

UBiQUITOUS cOMPUTiNG

Summer 2004



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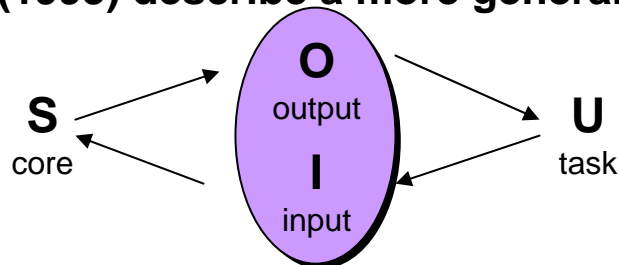
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schrader@isnm.de

What are Human-Computer Interfaces (HCI)?

- ❑ The ACM Special Interest Group on Computer Human Interaction defined a model for HCI, which can be interpreted as a standard definition (<http://sigchi.org/cdg/cdg2.html>)

Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.

- ❑ The document contains a large set of areas which are relevant for HCI:
 - Nature of Human-Computer Interaction
 - Use and Context of Computers
 - Human Characteristics
 - Computer System and Interface Architecture
 - Development Process
- ❑ Dix et. al (1993) describe a more general interaction model:



What are Human-Computer Interfaces (HCI)?

- ❑ In the traditional PC era, typically the WIMP paradigm is used
 - **WIMP** = Window Icon Mice, Pull down menus
 - A graphical-user-interface environment metaphor using a display



- ❑ For small handheld devices, WIMP is often not very useful
 - No (or too small) display
 - No mouse
 - No keyboard
 - etc.
- ❑ A tradeoff between requirements and possibilities is required

UBIQUITOUS USER INTERFACES

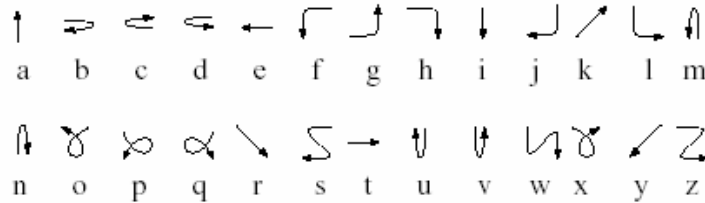
Example: Xerox PARC - **PARCTAB**

❑ Problem:

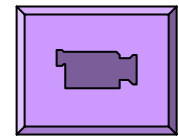
- ❑ Small display makes input interactions difficult

❑ Solution:

- ❑ 3-Button approach (up/down/select)
 - ❑ Stylus for touch screen actions (on-screen keyboard, icons)
 - ❑ **Unistroke** system allows for fast typing of letters but people have to learn the language
- Later this evolved to Graffiti used on PDAs

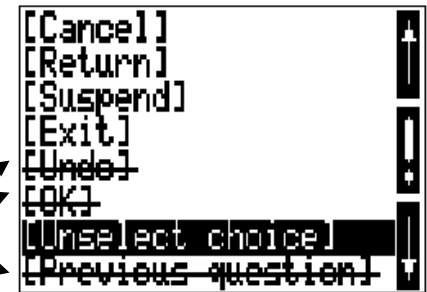


The Unistroke alphabet

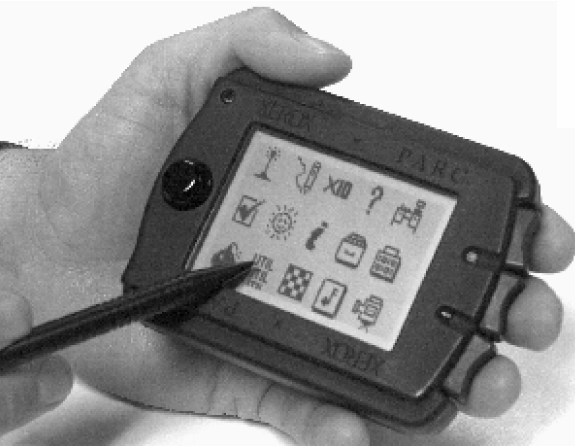


Tab

Unavailable options, that do not make sense in the location context are crossed out.



A scroll list

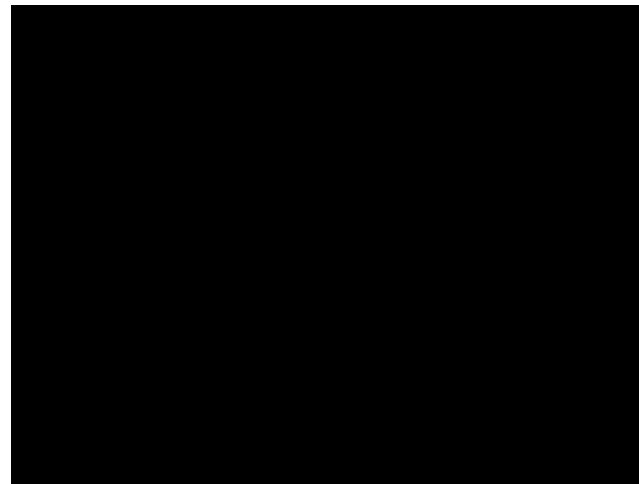
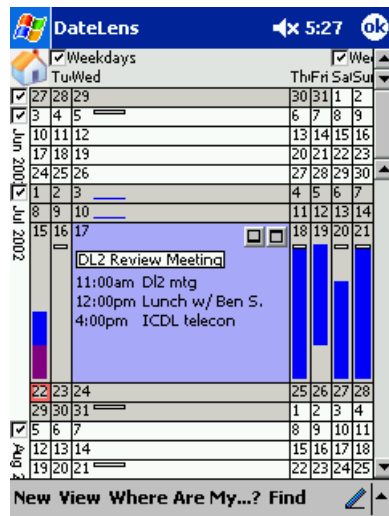


Source: <http://www.ubiq.com>

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Example: **DateLens** (University of Maryland)

- ❑ Calendar interface for PDAs
- ❑ Fisheye representation of dates coupled with compact overviews, user control over the visible time period, and integrated search

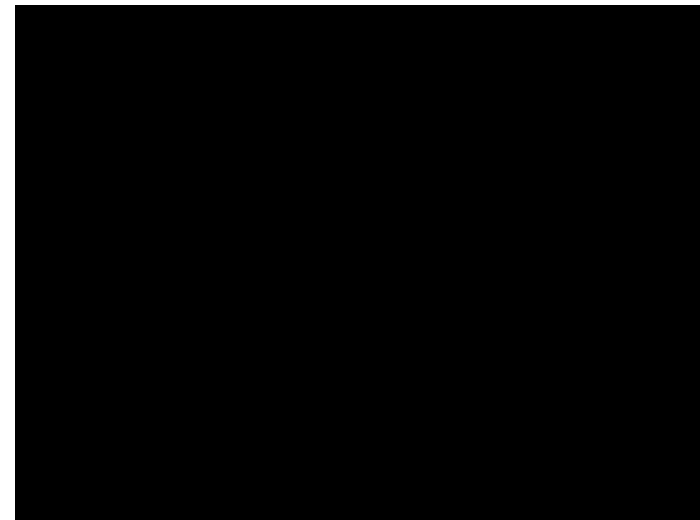
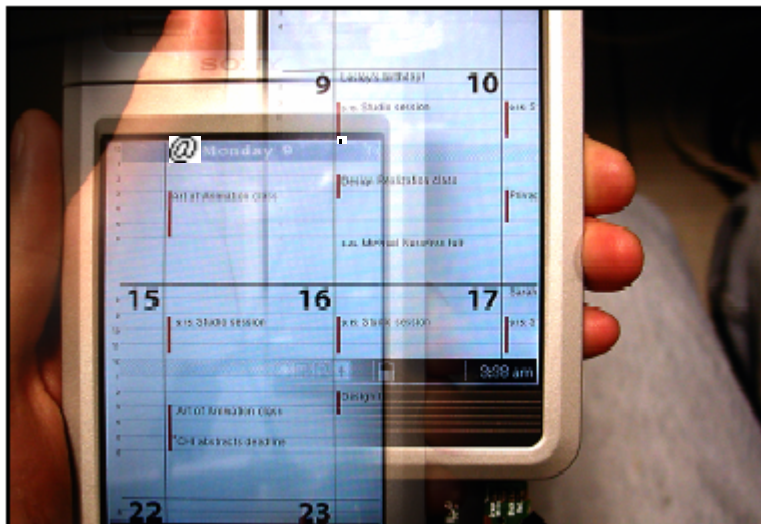


Video

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Example: **Peephole Display** (Berkeley)

- ❑ Spatial aware display
- ❑ Position is tracked to provide a window on a larger virtual workspace
- ❑ Applications: drawing program, map viewer, and calendar



Ka-Ping Yee:

Peephole Displays: Pen Interaction on Spatially Aware Handheld Computers

CHI 2003

Source: <http://www.sims.berkeley.edu/~ping/peep/>

UBIQUITOUS USER INTERFACES



Example: Halo (FhG Darmstadt, IPSI)

- Arcs are used to indicate off-screen data points



Source: Patrick Baudisch

Halo

A Technique for Visualizing
Off-Screen Locations

Patrick Baudisch: "Halo: A Technique for Visualizing Offscreen Locations," presented at the Association of Computing Machinery (ACM) Computer-Human Interaction (CHI) Conference 2003 Fort Lauderdale, Florida April 5-10, 2003, and posted at www.ipsi.fhg.de/~baudisch/Publications/2003-Baudisch-CHI03-Halo.pdf.



UBIQUITOUS USER INTERFACES

Computer interfaces for invisible computers?

- ☐ Interacting with smart real objects (no WIMP interface)
- ☐ Mobile users are moving around (hard to use mouse, pen, etc.)
- ☐ Interaction involved many smart objects (co-ordination required)
- ☐ New attributes of interaction are required:
 - **Presence**: Somebody out there?
 - **Location**: Where are they?
 - **Identity**: Who are they?
 - **Activity**: What are they doing?



UBIQUITOUS USER INTERFACES

Computer interfaces for invisible computers?

