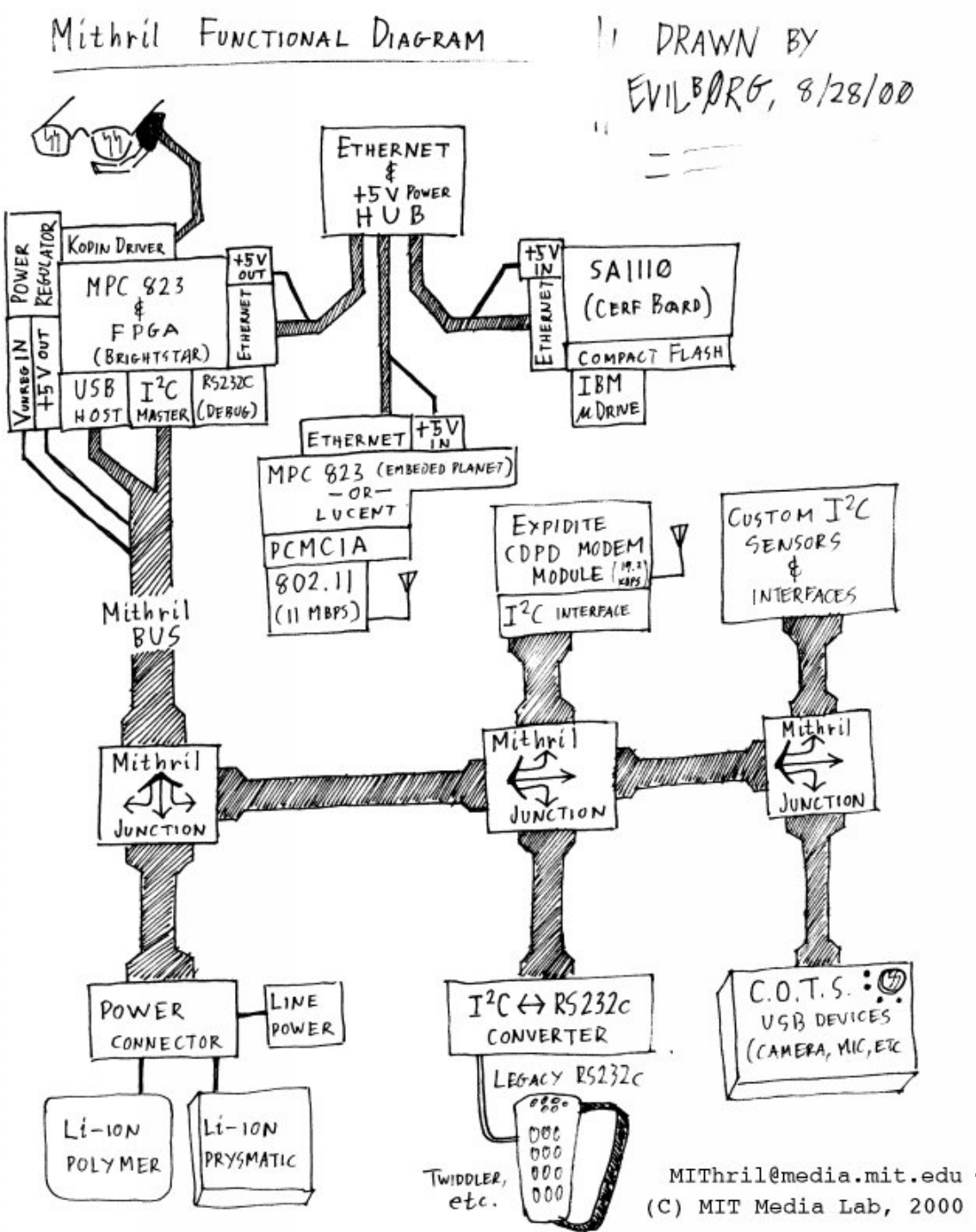
- Infineon & O‘Neill „Hub Jacket“ (2004)
  - Includes custom unit which…
    - Contains a 128MB MP3 player
    - Acts as a bluetooth headset for mobile phones
  - Player and phone control integrated in sleeve
  - €550 including player/headset electronics

MIT Wearables

- MIThril
- Platform to develop wearable computing applications
- www.media.mit.edu/wearables/

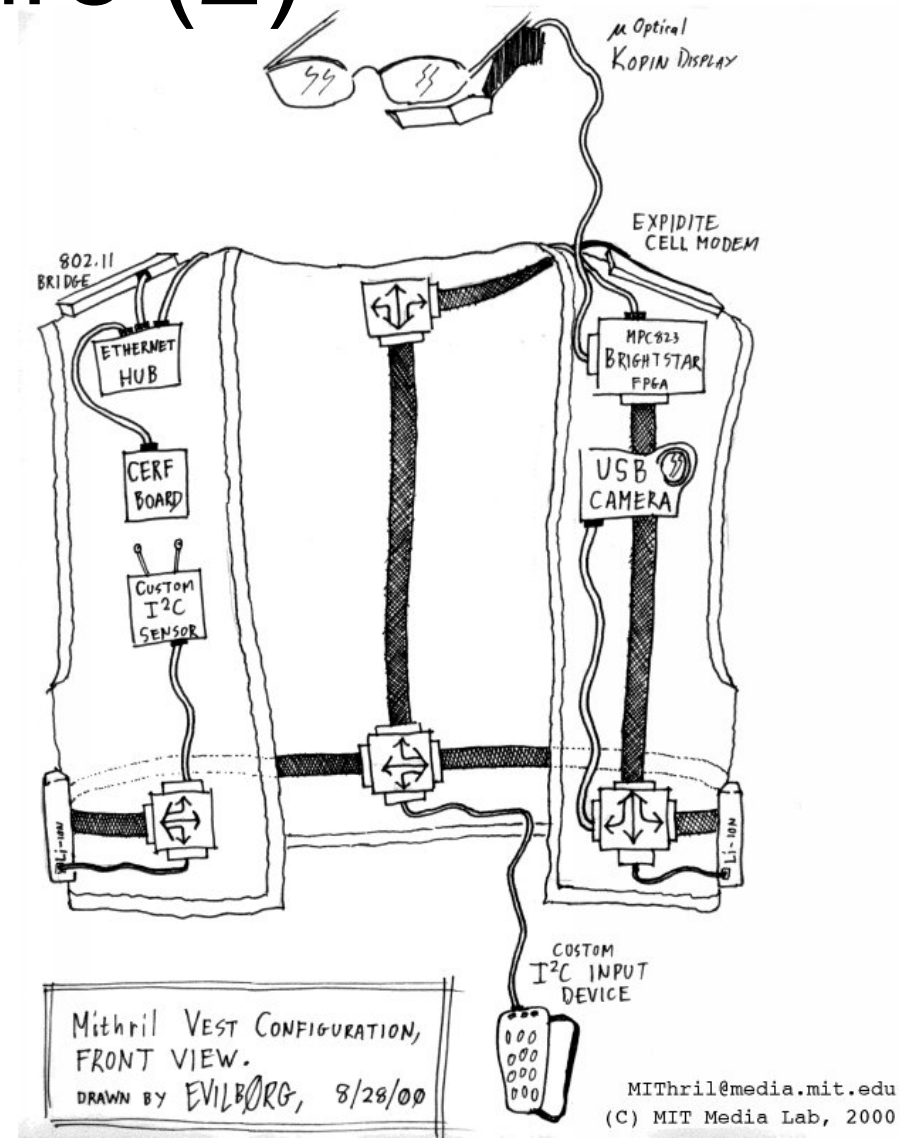


MIThril Architecture



MIThril Architecture (2)

- CERF single board computer
- Brightstar Linux
- 802.11 bridge
- SAK data acquisition
- MIThril networking:
  - Body network
    - Ethernet, TCP/IP
  - Body bus
    - USB, I2C



First Applications

- Internet services:
  - Web browsing
  - Image transmission
  - Email
- Signal processing
  - Step recognition
  - Temperature, skin conductivity

Applications today

- Concentrate on context sensing and classification (examples later)
- E.g.: the Memory Glasses
  - Try to associate pictures with places
  - Provide users with information tagged to their actual location

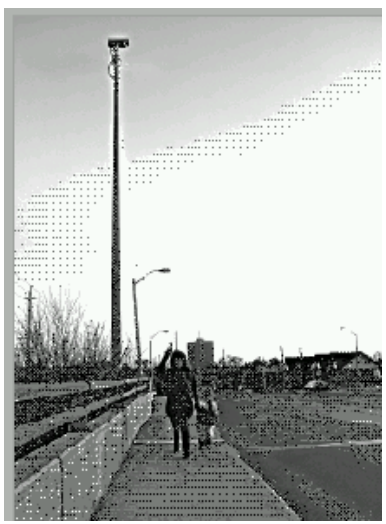
“Smart Clothing” in Research

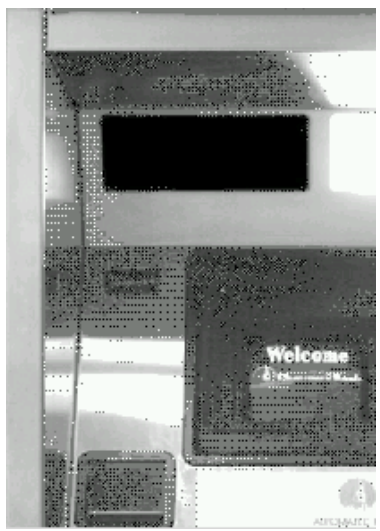
- http://wearcam.org/smart_clothing/
- Reduce amount of single devices with similar functionalities

  (mobile phone, Organizer, Wrist watch, recorder, walkman, Camcorder, calculator, etc.)
- Laptops and PDAs need too much attention
- Smart Clothing helps to counterbalance public cameras

Why not Smart Places ?

