

Tapio Takala, Lauri Savioja,
Tapio Lokki, Timo Tossavainen



Art and Magic Research

*technology for
sound, motion and
interactive installations*

*"Any sufficiently advanced technology is indistinguishable from magic."
Arthur C. Clarke*

Outline

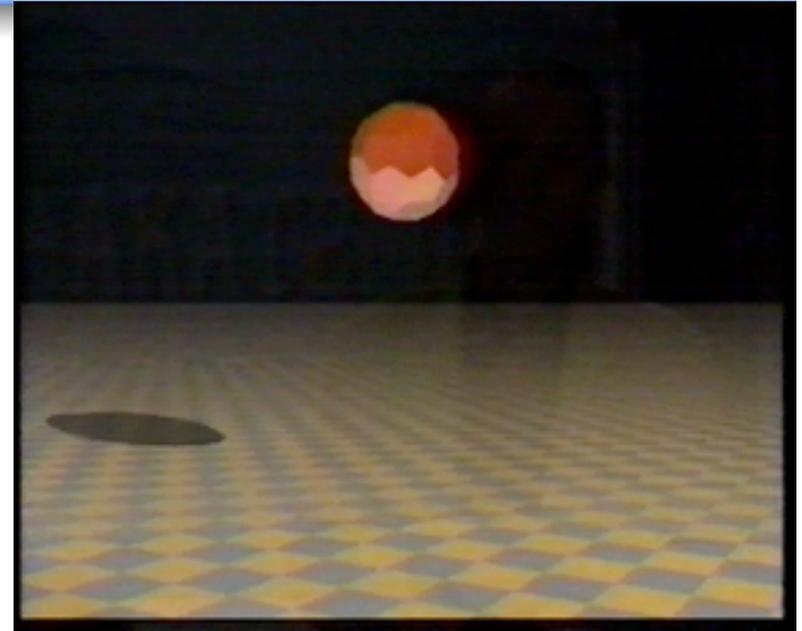
- historical background (sound rendering, cooperation with Acoustics lab)
- virtual acoustics (room modeling)
- concert hall acoustics (ERC focus)
- computer graphics (3DR)
- immersive virtual reality (EVE, visualization, Upponurkka, art applications etc.)
- interactive entertainment (games, installations)
- embodied interaction (enactive/affective media, design in 3D, mocap, virtuaaliorkesteri/-instrumentit)
- augmented reality (tracking, augmented audio, applications – oopperakin menee tähän kategoriaan?)

Department of Media Technology

- founded in 2008, combining two related units
 - ◆ Laboratory of Media technology
 - ◆ Telecommunications software and multimedia laboratory
- research groups and professorships
 - ◆ visual media (Oittinen)
 - ◆ multimedia and networked media (Vuorimaa)
 - ◆ semantic web (Hyvönen)
 - ◆ **graphics, virtual reality and interactive systems**
 - virtual acoustics (Savioja)
 - interaction technology (Takala)
- <http://www.tml.tkk.fi/Research/projects.php>

Background: Sound rendering (1992)