□ New Forms of interfaces are required:

- **Speech Recognition**
- **Gesture Recognition**
 - (Hand/arm/finger/head) tracking
 - Gaze tracking
 - Lip reading
 - Face Recognition, Facial expressions
 - (Hand/arm) gestures
- **Augmented Reality/Virtuality**
- **Tangible Media**

□ Also:

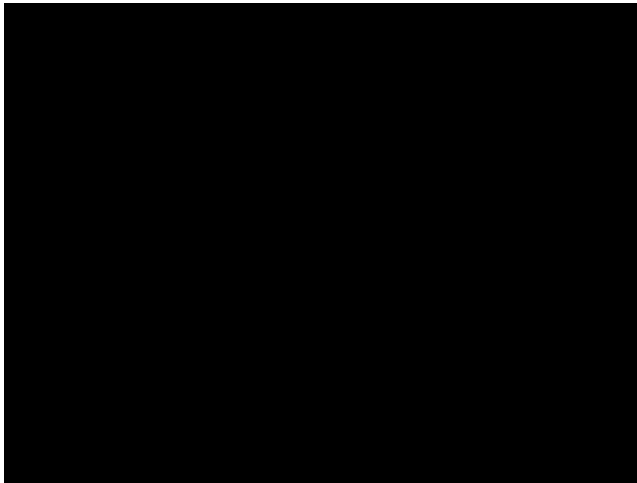
- **Affective User Interfaces**
- **Attentive User Interfaces**



UBIQUITOUS USER INTERFACES

Example: **AcceleGlove** (George Washington University)

- ☐ Electronic glove turns American sign Language into spoken words or text
- ☐ Developed to help deaf people
- ☐ Speed is fast enough to follow rapid hand movements



Jose Hernandez-Rebollar

Source: PC Magazine, <http://datacenter.ap.org/wdc/glove/index.html>, <http://home.gwu.edu/~jreboll/>

UBIQUITOUS USER INTERFACES



Example: **Haptic Interfac** (BT Exact)

- ❑ 3-D Scanner and special ,touch-related' monitor
- ❑ System delivers haptic sensations over the Internet



Source: PC Magazine

Andreas Schrader

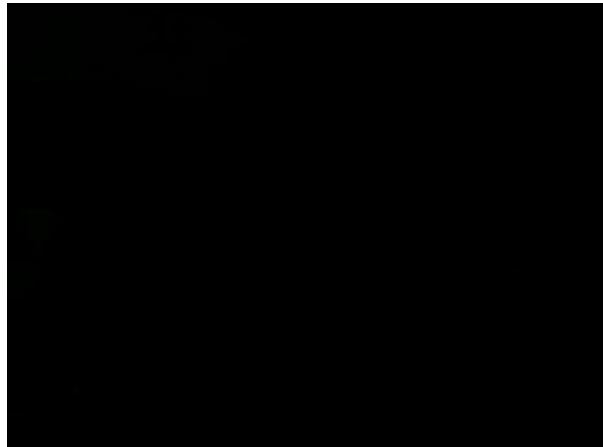
UBIQUITOUS COMPUTING



UBIQUITOUS USER INTERFACES

Example: **Living Memory** (Philips)

- ❑ Living Memory (LiMe) started as a 3 years EU funded project, and is now continued to be developed by Philips Design
- ❑ Lime is a network of augmented places within the local community
- ❑ It supports the creation and distribution of information
- ❑ LiMe provides low-threshold interfaces in natural meeting and crossing points within that community, such as cafes and bus stops.

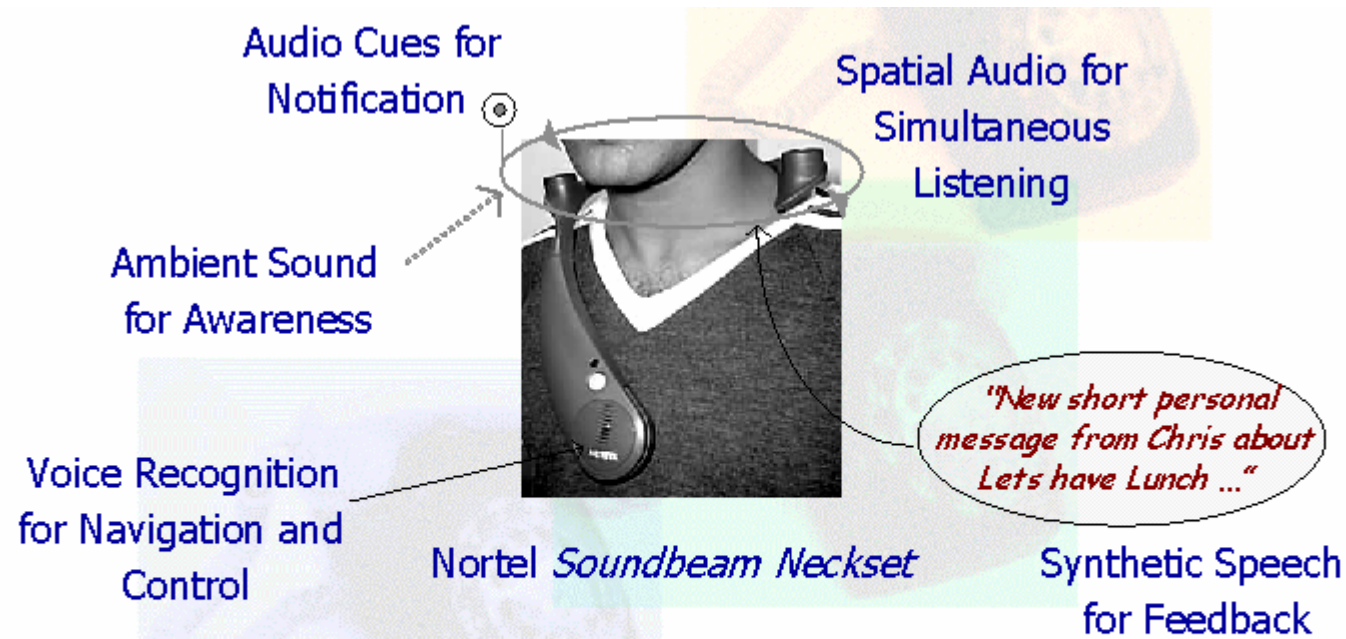


Source: <http://www.design.philips.com/smartconnections/lime/index.html>

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Speech Communication: **Nomadic Radio** (MIT)

- Nitin Sawhney & Chris Schmandt **Nomadic Radio**: wearable audio messaging



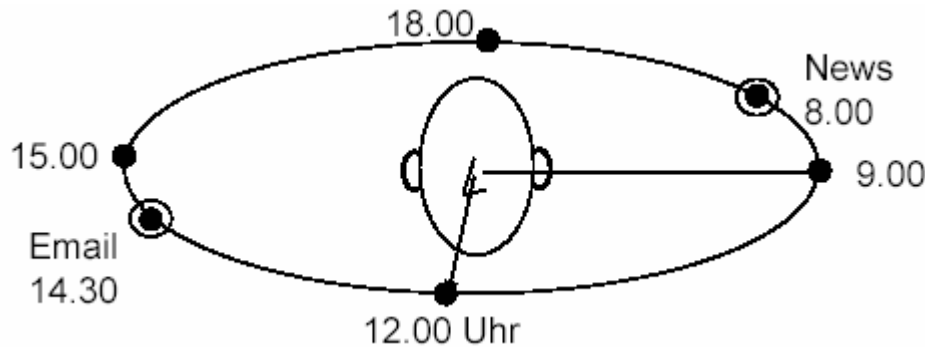
SPEECH
iINTERFACE
GROUP

Source: <http://web.media.mit.edu/~nitin/NomadicRadio/>

UBIQUITOUS USER INTERFACES

Speech Communication: **Nomadic Radio** (MIT)

- ☐ Active Communication
- ☐ Special vocabulary for speech navigation
 - Meta commands, e.g. „Go to my {email / news / ... }
 - General vocabulary for all applications
- ☐ Spatial direction of news in 3D audio system
 - Body-stabilized, e.g. due to time of message arrival



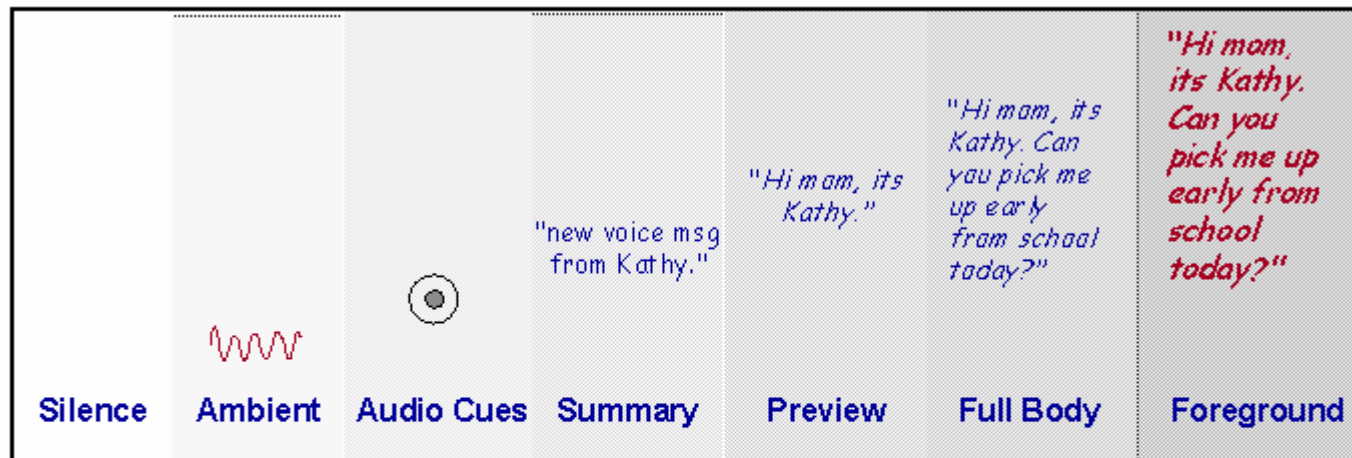
- ☐ Simultaneous Hearing: e.g. email in foreground, news in background

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Speech Communication: **Nomadic Radio** (MIT)