- Expensive infrastructure
- Problems to trust the infrastructures





History of Smart Clothing

- 1968 (Ivan Sutherland) :
  - First visions of head mounted displays

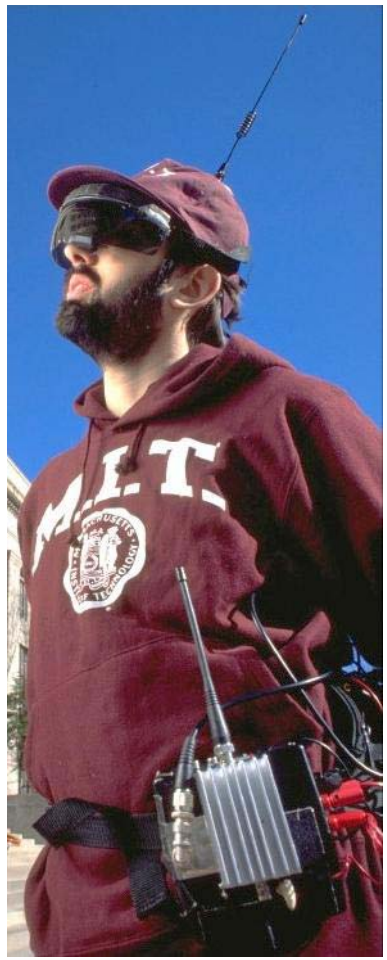
- 1970s :
  - (Amateur radio) : Communication with mobile transceivers
  - (the Eudaemons) : First wearable computer, embedded in a shoe. Helped to play roulette.

Steve Mann's Inventions

- 1980:
  - Tools for artists
  - 1,5-inch CRT attached to a bicycle helmet
  - Two antennas for transmission
  - Battery lamp to be used in the dark
  - CPU in the backpack
  - Remote server for more complicated operations

- 1990s :
  - Miniaturization :
    - Camcorder → 0,6-inch CRT
    - Laptops → all calculations on the body
  - Permanent internet access:
    - Receive/send emails
    - Use mobile camera to run web server.

- 1995:
  - VR-Displays allow first mediated reality scenarios
  - Small, wearable and wireless webcam



- 1999 :
  - Goggles :
    - 24-bit color display
    - camera
    - microphone
    - loudspeaker
  - Internet connection:
    - WLAN, GPRS, UMTS
  - Infrared sensors and radar enhance perception.
  - Biometric measurements
    - Pulse
    - Breathing
    - Skin conductivity

- Smart shoes sense
  - Acceleration
  - Step forces
- Analog → digital Converter
  - To process biometrical data
- Smart underwear
- Input device: Combination of keyboard and mouse

Smart Underwear

wearcam.org/smart_clothing/node4.htm

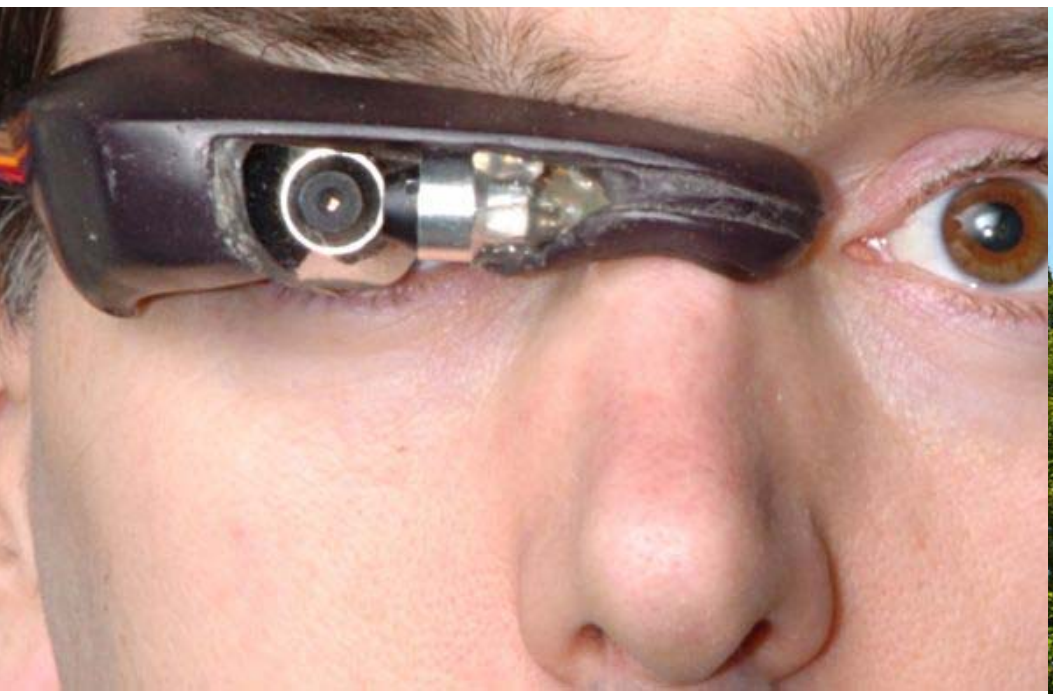
- Regulation of heating and air conditioning
- Sensors (sweat), Transmitter and antenna are worn in the underwear
- Monitor health
  - EEG and EKG
  - Respiration
  - alert physician

Expected Future Developments

- More bio sensors
  - Medical devices integrated into clothing
  - Store and process data locally
  - Impact:
    - Patient has all his medical information/data in his hand.
    - Misuse of information is reduced
    - Better emergency handling
    - Information is always up-to-date
    - No requests for certain information

WearCam platform

- http://wearcam.org/
- Permanently recording images of the environment
- Concept of “inverse surveillance”

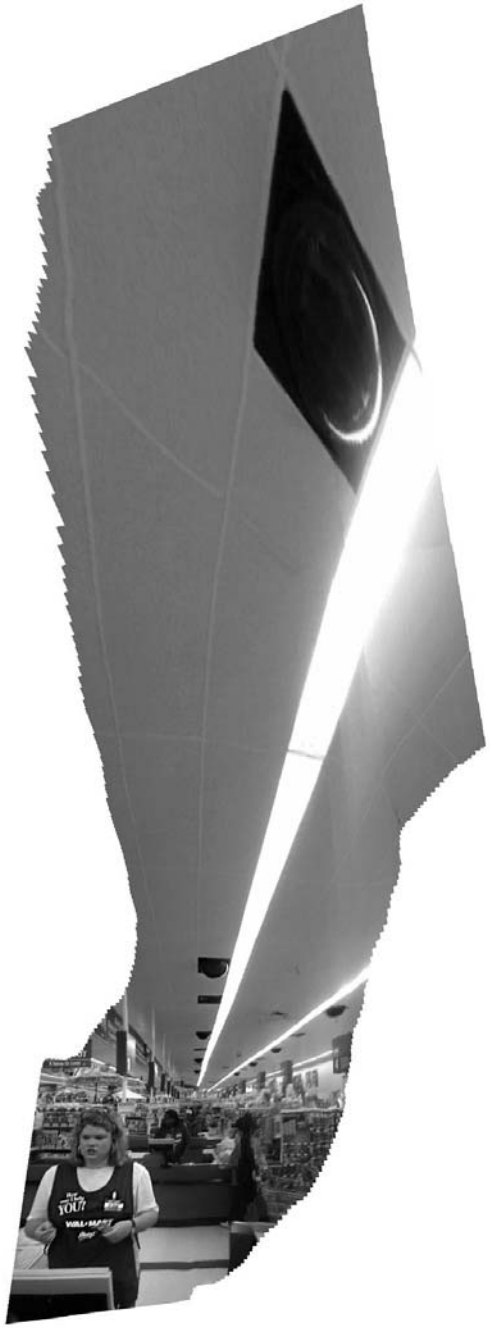


WearCam applications

- Edgertonian Eyes :
  - Periodic freezing of images (1/10.000 sec.)
  - Results:
    - While driving : Stronger perception of repeating image pattern (rails running along)
    - Rotating objects : rotate more slowly fore- or backwards (similar to strobe-light effect)
    - Non moving images are easier to remember (e.g. faces)

WearCam applications

- Deja vu
  - Storing streams of images
  - Compare stored images with actual image to detect if the user is moving in circles.
  - Notify user, if he comes to a “known” location.
- “Visual Clew”
  - Memorize stack of image while walking
  - Use images to find your way back