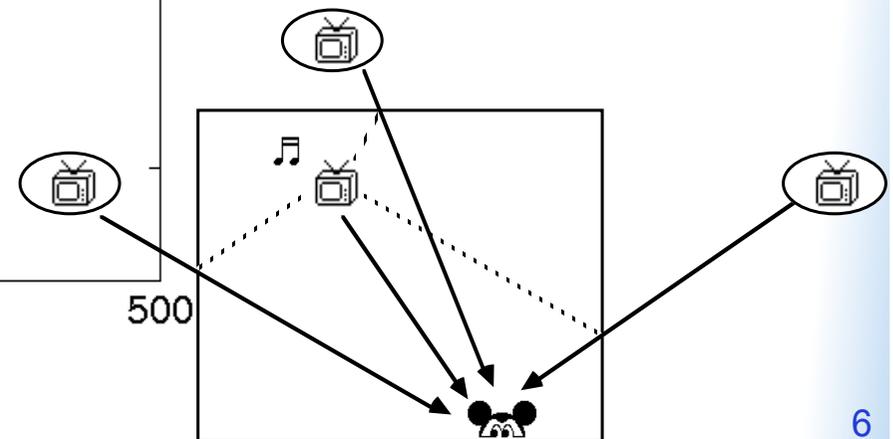
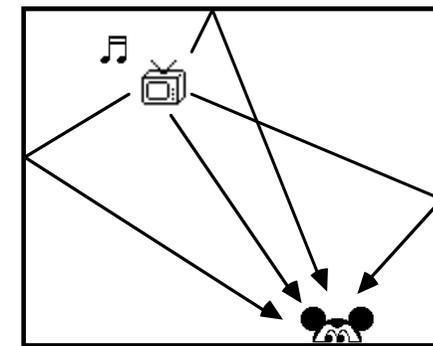
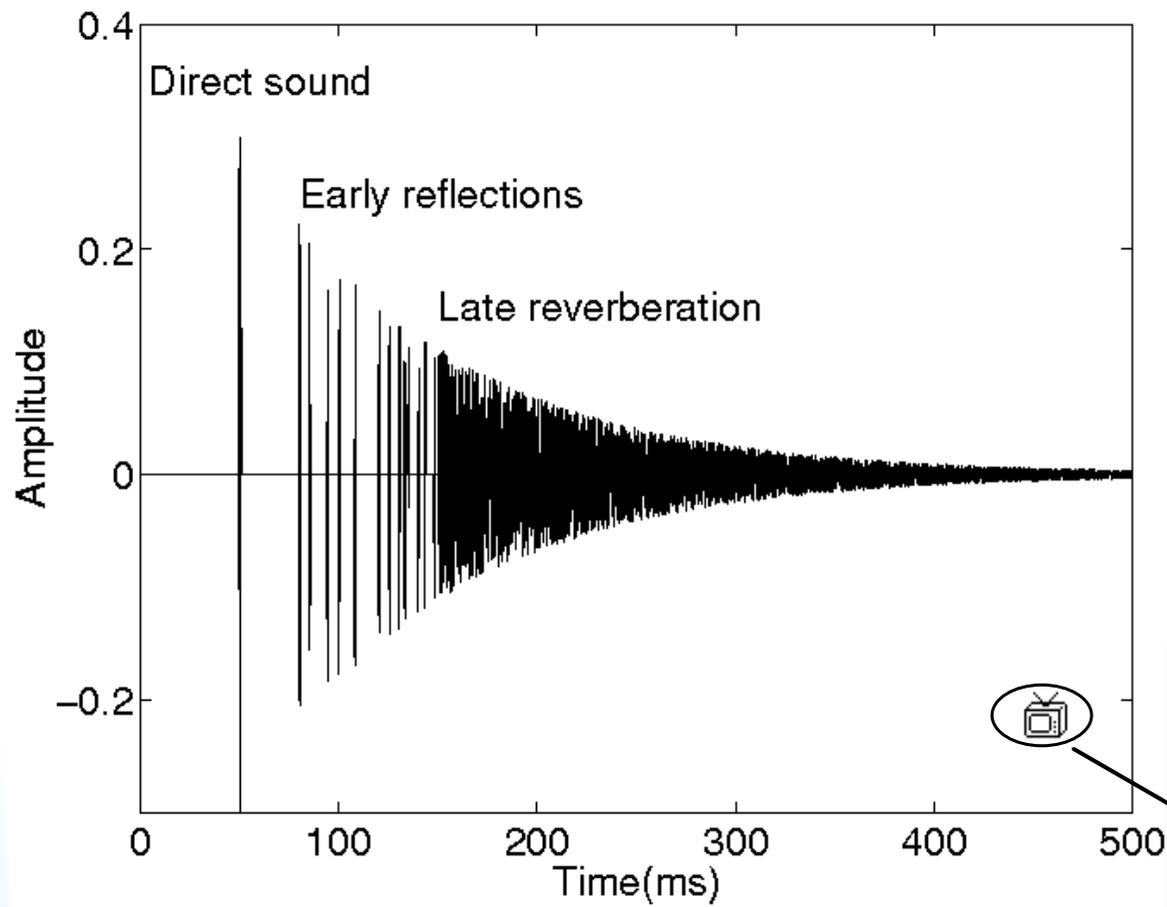
- computational model drives both animation and sound
 - bouncing balls
 - ◆ each collision initiates a sound
 - ◆ force determines amplitude
 - ◆ arbitrary sound samples
 - walls around an ambulance
 - ◆ reflected sound when the source is visible
 - ◆ direct sound disappears when the source is occluded
 - driving car
 - ◆ amplitude changes inversely to distance
 - ◆ changing delay causes Doppler effect