□ Passive Communication

- step-wise increase of disturbance in accordance to importance

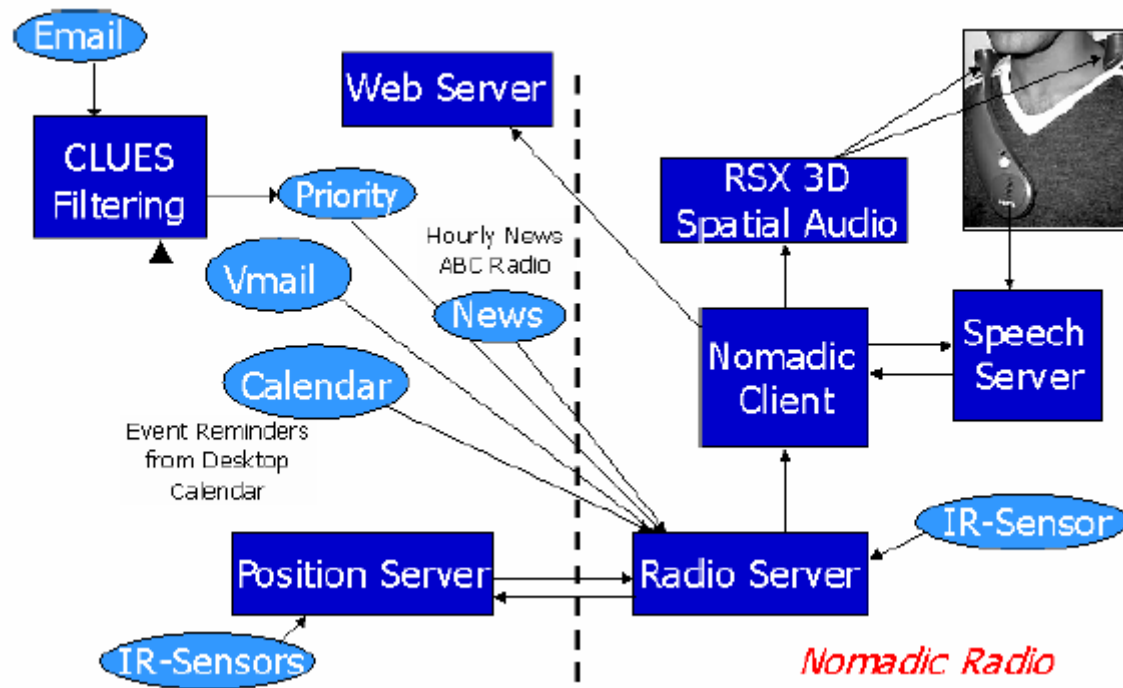


Progressive Scaling
of Incoming Messages

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Speech Communication: **Nomadic Radio** (MIT)

□ Architecture



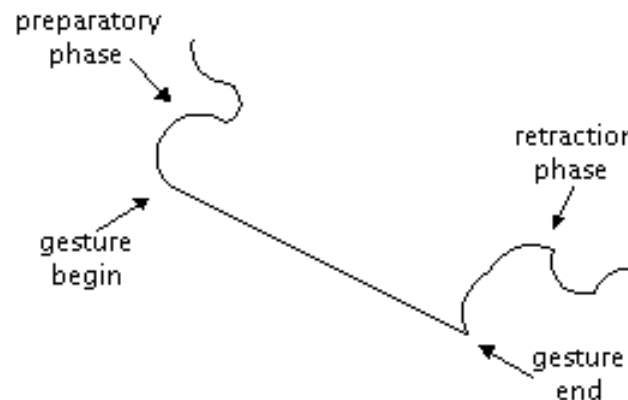
Source: <http://web.media.mit.edu/~nitin/NomadicRadio/>

UBIQUITOUS USER INTERFACES



Gesture recognition

- ❑ Camera tracks gestures (position of hands, fingers, etc.)
- ❑ Certain gestures or sequences of gestures are mapped to certain actions
- ❑ Gestures are usually bounded by start and end points in a continuous phase or by using minimum rest times in the same position
- ❑ Location of gesture elements can be used to identify 'touched' objects
- ❑ Example: The KidsRoom (MIT)

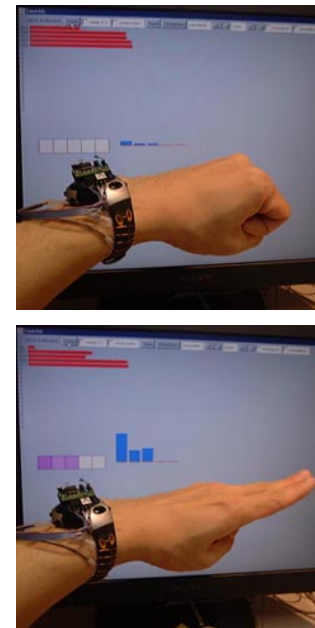
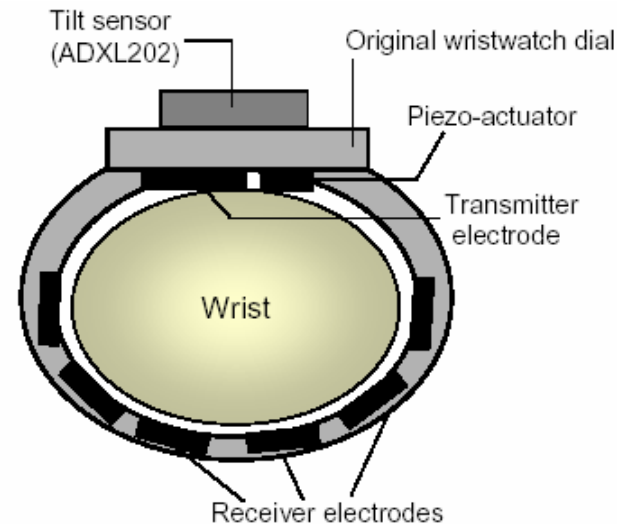
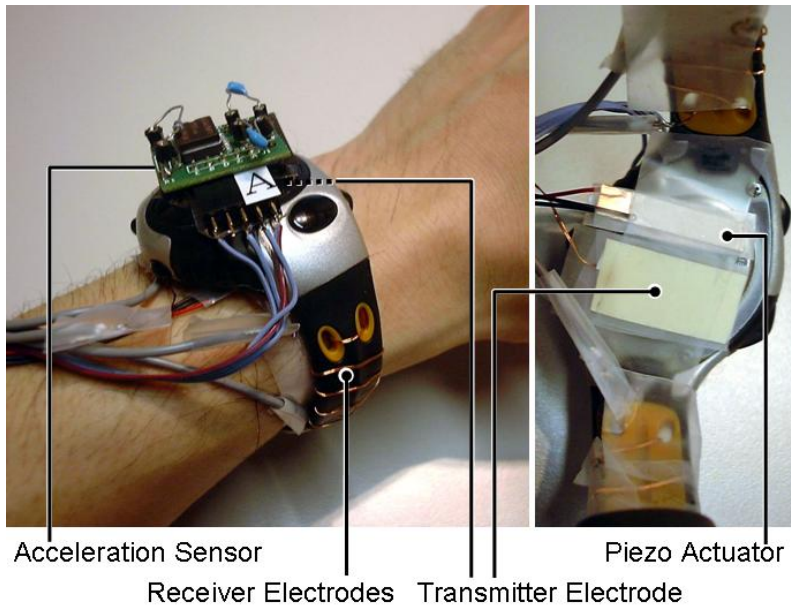


Phases in the creation of a gesture

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Gesture recognition: **GestureWrist** (Sony)

- ❑ Jun Rekimoto: GestureWrist and GesturePad: Unobstrusive Wearable Interaction Devices, ISWC'2001
- ❑ GestureWrist recognizes hand gestures and forearm movements. All sensing elements are embedded in a normal wristband.
- ❑ Piezoelectrical sensor signals are analyzed

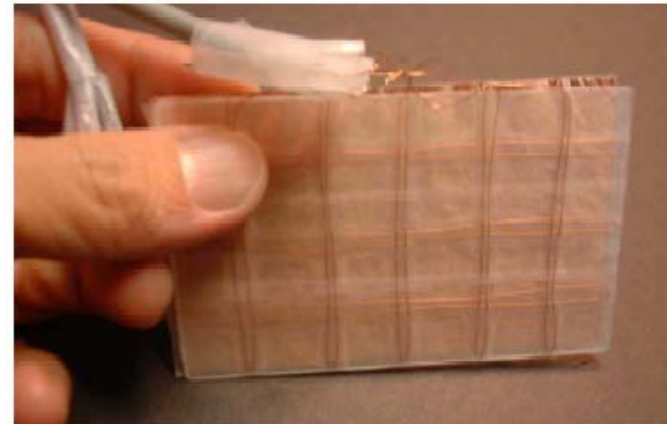
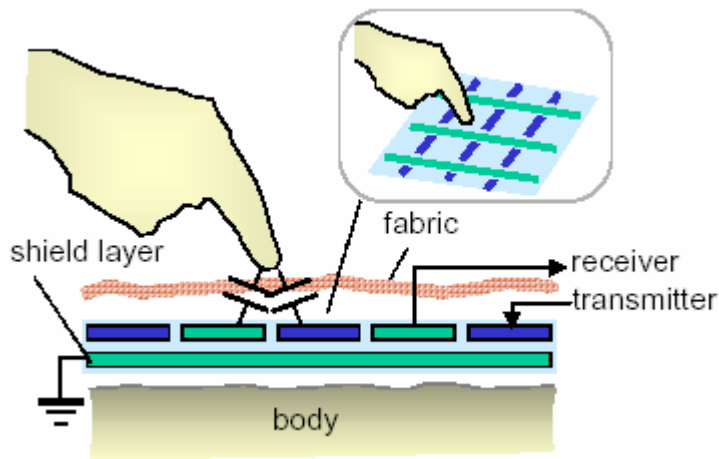


Source: <http://www.csl.sony.co.jp/person/rekimoto/gwrist/>

UBIQUITOUS USER INTERFACES

Gesture recognition: **GesturePad** (Sony)

- ❑ GesturePad can be attached on the inside of conventional clothes to transform them into interactive devices without changing their appearance



Source: <http://www.csl.sony.co.jp/person/rekimoto/gwrist/>

UBIQUITOUS USER INTERFACES

Example: A Nose Gesture Interface Device

- Tyson Henry, Scott Hudson, Andrey Yeatts, Brad Myers, Steven Feiner, "A Nose Gesture Interface Device: Extending Virtual Realities", April 1992. Proceedings of the ACM Symposium on User Interface Software and Technology, pp. 65-68, November 1991.



Motorcycle Helmet Platform

Source: http://www-2.cs.cmu.edu/~hudson/datanose/uist91_henry_datanose.pdf

UBIQUITOUS USER INTERFACES

Virtual Reality

- ❑ Should we replace our boring reality with a more exciting one?