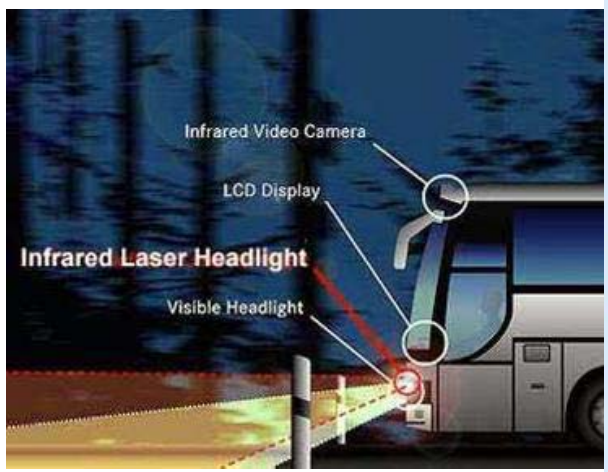


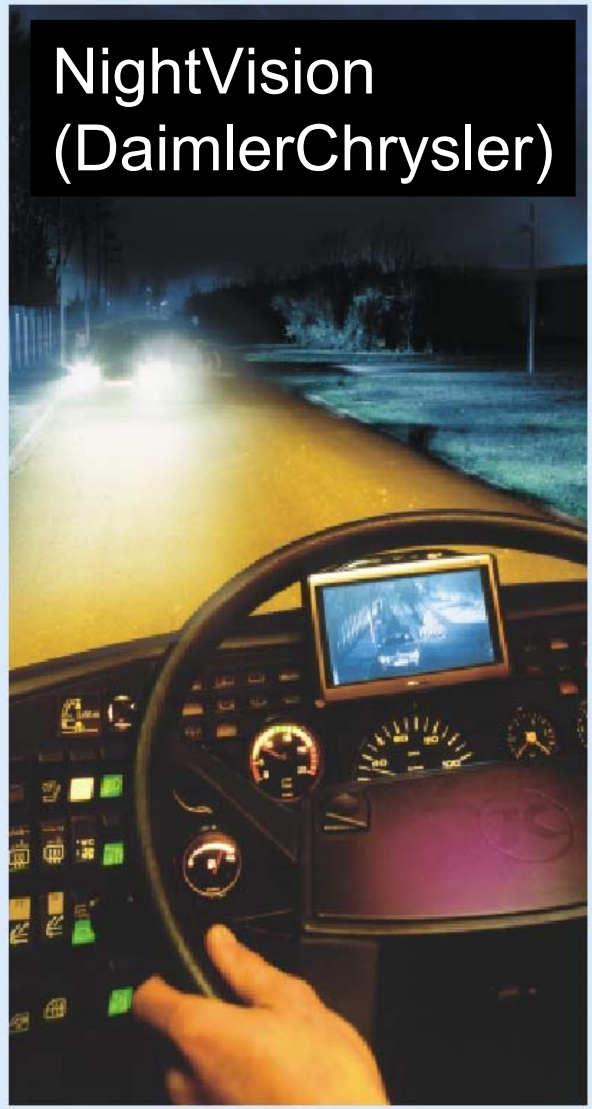
- High resolution imaging
  - Merge different perspectives into one image
  - Compose very large images out of small ones

- Wearable Face-Recognizer :
  - Recognition of faces
  - Use online and local databases
  - On positive match:
    - Tag and track person
    - Add more information (address, email, etc..)

Enhancing perception

- Reading aids
  - Strong enhancement of focus
  - Edge detection
  - Light enhancement