Background: acoustic modeling

- Collaboration with the Acoustics Lab at TKK
 - ◆ Physical modeling of musical instruments and their new interfaces (joku hyvä ALMA-kuva?)
 - ◆ Ray-based and wave-based room acoustic modeling
 - ◆ Use of new 3D sound reproduction techniques

Modeling room acoustics



Marienkirche (1998)

- concert hall designed for a renovated church in Neubrandenburg, Germany
- music recorded “dry” in a studio

video sample:

- lobby: recording as such
- hall: sound rendered to a moving camera



Concert Hall Acoustics

- Use of sensory evaluation methods in assessment of concert halls
 - ◆ Virtual loudspeaker orchestra
- Role of early reflections in concert hall acoustics
- New analysis techniques of acoustic measurements

Modeling of room acoustics

- The room acoustic rendering equation
- The acoustic radiance transfer method
- Geometry reduction of acoustic models
- Optimization of room geometry for ideal early reflections

Parallelization in audio and acoustics

- Real-time audio signal processing using GPUs
 - ◆ 2–3 orders of magnitude performance gains in certain tasks
- Real-time wave-based modeling of room acoustics

Computer graphics (3DR)

- Shadows are needed for realistic rendering
- Visibility and shadows are two sides of the same coin

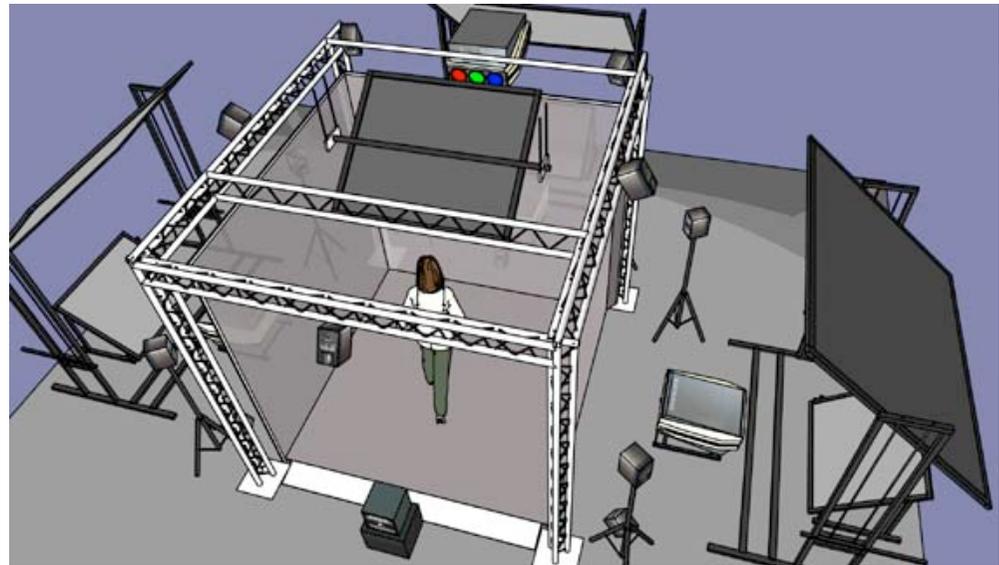


- For truly photo-realistic images global illumination is required



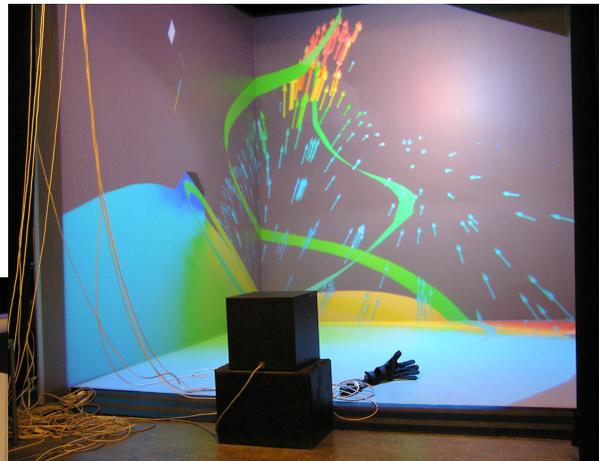
Experimental Virtual Environment EVE (1997–2007)

- CAVE-like installation
 - ◆ 3D images on three back-projected walls and the floor
 - ◆ magnetic motion tracking device
 - ◆ wand and data gloves
 - ◆ 16 loudspeakers for 3D audio
- applications
 - ◆ scientific visualization
 - ◆ architecture and building services
 - ◆ entertainment and art
 - ◆ <http://eve.hut.fi/>

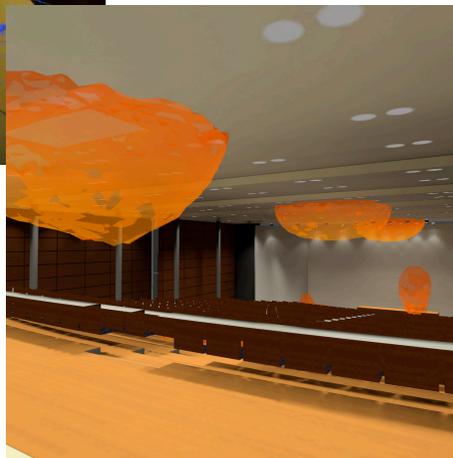
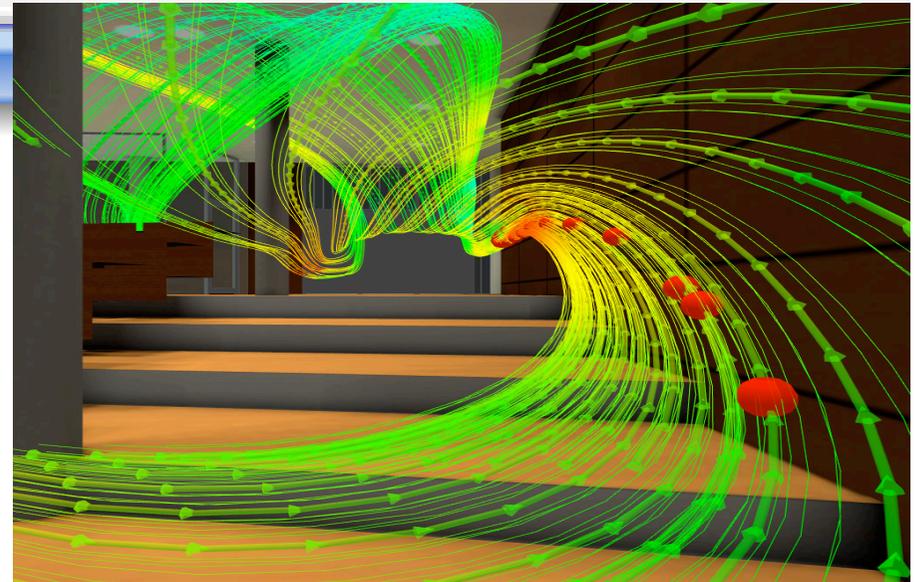
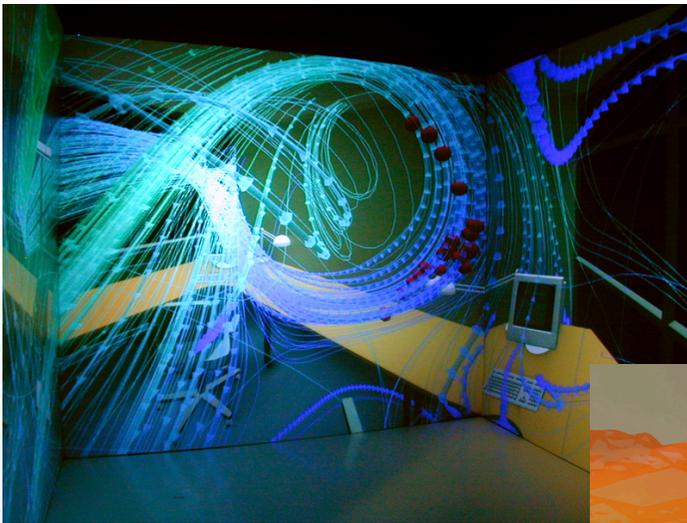