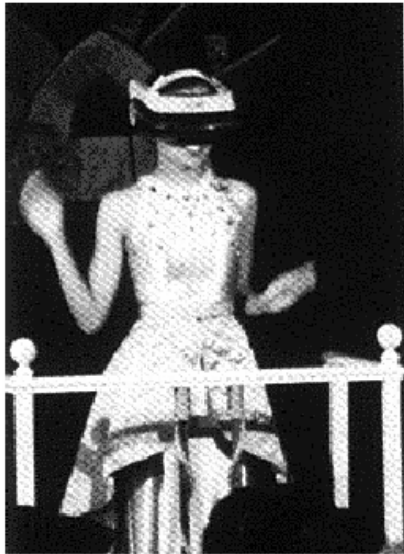


Source: Schmalstieg (University of Vienna)

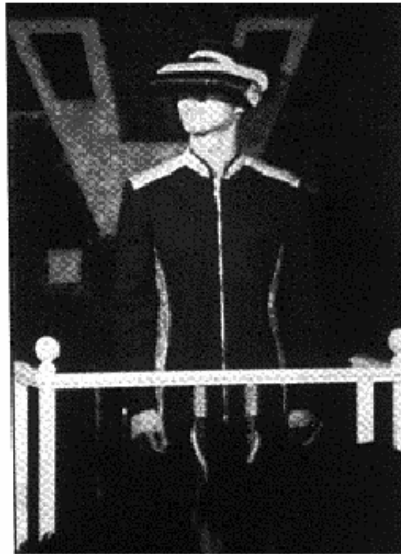
UBIQUITOUS USER INTERFACES

Virtual Reality tries for **eliminating the reality**

- ❑ Goal: create a perfect aural, visual, and other media sensation such that people forget the real environment and dive into another world
- ❑ Why?
 - Participants can join at distant locations
 - Physical limitations can be avoided
 - Dangerous situations can be trained
 - Etc.



Virtual Weddings

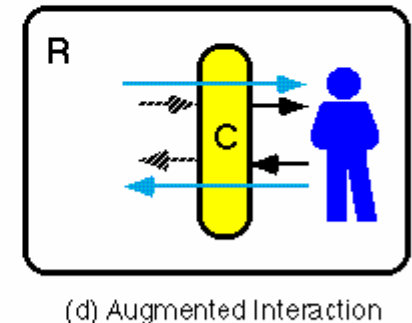
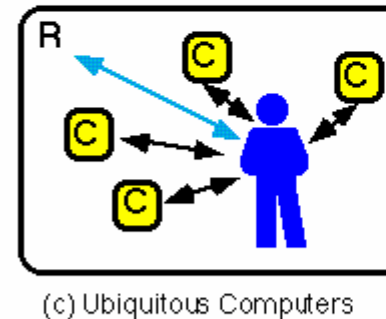
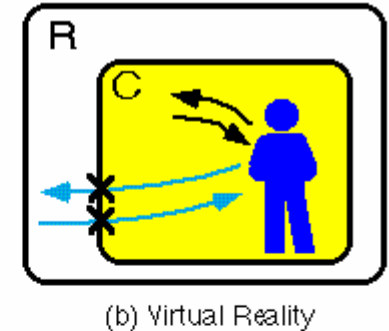
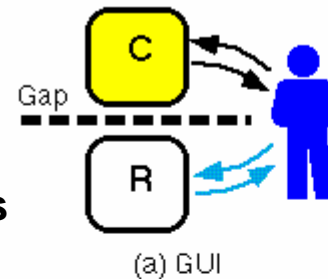




Virtual Bungee Jumping




UBIQUITOUS USER INTERFACES

Augmented Reality

- ❑ Goal: enhance the real world sensation with useful information
- ❑ Users see real and virtual objects
- ❑ Location-dependent additional information can be provided (display menu cards for restaurants)
- ❑ The real sensation can be partially disabled (replace all billboards with pictures from last holiday ...)



 Computer World
 Real World

 Human - Computer Interaction
 Human - Real World Interaction
 Real World - Computer Interaction

- ❑ Photo-realism not necessarily first goal but in the ultimate system, people cannot decide whether parts are virtual or real

Source: <http://www.csl.sony.co.jp/person/rekimoto/uist95/uist95.html>

UBIQUITOUS USER INTERFACES

Augmentation can be done for video ...

Example: Travel or shopping guidance

©2001 How Stuff Works



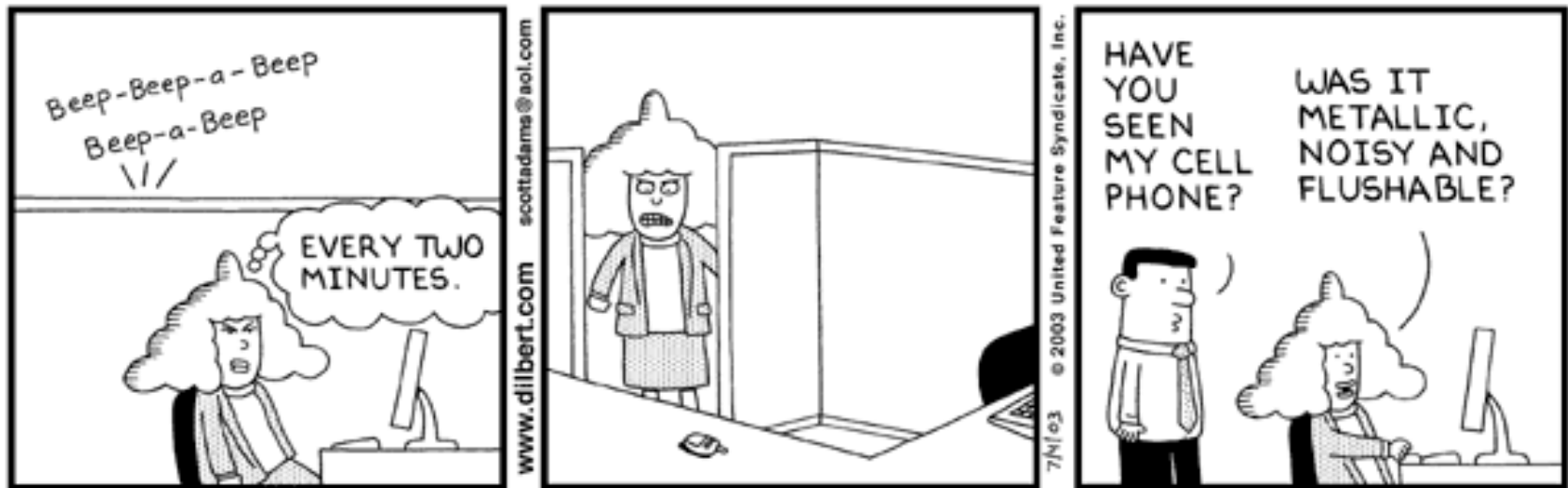
Source: <http://www.howstuffworks.com/augmented-reality.htm>

UBIQUITOUS USER INTERFACES



... and audio

❑ But Augmented Reality is not always welcomed ...

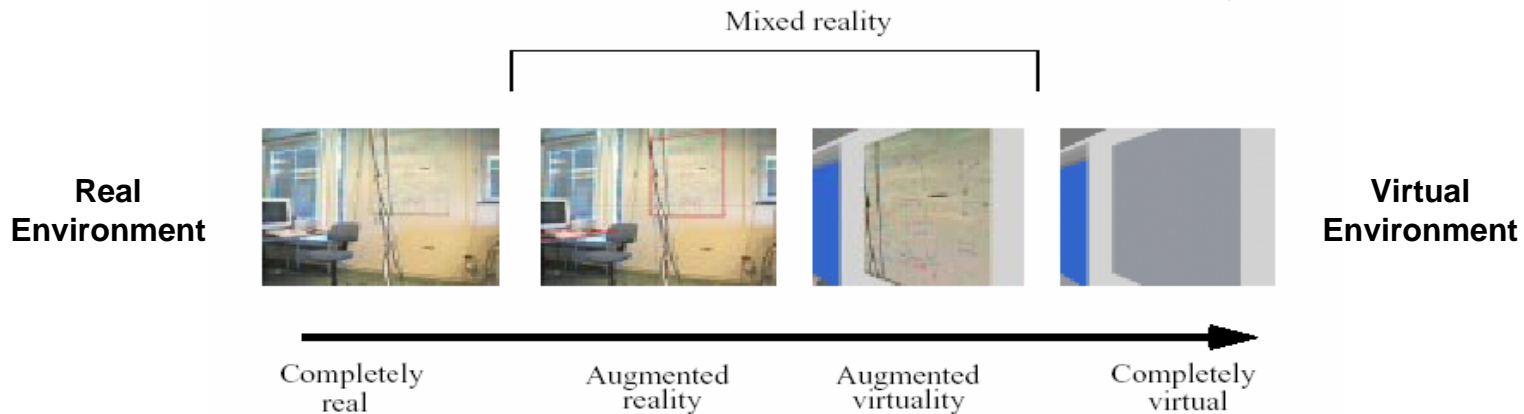


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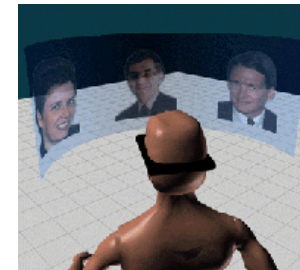
UBIQUITOUS USER INTERFACES

The Reality-Virtuality Continuum

- P. Milgram, H. Takemura, A. Utsumi, F. Kishino:
Augmented Reality: A class of Displays on the Reality-Virtuality Continuum
SPIE Vol. 2351, Telemanipulator and Telepresence Technologies, 1994.



- **Augmented Virtuality:**
A complete virtual environment is augmented with real object presentations (e.g. Avatars with real people faces in virtual shop)