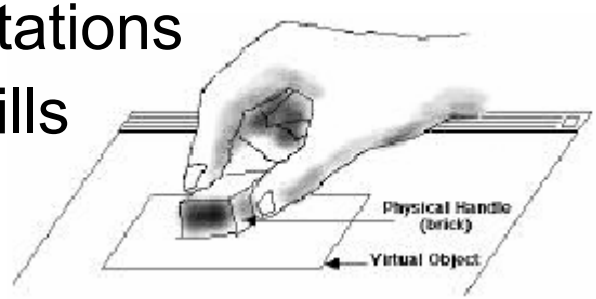


Tangible User Interfaces

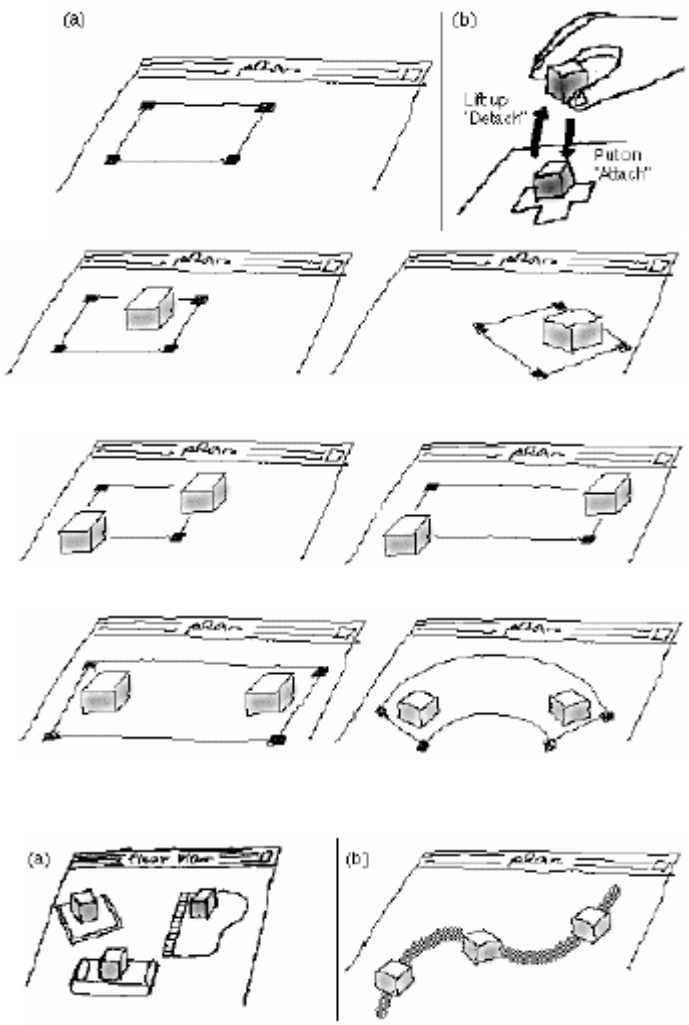
General purpose TUI frameworks

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: basic operations

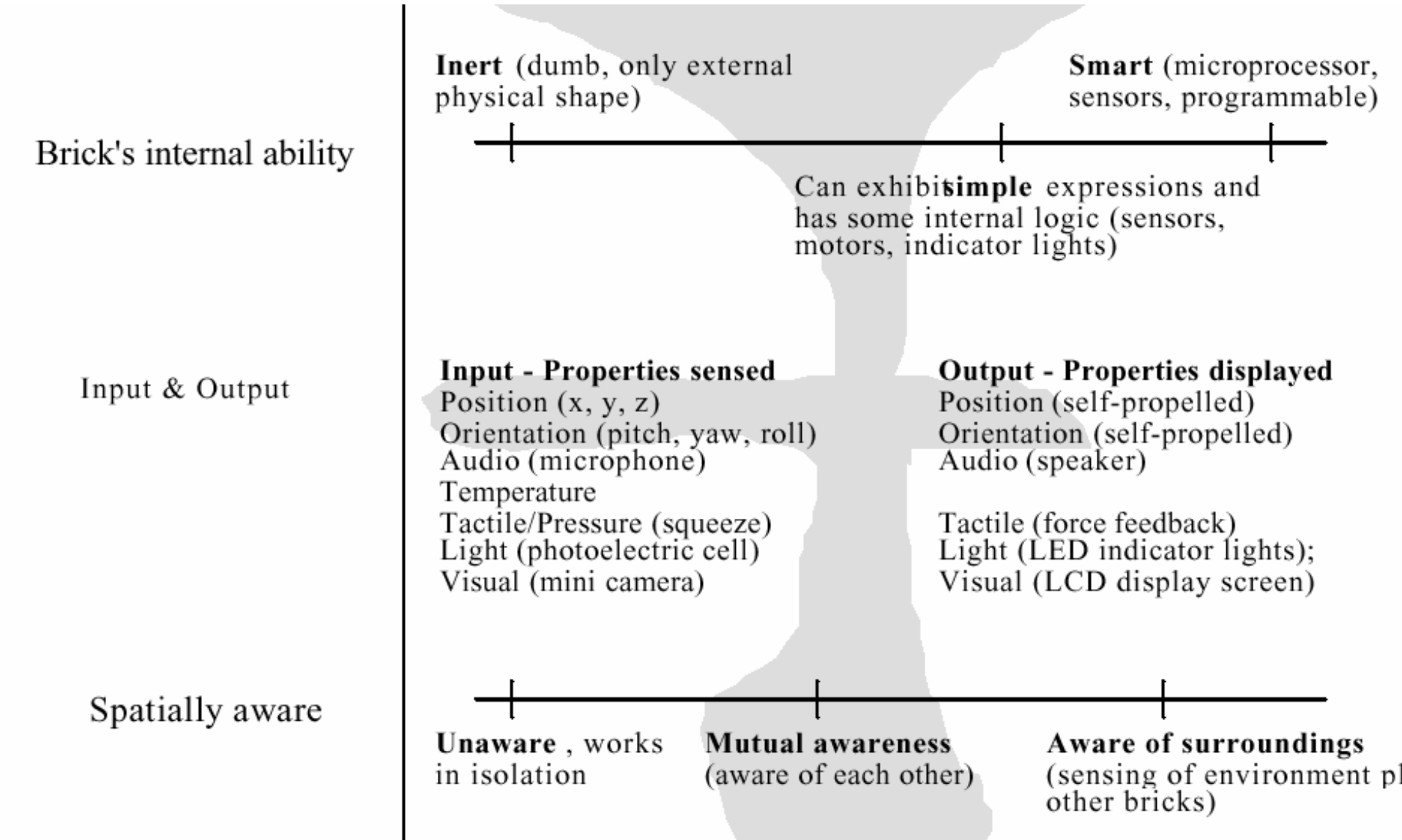


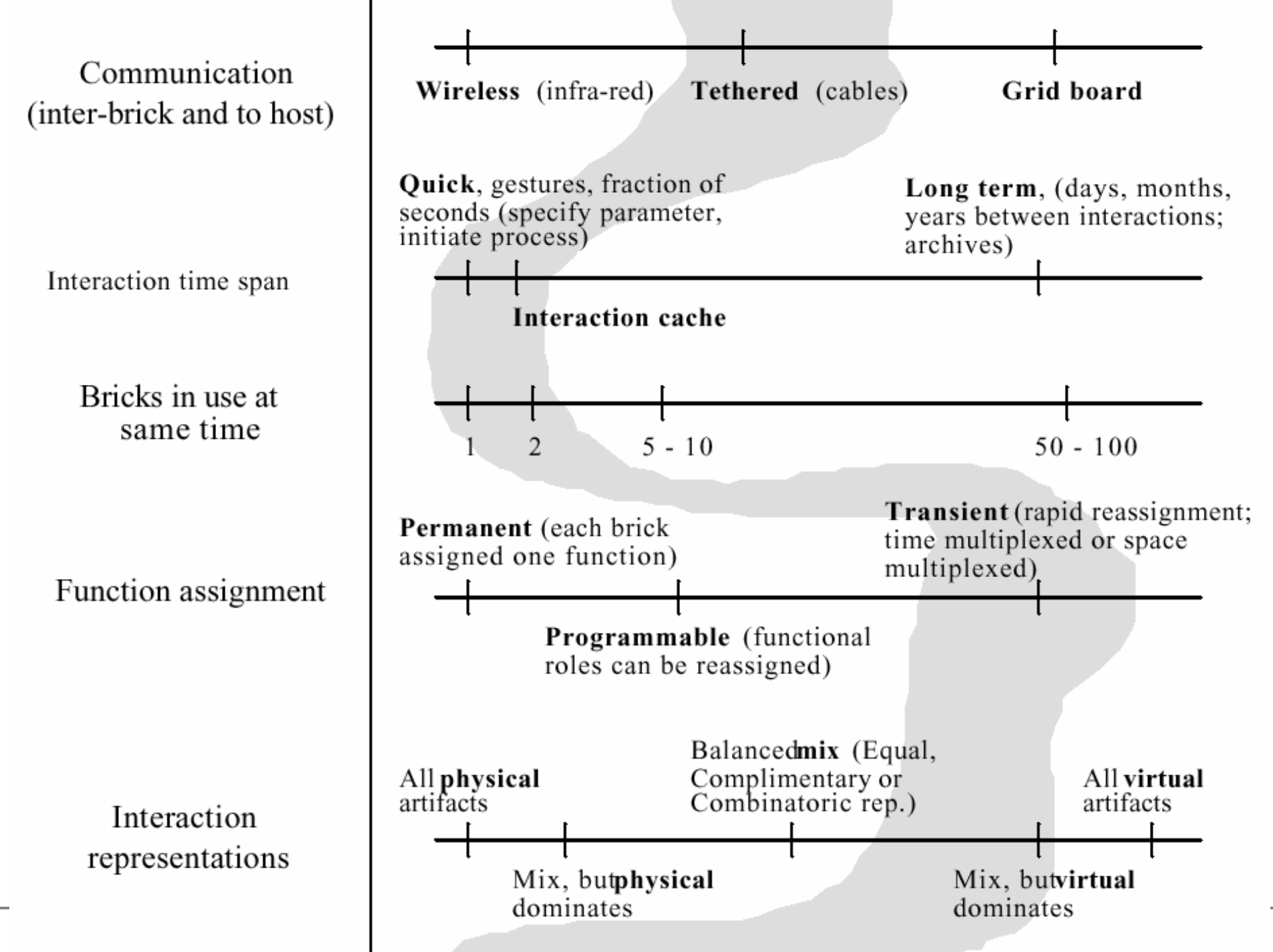
- Select an object
- Move and rotate
- Scale and stretch
- Bend and deform
- Floor planning, curve drawing

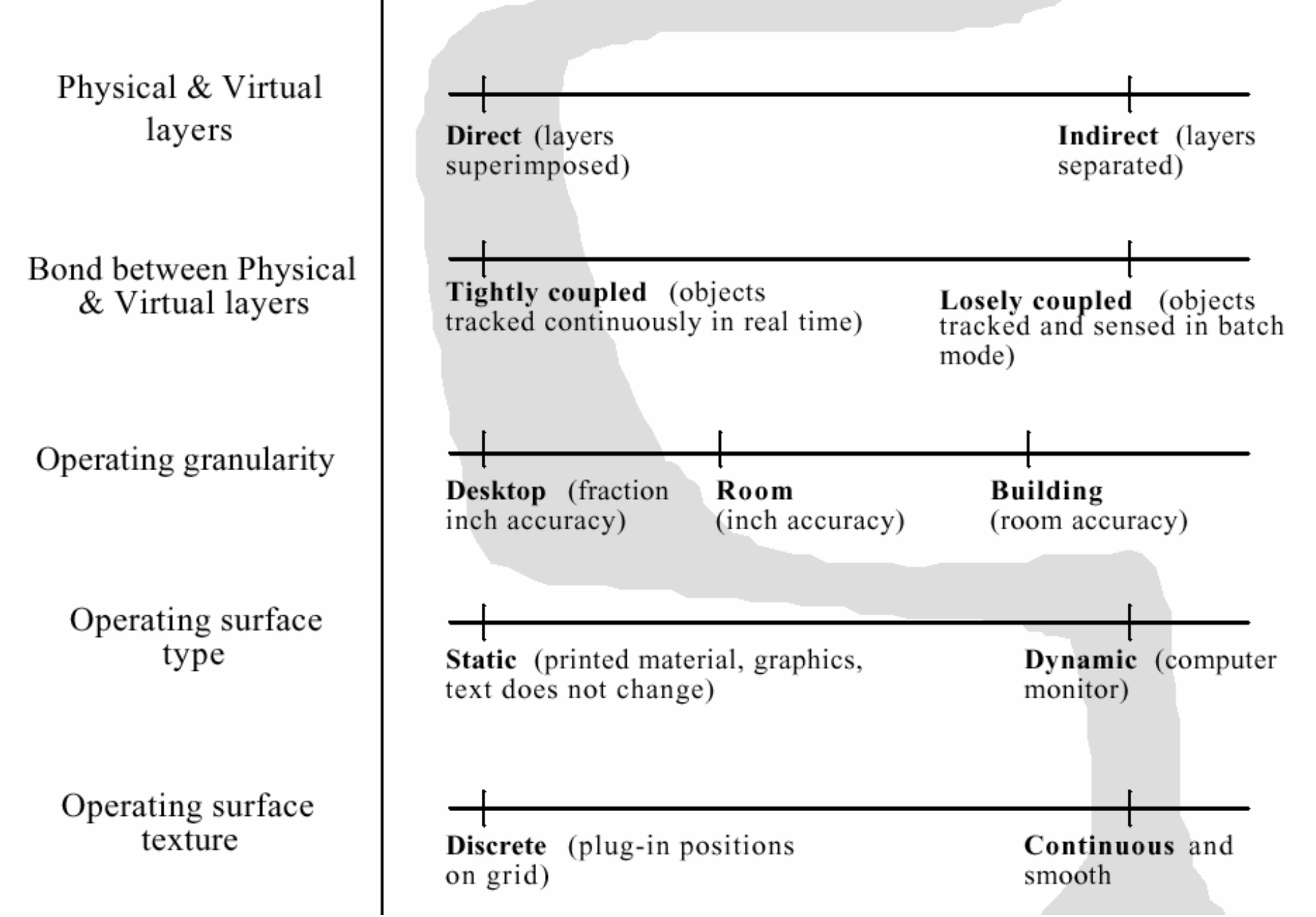
Bricks application: GraspDraw

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

Bricks: 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

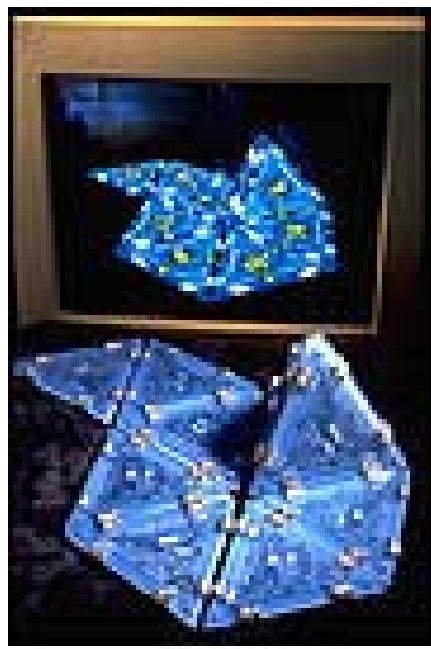
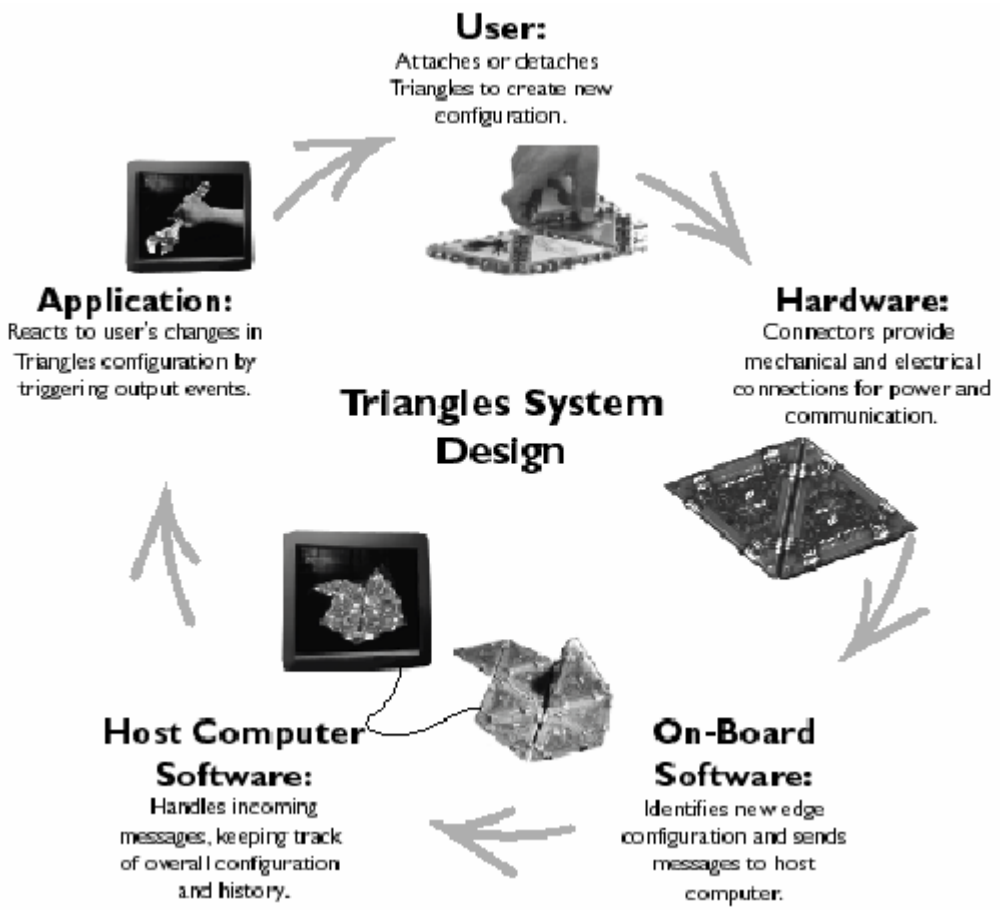


photo:
Webb Chappell

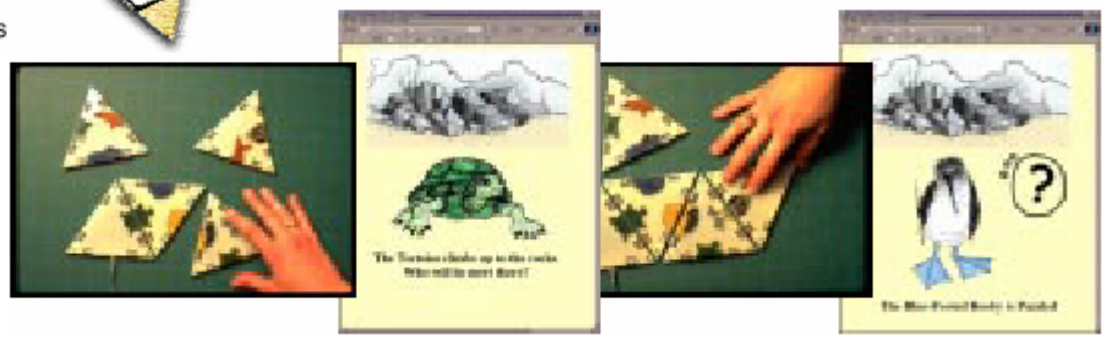
Triangles: System overview



Triangles: Example applications

Fig. 8: The *Cinderella 2000* Triangles

Non-linear storytelling



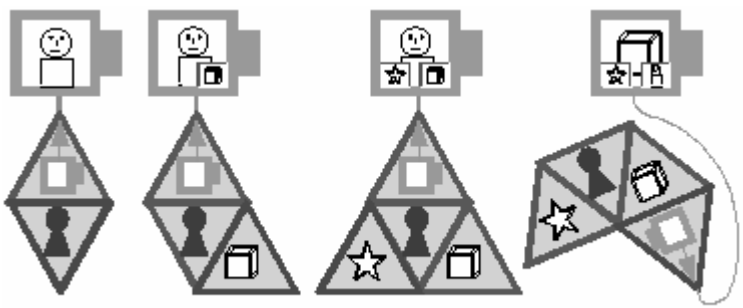


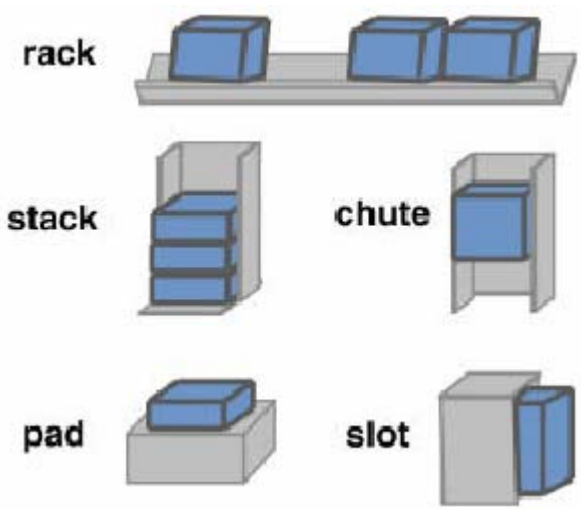
Fig. 9: *TriMediaManager*

Media Management

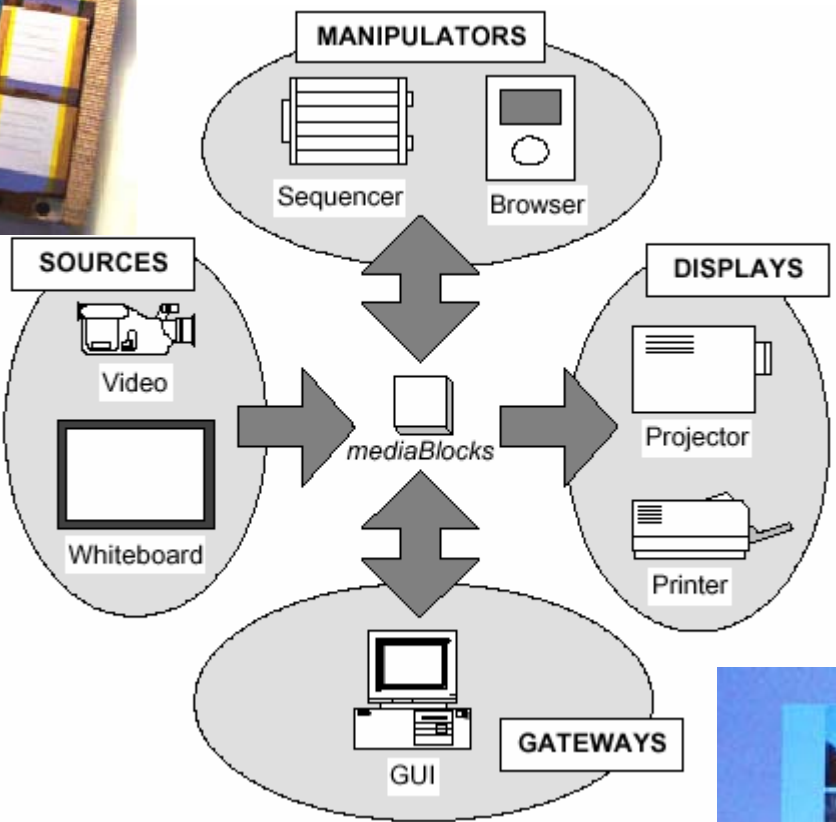
MediaBlocks

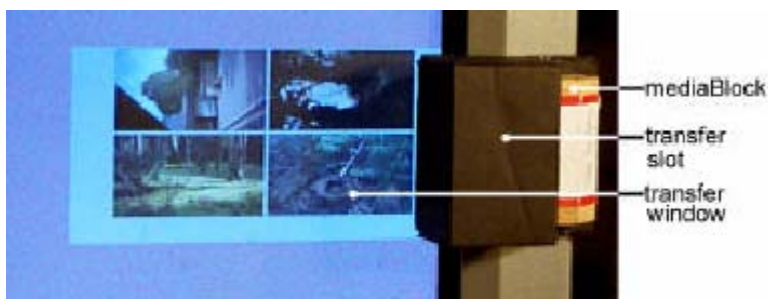
(Ullmer, Ishii, Glas, SIGGRAPH 98)

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



MediaBlocks (contd.)

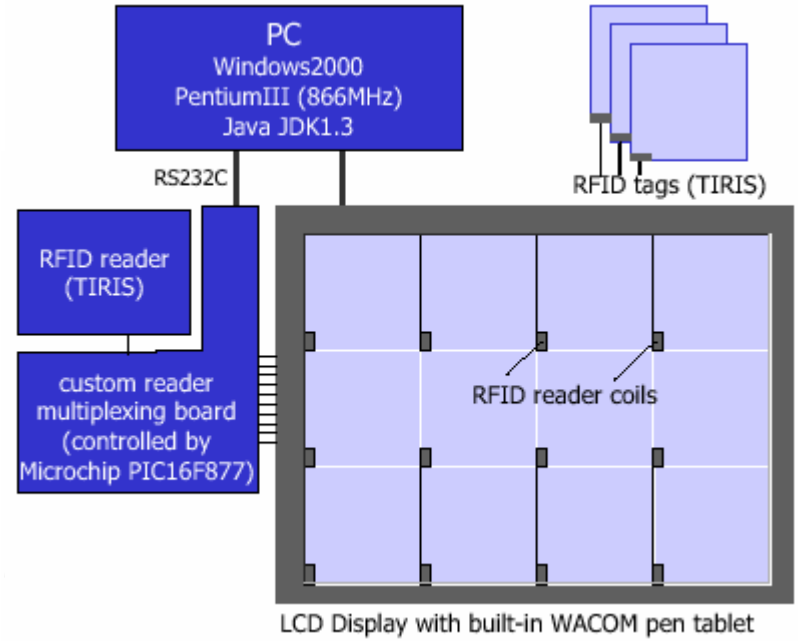




DataTiles

(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.)

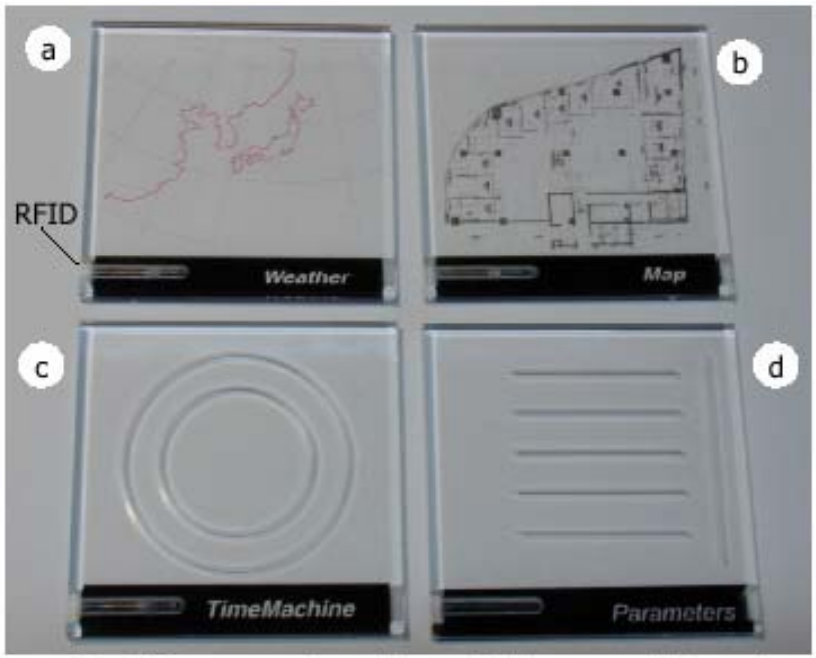


Figure 3: Tile examples. (a) and (b): partially printed tiles, (c) and (d) tiles with "grooves".