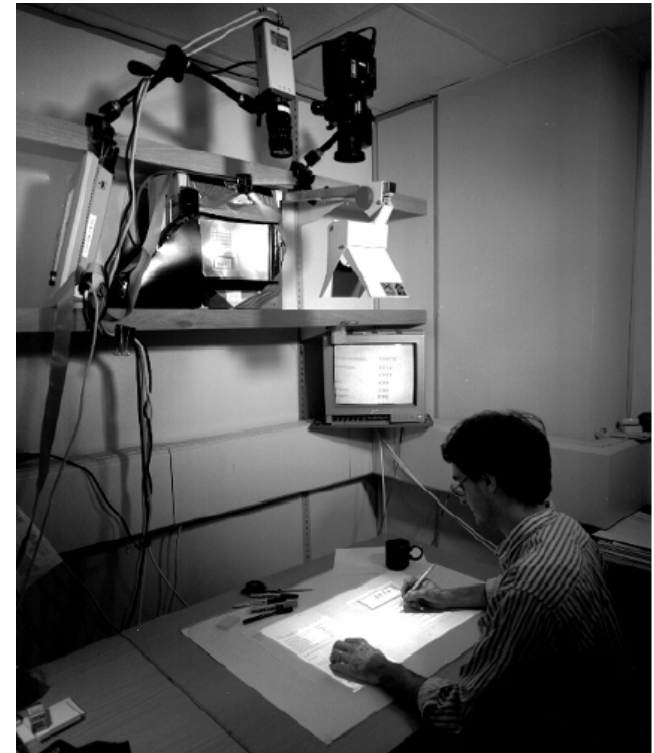
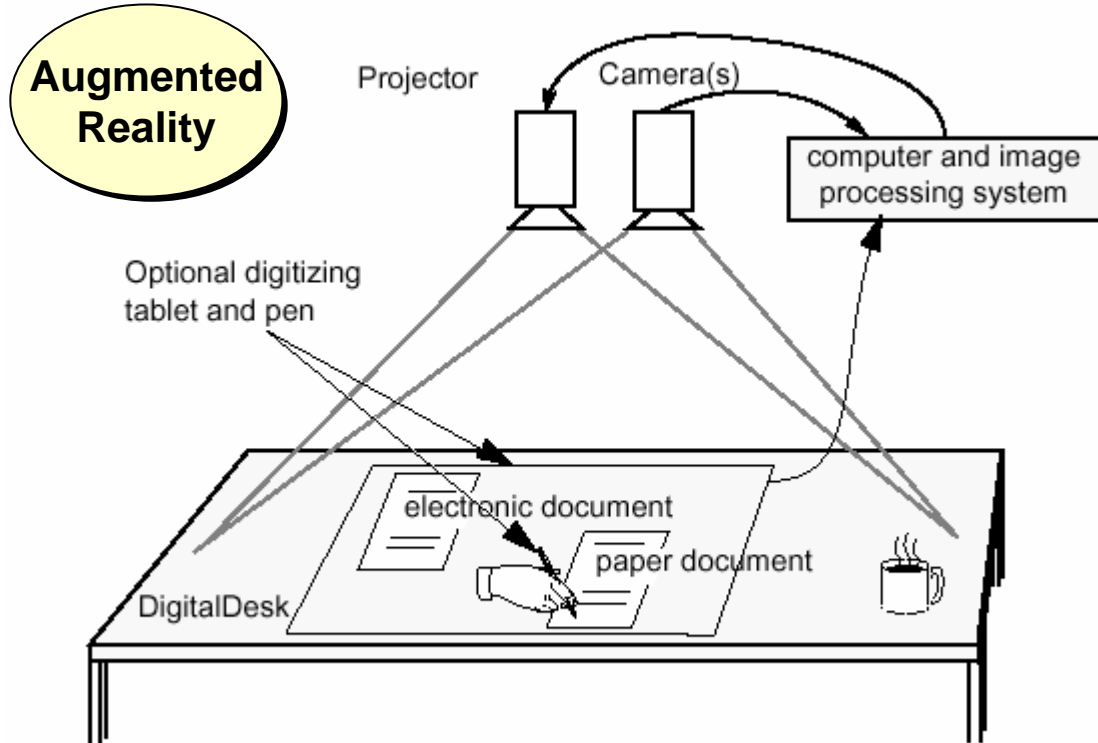
- Karl-Petter Akesson:
Augmented Virtuality: A method to automatically augment virtual worlds with video images, Master Thesis, SICS, Sweden, 1996.

Source: http://www.sics.se/~kalle/projects/Master_Thesis/index.html,
http://vered.rose.utoronto.ca/publication/1994/Milgram_Takemura_SPIE1994.pdf

UBIQUITOUS USER INTERFACES

Example: **Digital Desk** (Wellner, Xerox, 1992)

- ❑ P. Wellner: "*DigitalDesk*", *Communications of the ACM*, 36(7), pp. 87--96, July 1993.
(<http://citeseer.nj.nec.com/wellner93interacting.html>)
- ❑ Extending the desktop metaphor to the real desk

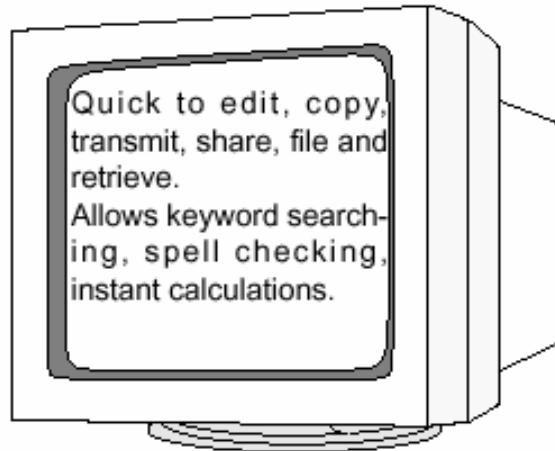


Also: <http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html>

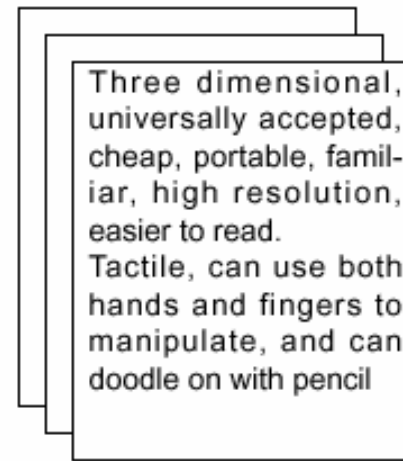
UBIQUITOUS USER INTERFACES

Example: **Digital Desk** (Wellner, Xerox, 1992)

- ❑ Both electronic and paper documents have their advantages
- ❑ Virtual (displayed) and real documents share the same space



Electronic documents
on a virtual desk

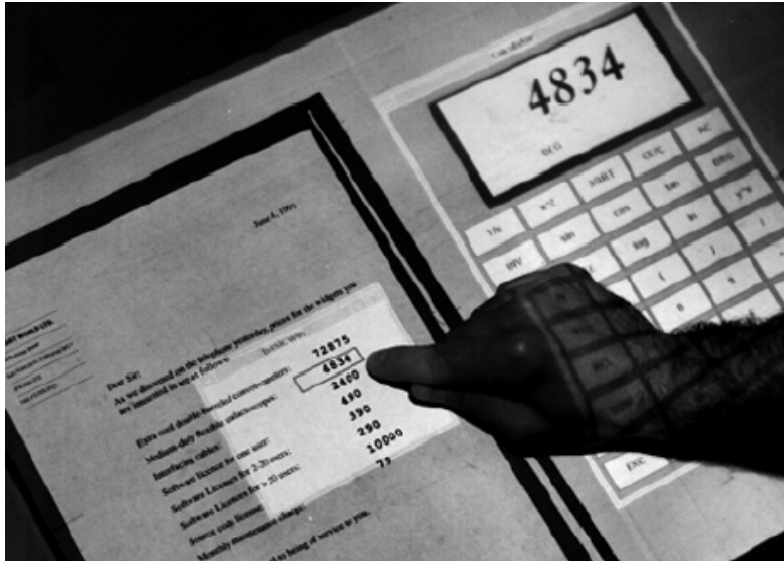


Paper documents
on a real desk

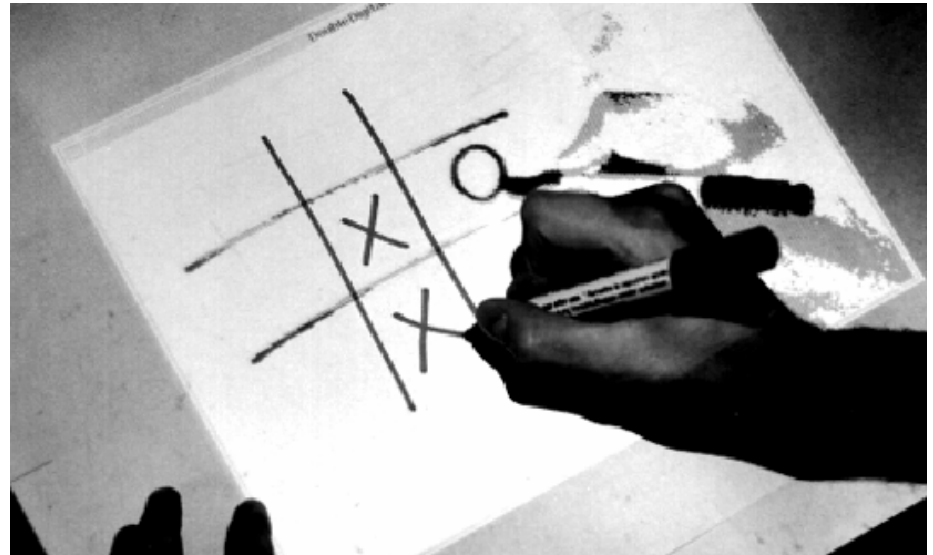
UBIQUITOUS USER INTERFACES

Example: **Digital Desk** (Wellner, Xerox, 1992)

- Allows for intuitive user patterns



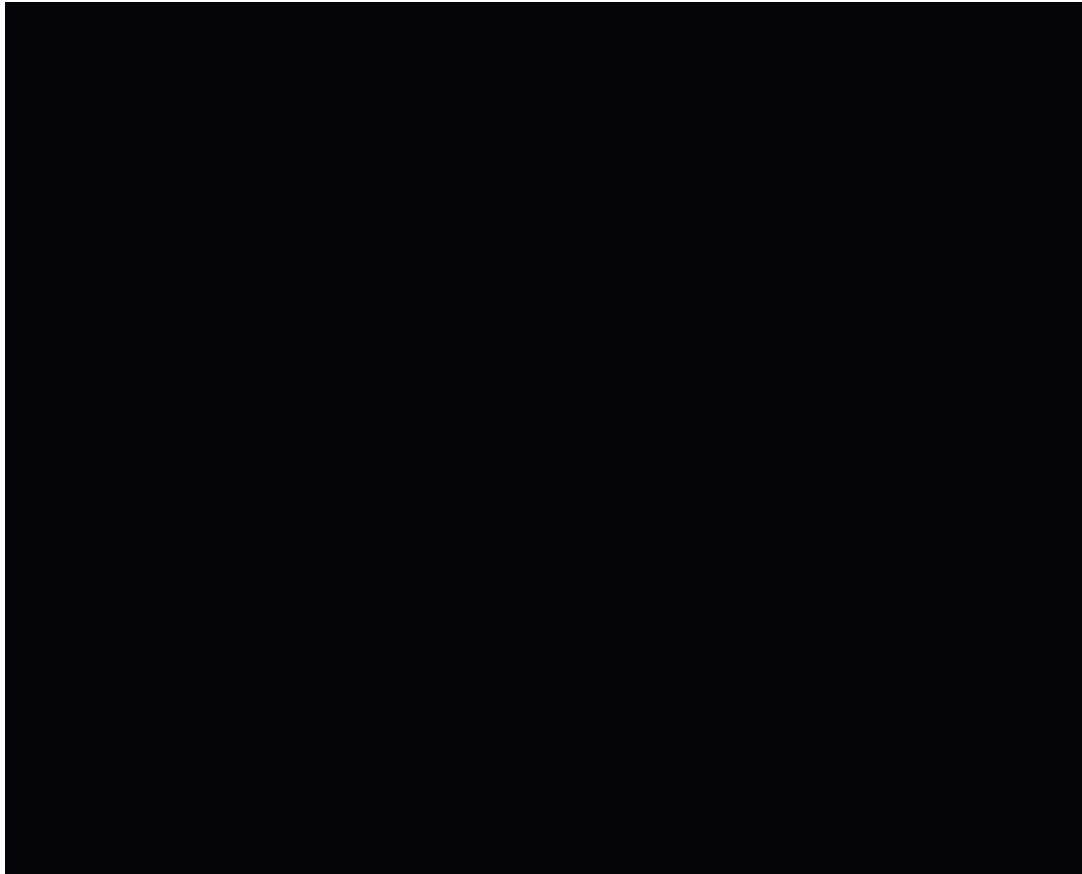
User selects the text „4834“ on a sheet of paper, the system recognizes the text and displays the result as an input for the virtual calculator on the right side.