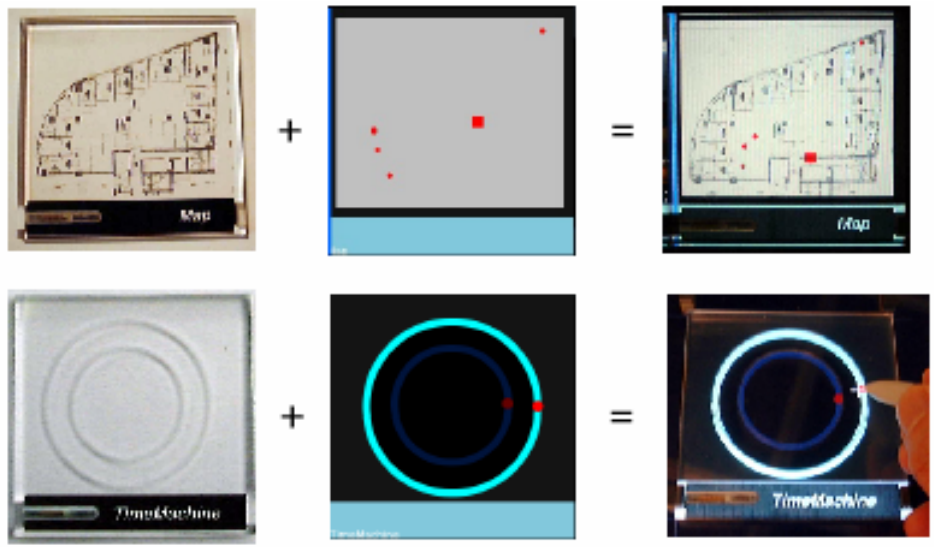


Figure 4: Combination of physical tiles and graphical information. Above: high-resolution printed information can be augmented by displayed graphics. Below: combination of physical grooves and graphical information creates a GUI widget with passive haptics.

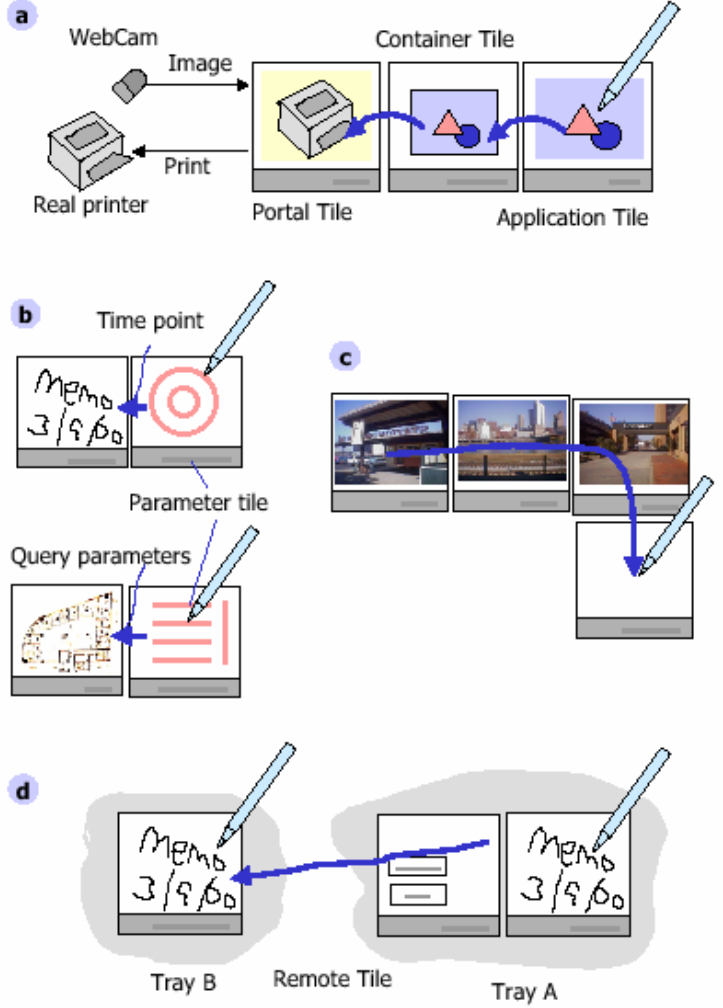


Figure 5: Examples of tiles and tile combinations. (a) An image from an application tile (right) is stored in a container tile (middle), and then transmitted to the portal tile. The portal tile represents a real world object (a printer in this example). (b) Parameter tiles can be used to specify various types of parameters. (c) Concatenates three video clips and stores item in a container tile. (c) Remote tiles are used to connect distributed tile trays. In this example, a shared drawing environment has been constructed.

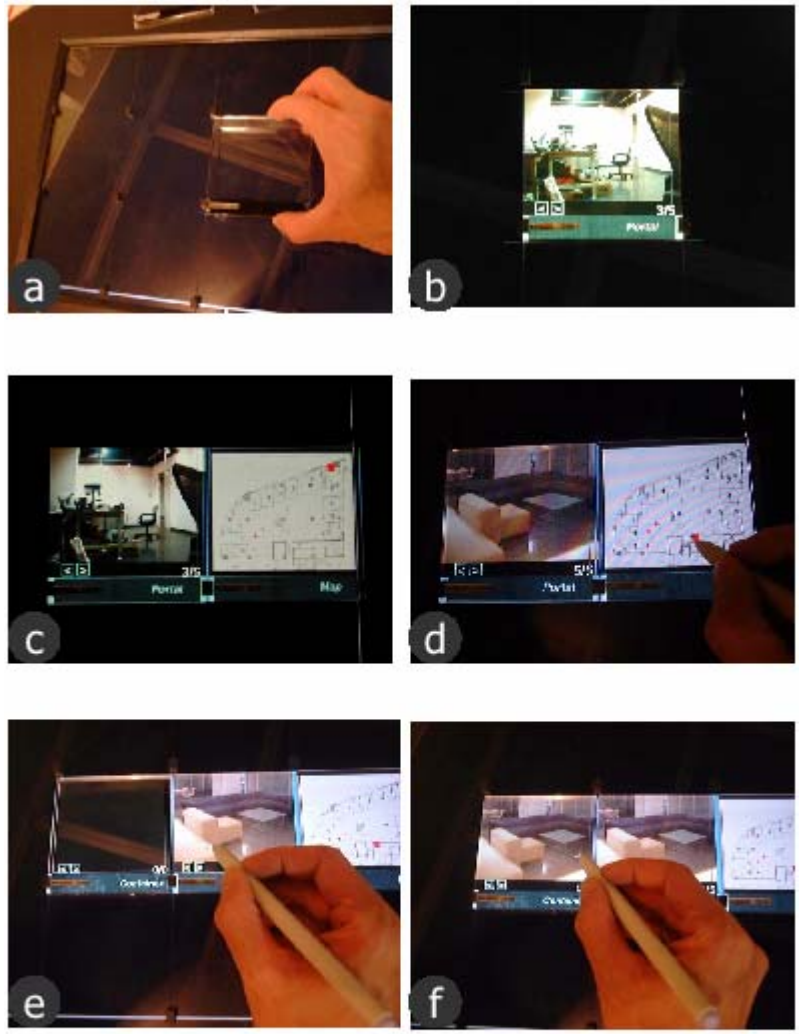


Figure 6: Examples of tile combination: (a) When a user places a portal tile on the tray, (b) an associated webcam image appears on the tile. (c) Then the user places a map tile, and the map displays locations of webcams. (d) The user clicks on a spot on the map to select another webcam. (e, f) Then the user makes an inter-tile gesture (from portal tile to the container tile) to store a snapshot image in the container tile.

DataTiles (contd.)

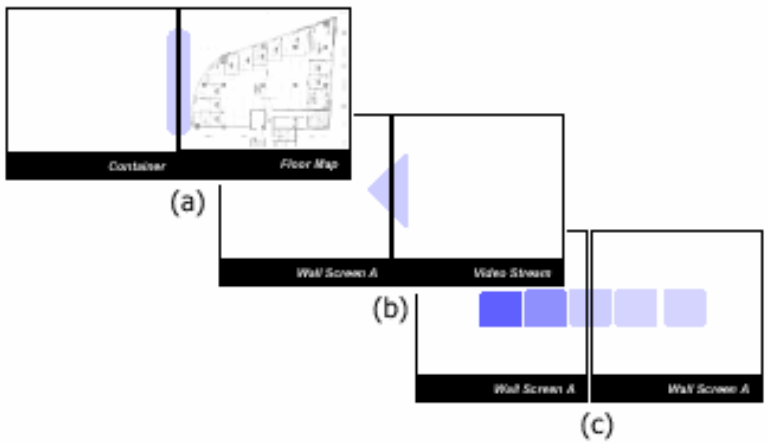


Figure 8: Several visual feedback approaches for indicating connection types. (a) one-way discrete data transmission from right to left, (b) one-way continuous data transmission, and (c) bi-directional continuous connection using animations.