DoubleDesk: The user is drawing on paper, while the system displays the remote player as a virtual copy of the real action on the remote location. Both players have the same impression.

UBIQUITOUS USER INTERFACES

Example: **Digital Desk** (Wellner, Xerox, 1992)



Video

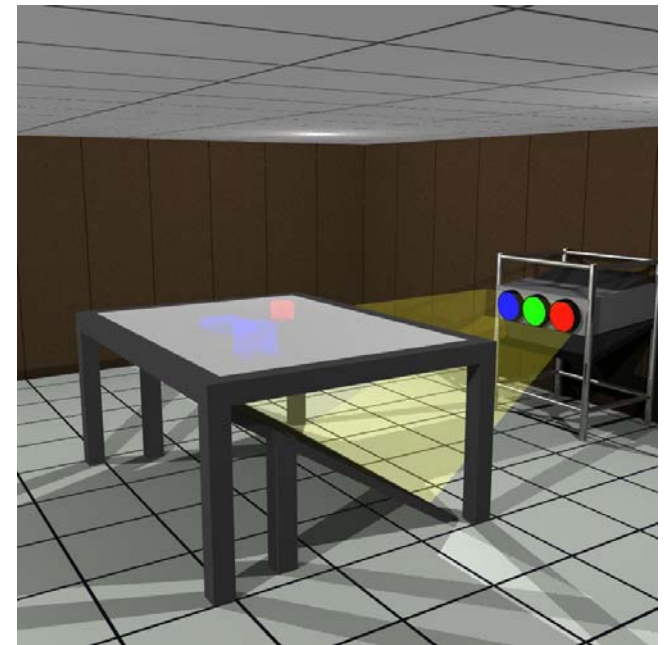
Also: <http://www.xrce.xerox.com/competencies/image-processing/past-projects/history.html>

UBIQUITOUS USER INTERFACES

Example: **Responsive Desk** (GMD/Berkeley, 1997)

- ❑ Combines the Digital Desk metaphor with 3D virtual reality
- ❑ Computer-generated stereoscopic images are projected onto a horizontal tabletop display surface via a projector-and-mirrors system, and viewed through shutter glasses to generate the 3D effect
- ❑ Is this still Ubiquitous Computing?

Augmented
Reality

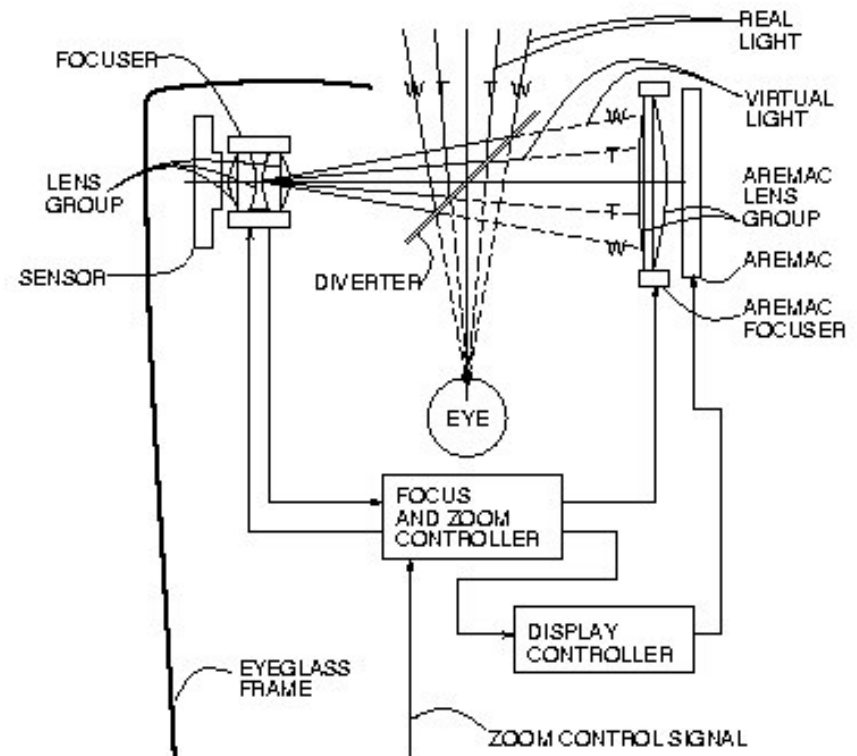


Source: <http://www.graphics.stanford.edu/projects/RWB/>

UBIQUITOUS USER INTERFACES

Example: aremac (EyeTap)

- ❑ ,aremac' : ,camera' spelled backwards
- ❑ The Eye itself as display and camera (used by Steve Mann)
- ❑ Sensors are used to detect what the user sees
- ❑ An augmented, diminished, or otherwise processed visual perception is presented to the user with appropriate focal distance and tonal range
- ❑ aremic visual results and environmental light have collinear rays and appear spatially aligned in the user's field of view (FOV)



Source: <http://eyetap.org/research/eyetap.html>

UBIQUITOUS USER INTERFACES

Example: Reality Window Manager (EyeTap)

□ Reality Window Manager

- Window manager for XWindows that overlays xterms and other windows onto planar patches in the environment around the user.
- Allows for realtime tracking, replacement and rendering.

Augmented Reality



Commercial sign replaced by message



Billboard replaced by a web browser

Source: <http://eyetap.org/research/medr/rwm.html>

UBIQUITOUS USER INTERFACES

Example: **LeMO** (Lebendiges virtuelles Museum Online)

- VRML based Web page with real pictures of exhibition objects in virtual space

Augmented
Virtuality



UBIQUITOUS USER INTERFACES

Commercial Applications



Advertisement



Sports



Entertainment



News

Also:

- ☐ Manufacturing
- ☐ Maintenance
- ☐ Repair
- ☐ Consumer and Engineering Design
- ☐ Hazard Detection
- ☐ (Tele-)Robotics
- ☐ Medical
- ☐ Military Training

UBIQUITOUS USER INTERFACES

Milgram's Taxonomy for mixed reality

Extent of World
Knowledge

Extent of
Presence
Metaphor

Reproduction
Fidelity

- ☐ **Reproduction Fidelity** – quality of computer generated imagery
- ☐ **Extent of Presence Metaphor** – level of immersion of the user within the displayed scene
- ☐ **Extent of World Knowledge** – knowledge of relationship between frames of reference for the real world, the camera viewing it, and the user

Source: http://vered.rose.utoronto.ca/publication/1994/Milgram_Takemura_SPIE1994.pdf

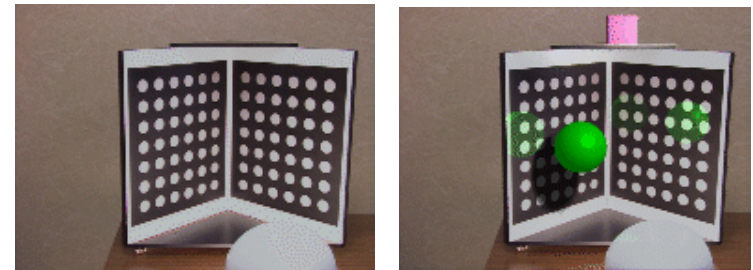
UBIQUITOUS USER INTERFACES

What do we need for the combination of real and virtual worlds?

- ☐ Precise Models
- ☐ Locations and optical properties of the viewer (or camera) and the display
- ☐ Calibration of all devices
- ☐ Combination of all local coordinate systems centered on the devices and the objects in the scene in a global coordinate system
- ☐ Registration of models of all 3D objects of interest with their counterparts in the scene
- ☐ Tracking of objects over time when the user moves and interacts with scene

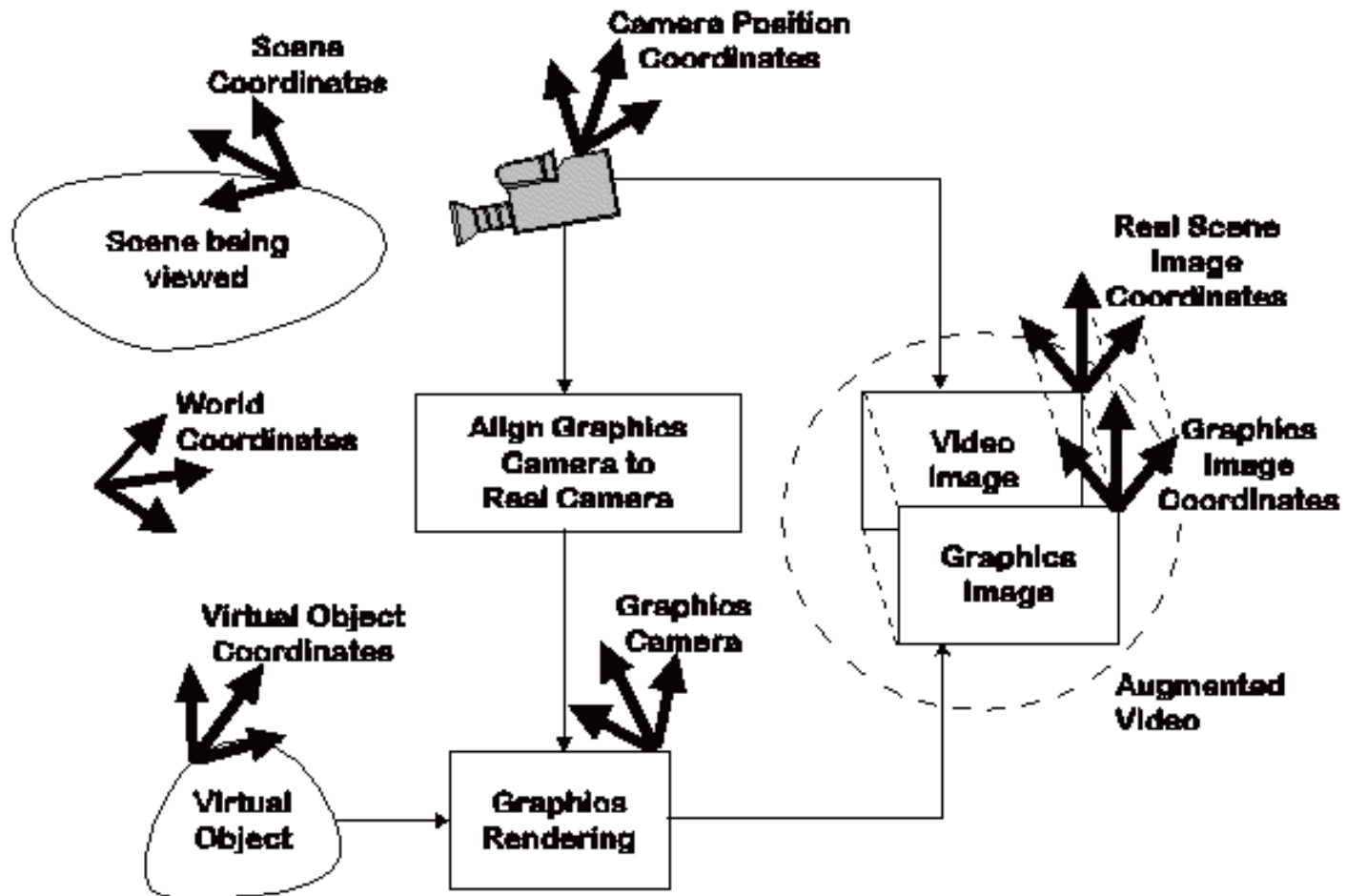
Realistic merging requires:

- ☐ Objects to behave in physically plausible manner when manipulated
 - ☐ Occlusion
 - ☐ Collision detection
 - ☐ Shadows
- ☐ All of these requires a very detailed description of the physical scene



UBIQUITOUS USER INTERFACES

Components of an Augmented Reality System

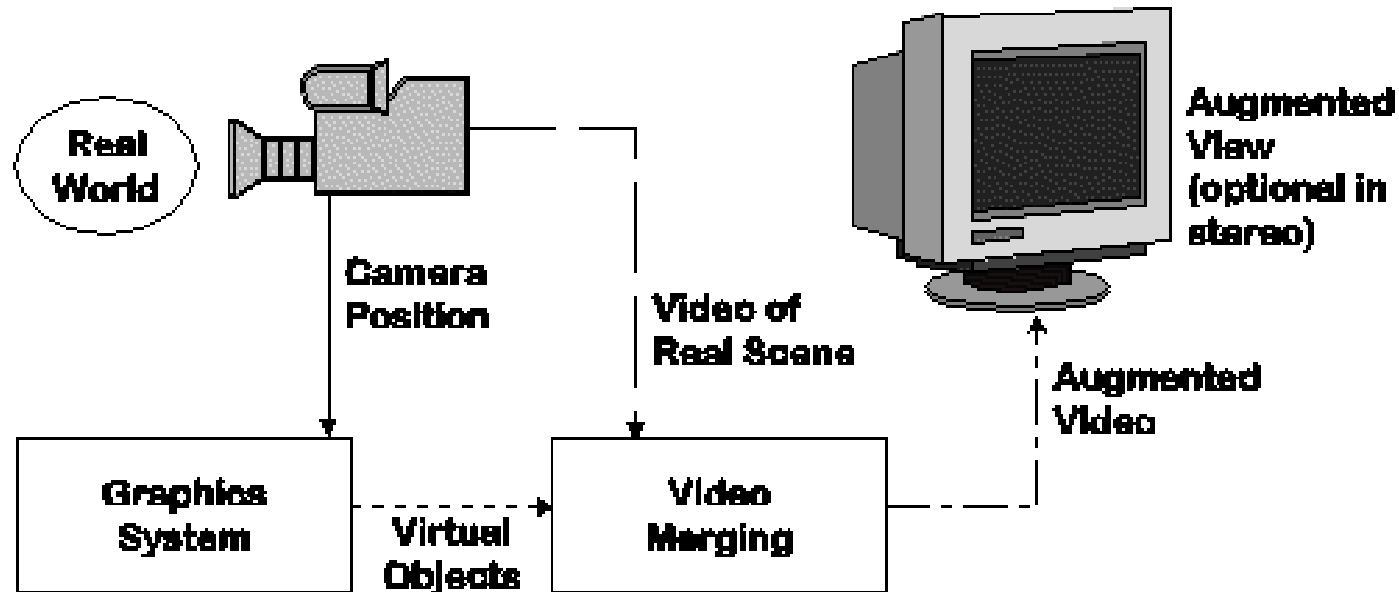


Source: Cindy Robertson (Georgia Tech)

UBIQUITOUS USER INTERFACES

Display Technologies

- ☐ **Monitor based**
- ☐ Simplest technique
- ☐ Little feeling of being immersed in environment



Source: Cindy Robertson (Georgia Tech)

UBIQUITOUS USER INTERFACES

Display Technologies

☐ Optical see-through Head Mounted Display

☐ Advantages:

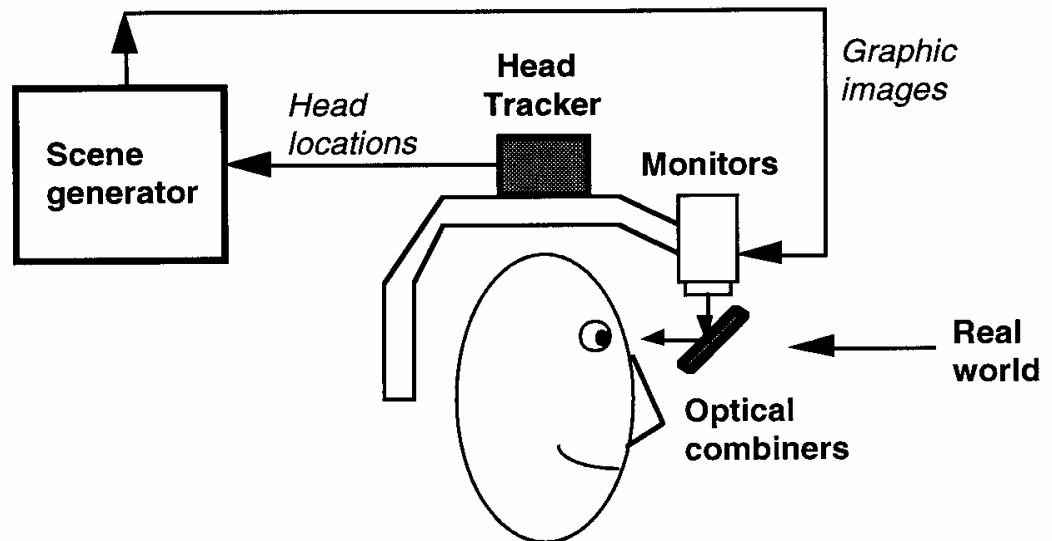
- Simple
- No resolution limitations for real world picture

☐ Disadvantages:

- Delay for virtual image may cause offset in motions
- Only bright objects can overpaint the reality, because 30% of the real worlds image and 70% of the virtual image can be seen in the display



Example: Glasstron (Sony)

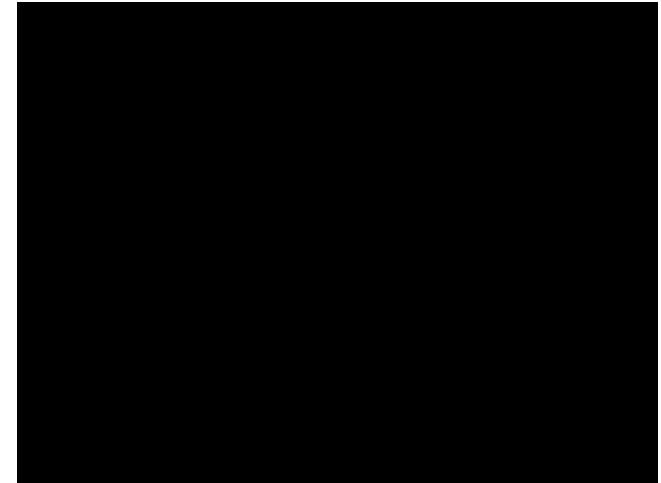


Source: Cindy Robertson (Georgia Tech), <http://www.vrealities.com/hmd.html>

UBIQUITOUS USER INTERFACES

Display Technologies

- Example: **Nomad** (Microvision)
 - SVGA 800 x 600 pixels
 - 20:1 @ 10-30° C
 - Monochrome red

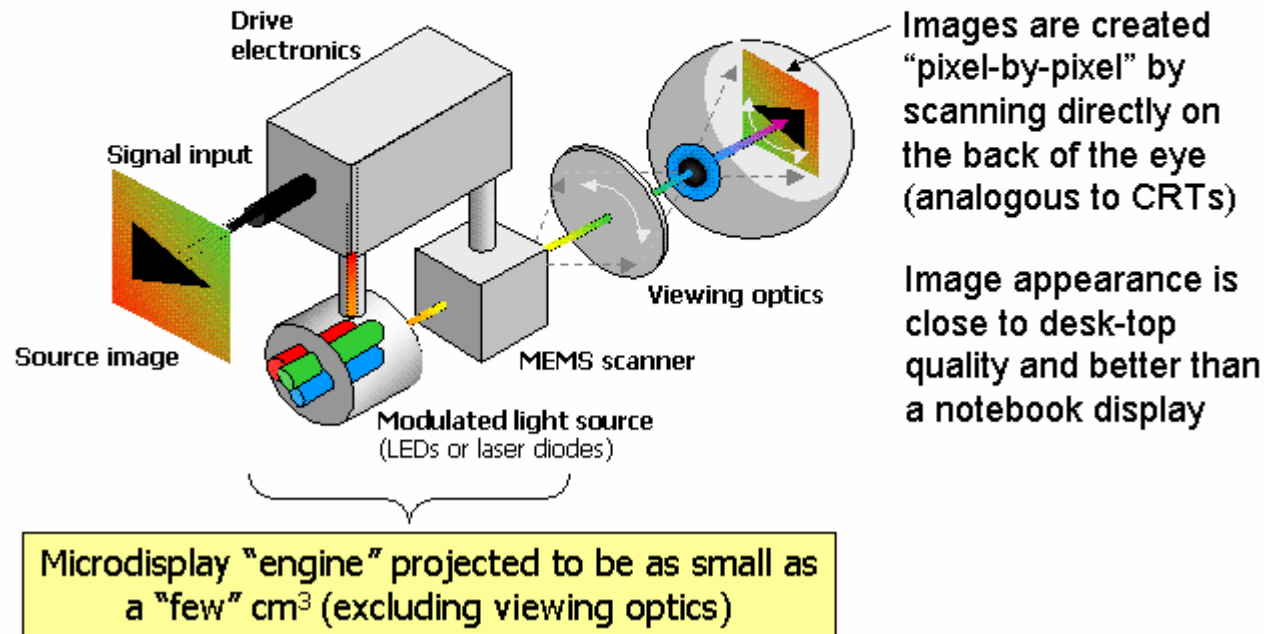


Source: <http://www.microvision.com/nomad/index.html>

UBIQUITOUS USER INTERFACES

Display Technologies

NEAR-EYE SCANNED BEAM DISPLAY DIAGRAM



Source: <http://www.microvision.com/nomad/index.html>

UBIQUITOUS USER INTERFACES

Display Technologies

☐ Video see-through Head Mounted Display

☐ Advantages:

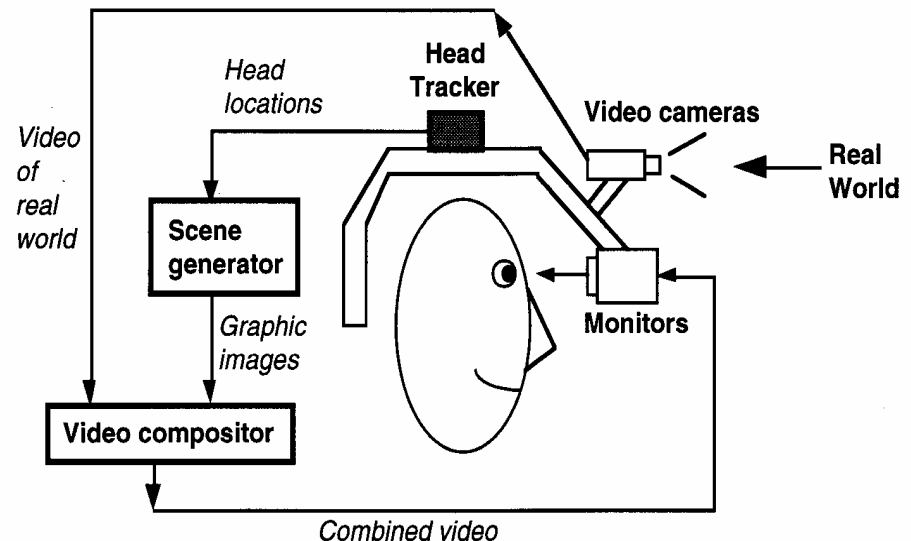
- No delay, since virtual and real images can be synchronized
- Easy to control visual behavior like brightness or shadows
- Virtual image can complete overpaint the real image.

☐ Disadvantages:

- Delay between mechanical and seen motion can cause motion sickness
- Real world image has the same (low) resolution than the display has



Example: COASTAR (Mixed Reality System Lab Inc.)

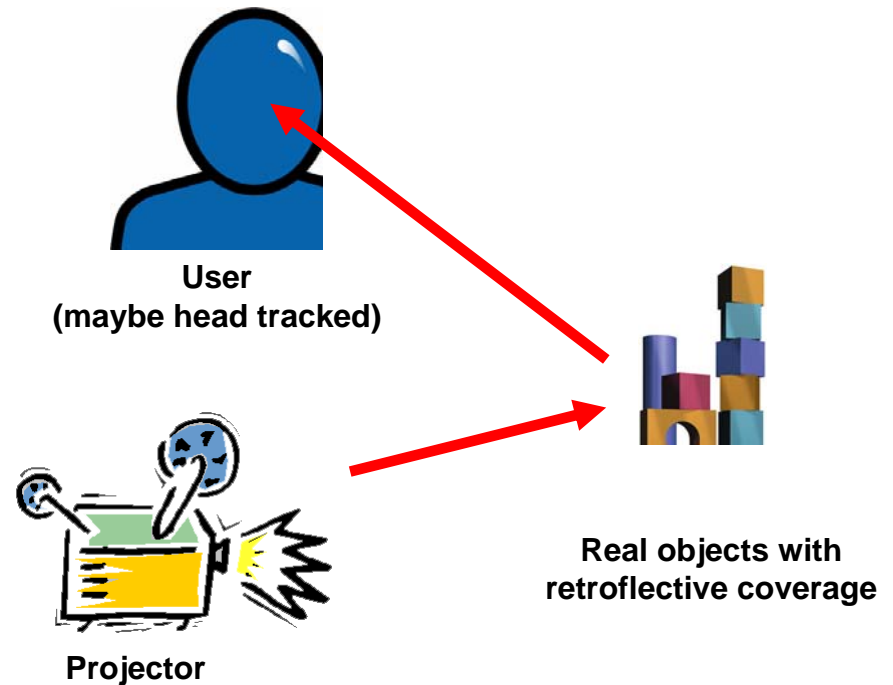


Source: Cindy Robertson (Georgia Tech), <http://citeseer.nj.nec.com/takagi00development.html>

UBIQUITOUS USER INTERFACES

Display Technologies

- ☐ **Projector based**
- ☐ **Advantages:**
 - User is completely free of devices
- ☐ **Disadvantages:**
 - User can be 'in the way'
 - Limited accuracy
 - Only one viewing direction



UBIQUITOUS USER INTERFACES

Projector based

Example: University of North Carolina at Chapel-Hill



Ramesh Raskar, Greg Welch, Wei-Chao Chen.

Table-Top Spatially-Augmented Reality: Bringing Physical Models to Life with Projected Imagery

Second International Workshop on
Augmented Reality (IWAR'99),
October 20-21, 1999, San Francisco, CA.

ISAR01 Demonstration Video Footage

Dynamic Shader Lamps: Painting on Movable Objects

Deepak Bandyopadhyay (1),
Ramesh Raskar (2), Henry Fuchs (1)

1) University of North Carolina at Chapel-Hill
2) Mitsubishi Electric Research Lab

D, Bandyopadhyay, R. Raska, H. Fuchs:

Dynamic Shader Lamps: Painting on Real Objects

The Second IEEE and ACM International
Symposium on Augmented Reality (ISAR'01)
New York, NY, October 29-30, 2001.

Source: <http://www.cs.unc.edu/~debug/papers/DSLpaint/>, <http://www.cs.unc.edu/~raskar/Office/index.html#pub>

UBIQUITOUS USER INTERFACES

Virtual Keyboard - VKB

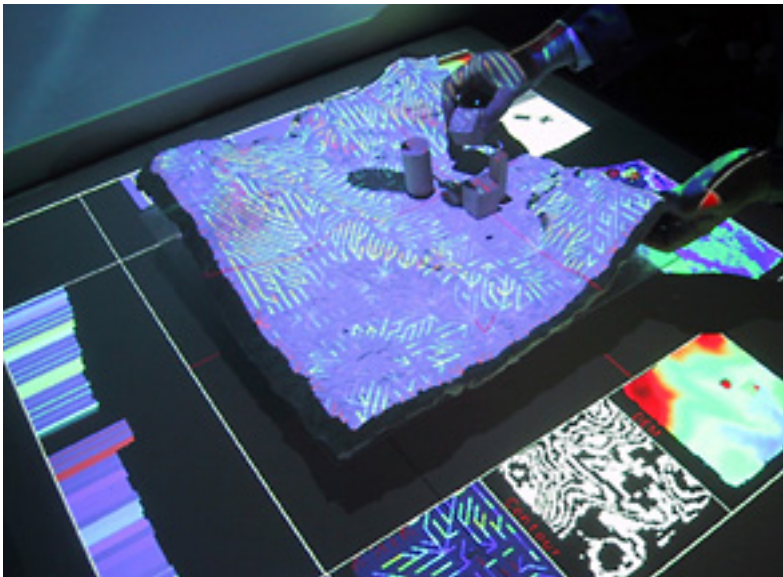
- ☐ LED projection of keyboard onto a flat surface
- ☐ Infrared motion detectors sense movements of fingers
- ☐ Also mouse and touchpad controls



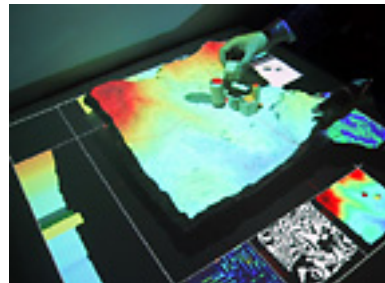
UBIQUITOUS USER INTERFACES

Tangible Media

- ❑ Present digital information in physical form
- ❑ Using physical forms as input devices („Tangible Interfaces“)
- ❑ Taking advantage of the richness of multimodal human senses and skills



SandScape - a tactile interface of topographical landscapes
(visual interpretation)

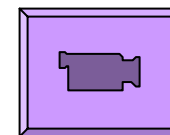


MusicBottles – opening and closing the lids starts and stops music of different styles
(electromagnetic sensors)

UBIQUITOUS USER INTERFACES

Example: **Super Cilia Skin** (MIT)

- ❑ Multi-modal interactive interface, conceived as a computationally enhanced membrane coupling tactile-kinesthetic input with tactile and visual output.
- ❑ An array of individual actuators (cilia) use changes in orientation to display images or physical gestures as physical or tactile information.



Video

Source: http://tangible.media.mit.edu/projects/Super_Cilia_Skin/Super_Cilia_Skin.htm

UBIQUITOUS USER INTERFACES

DECONcert/Regenerative Music in the key of EEG

Toronto cyborgs James Fung and Corey Manders have combined PhD research into biofeedback with an interest in improvisational musical forms like jazz. The result is the second DECONcert, a reprise of the enormously popular regenerative soundscapes in which members of the audience actively (and unconsciously) choreograph a collective cyborg consciousness by contributing their own brainwave patterns. This is an open-ended and participatory performance that incorporates leading-edge EEG (brainwave) technology with traditional musical instruments. Regenerative Music places the human being into the feedback loop of a computational artistic process.

Thursday, May 29.03

@ **DECONISM**

Deconism Gallery is located at 330 Dundas Street West directly across the street from the main entrance to the Art Gallery of Ontario (AGO)
phone: 416-593-9330
<http://eyetap.org/deconism.htm>

\$10 at the door, space is limited.
Tickets can be purchased in advance at the gallery.

**Music event
at the deconism gallery
in Ontario, Canada**



Source: <http://www.eyetap.org/deconism/>