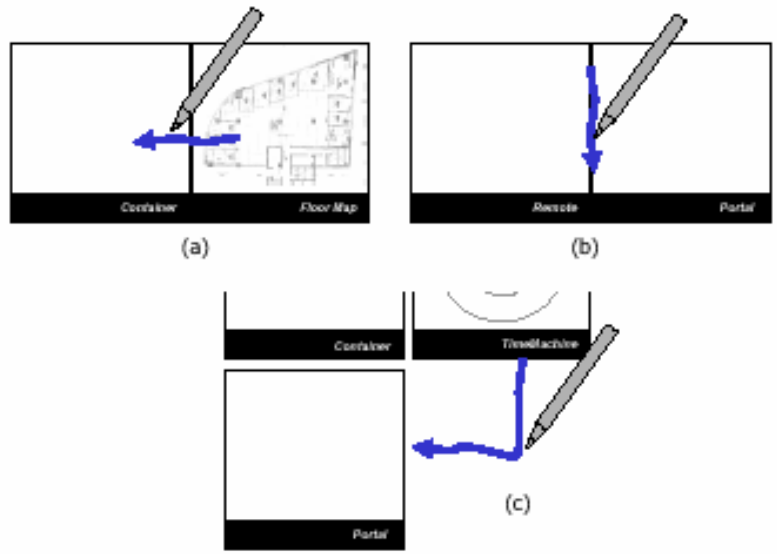
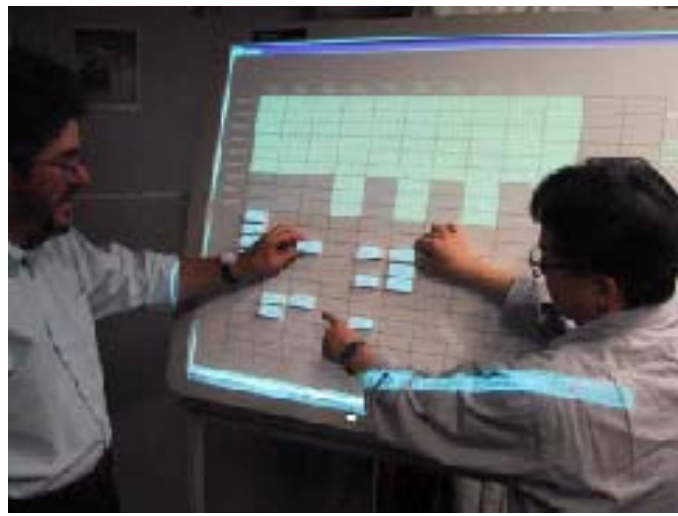


Figure 9: Inter-tile gestures by a pen to control a data connection between two adjacent tiles. (a) triggers a discrete data transmission, (b) suspends a continuous data transmission, and (c) connects two disjoint tiles. (Note: During these operations, the pen tip must be sufficiently close to the tile 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 into sessions

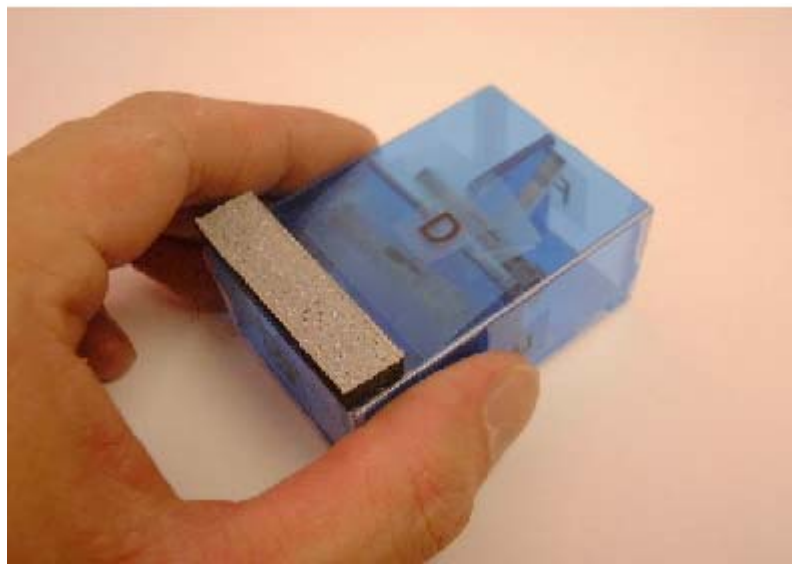


- Other tasks: arrange songs in a playlist, newspaper articles, slides for a talk, ideas from a brainstorming, emails, bookmarks, notes,...

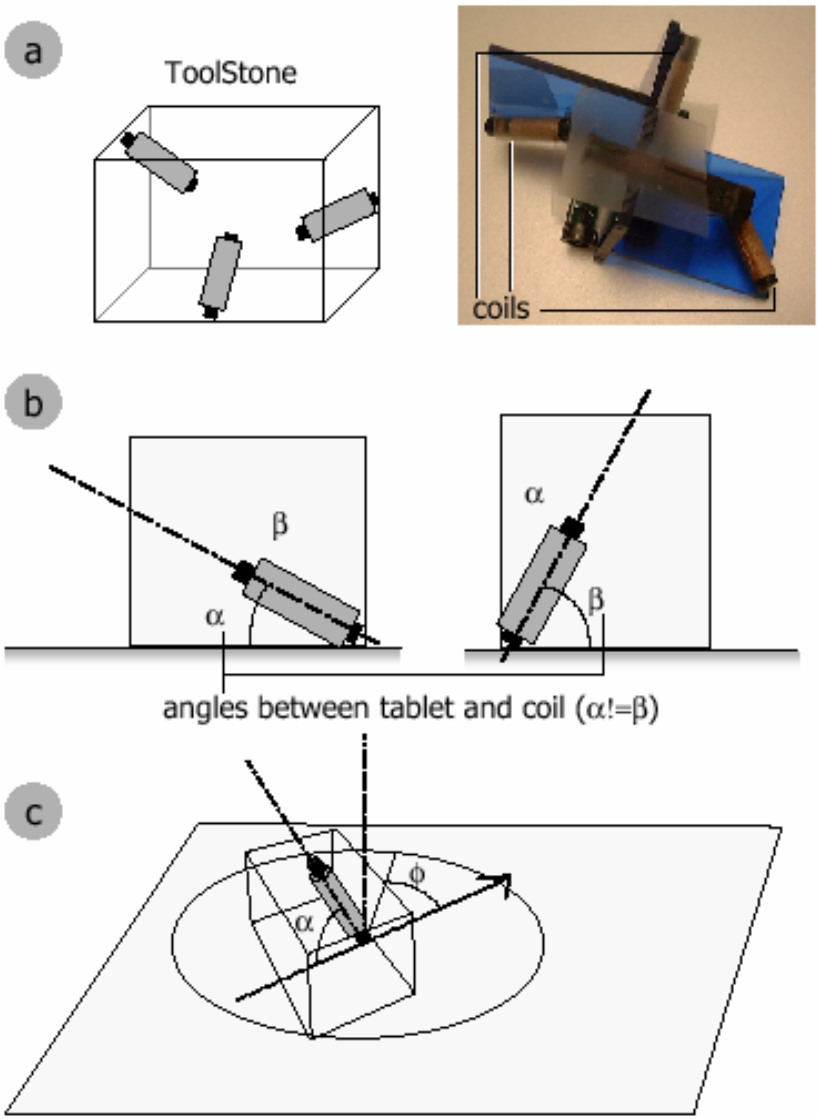
ToolStone

(Rekimoto, Sciammarella, UIST 00)

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



ToolStone working principle



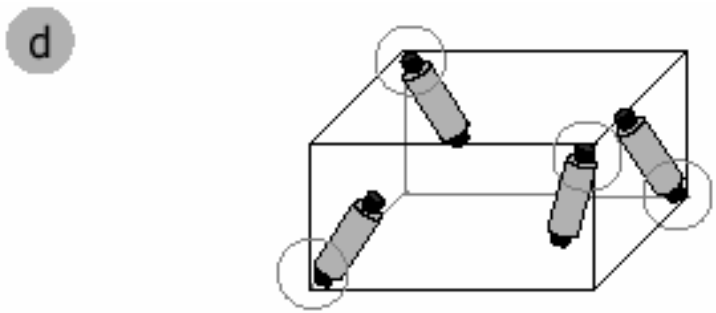


Figure 12: Detection of the touching face and orientation: (a) Inside the ToolStone: Three WACOM coils are embedded, and only one of them will be close enough to the tablet surface when the ToolStone is placed on the tablet. (b) When a coil touches the tablet, it can be identified by its unique resonance 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

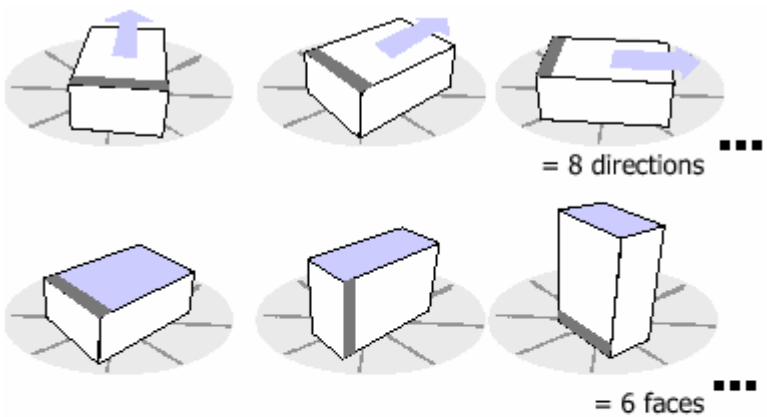


Figure 6: Selecting multiple functions by rotating and flipping the ToolStone: The combination of eight directions and six faces allows a user to quickly select 48 different functions (e.g., toolpalettes) with a single physical action.

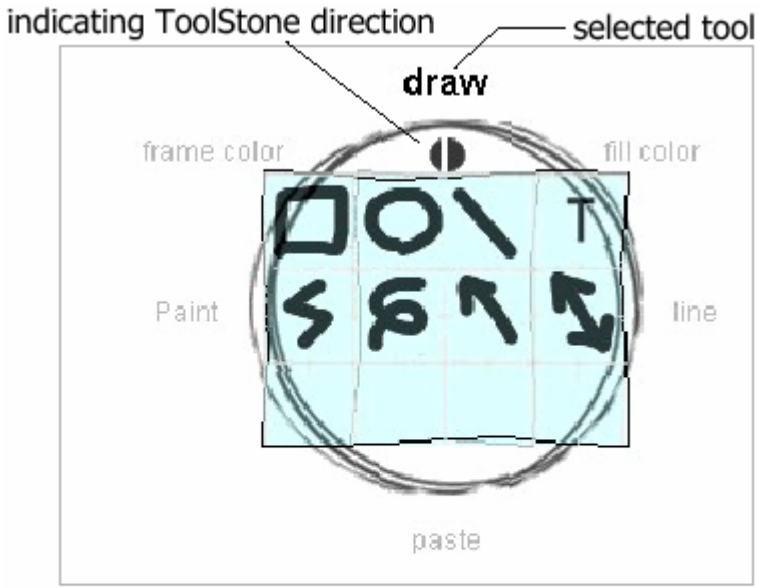


Figure 7: Example of a selected toolpalette: A dial and labels around the tool palette indicate available functionalities attached to the same face. The currently selected one is shown in bold. The selected toolpalette acts as a ToolGlass sheet.

ToolStone interaction

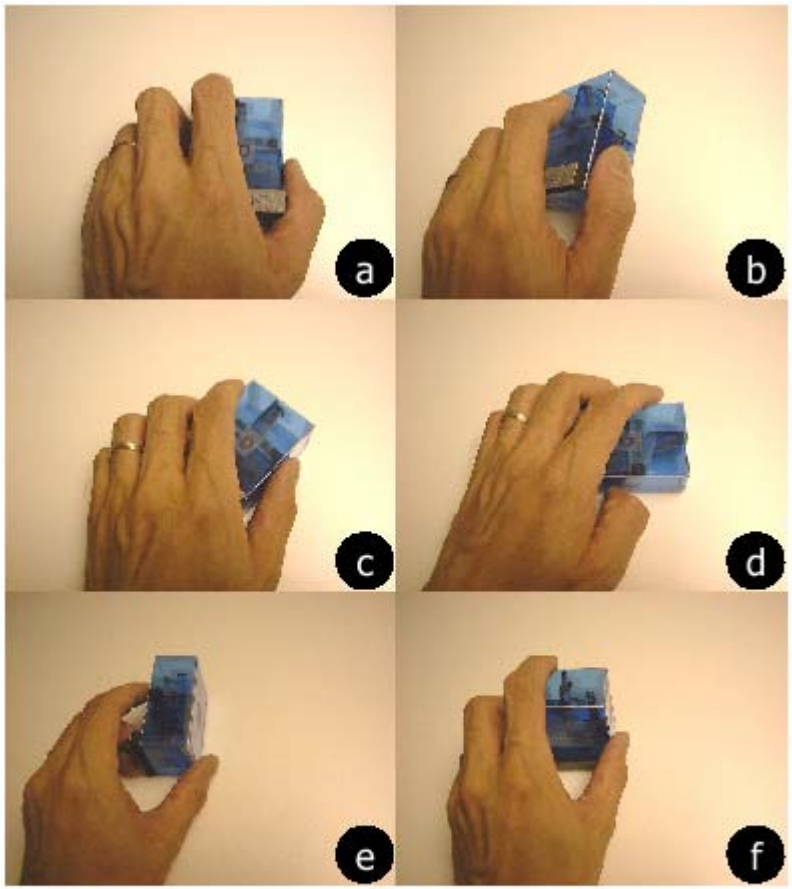


Figure 5: Several possible ways of holding the ToolStone: (a) Normal mode (Note: a projection attached near the lower edge of the upper face can be felt by the hand). (b) Tilting while one edge is contacting the tablet (c, d) Rotating, and (e, f) Flipping to select other faces.

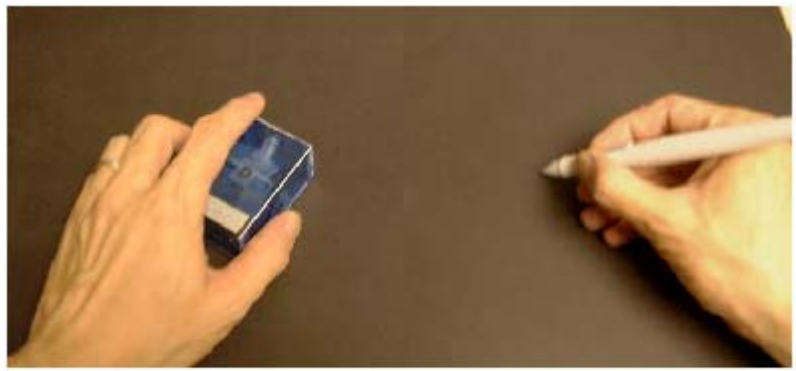


Figure 4: Bimanual interaction with the ToolStone.

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

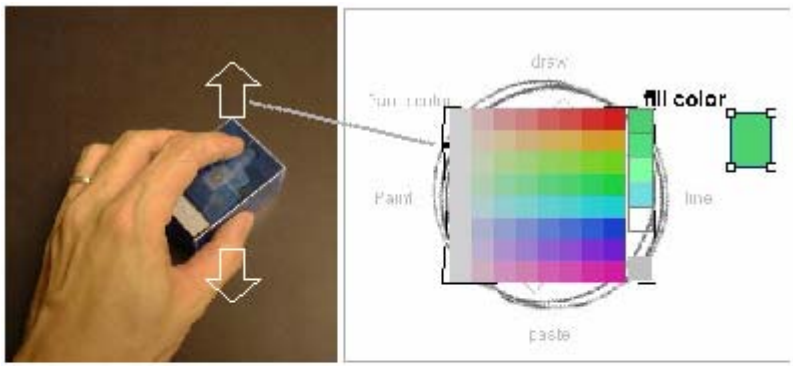


Figure 9: A color selection tool example: ToolStone's vertical motion controls the brightness parameter of the color space, while two other parameters (hue and saturation) are mapped according to the x and y axes of a 2D palette. A user can dynamically navigate though the color space before selecting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

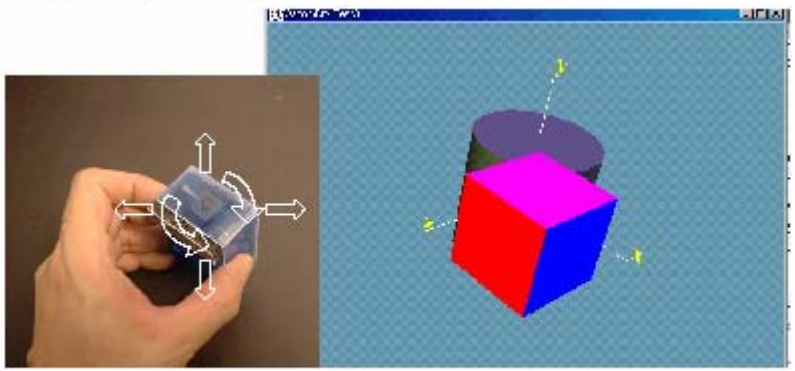


Figure 10: MDOF movement of the ToolStone can be mapped for 3D object control.

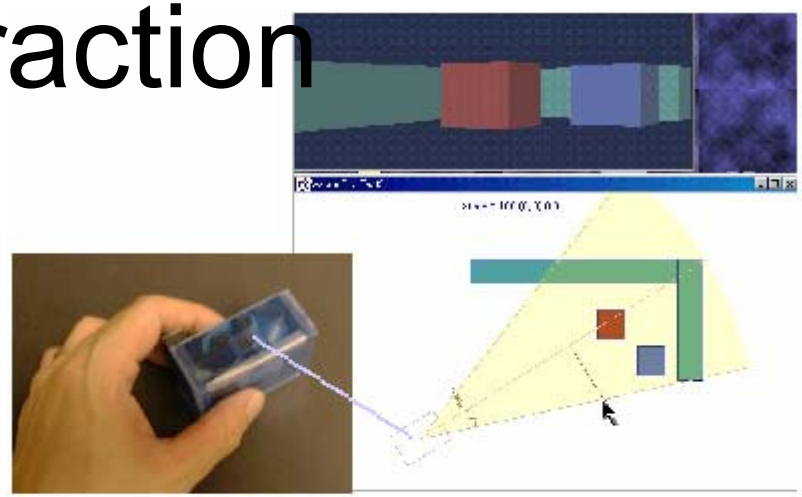
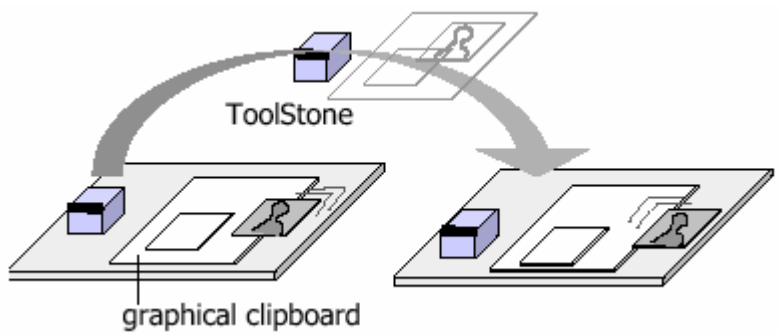


Figure 11: A user is manipulating a virtual camera of a 3D world. While the non-dominant hand is used to control the camera's position and orientation, the user can also change the field of view by dragging a viewing area (projected as a filled arc) with the dominant-hand's pointing device. Note that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



ToolStone design variations