Visualization

- Scientific visualization
- Architecture visualization

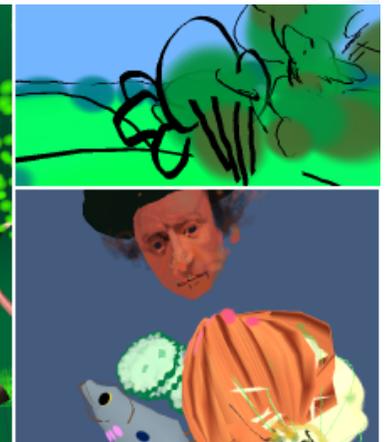
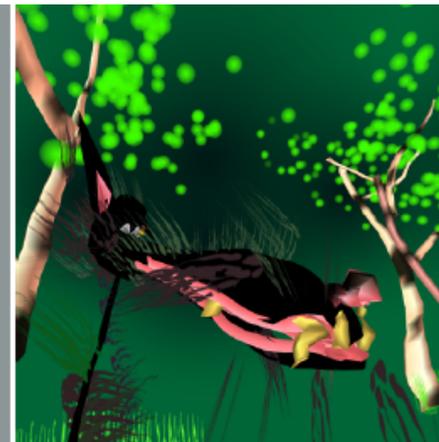
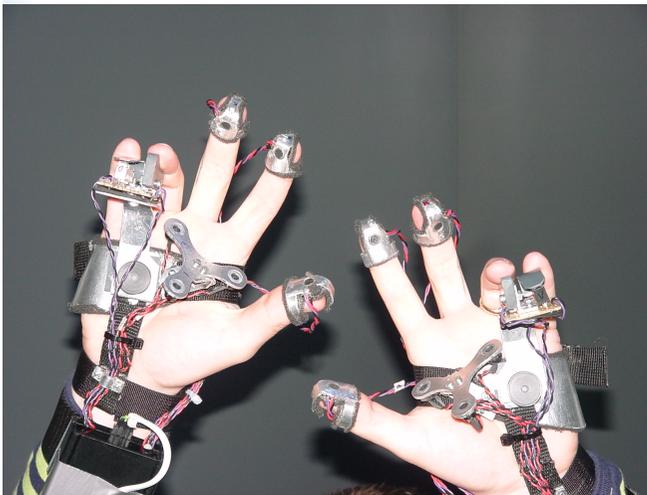


- 2000 – 2003
- New project: FoundIT (2006–)
 - ◆ Visualization of building...

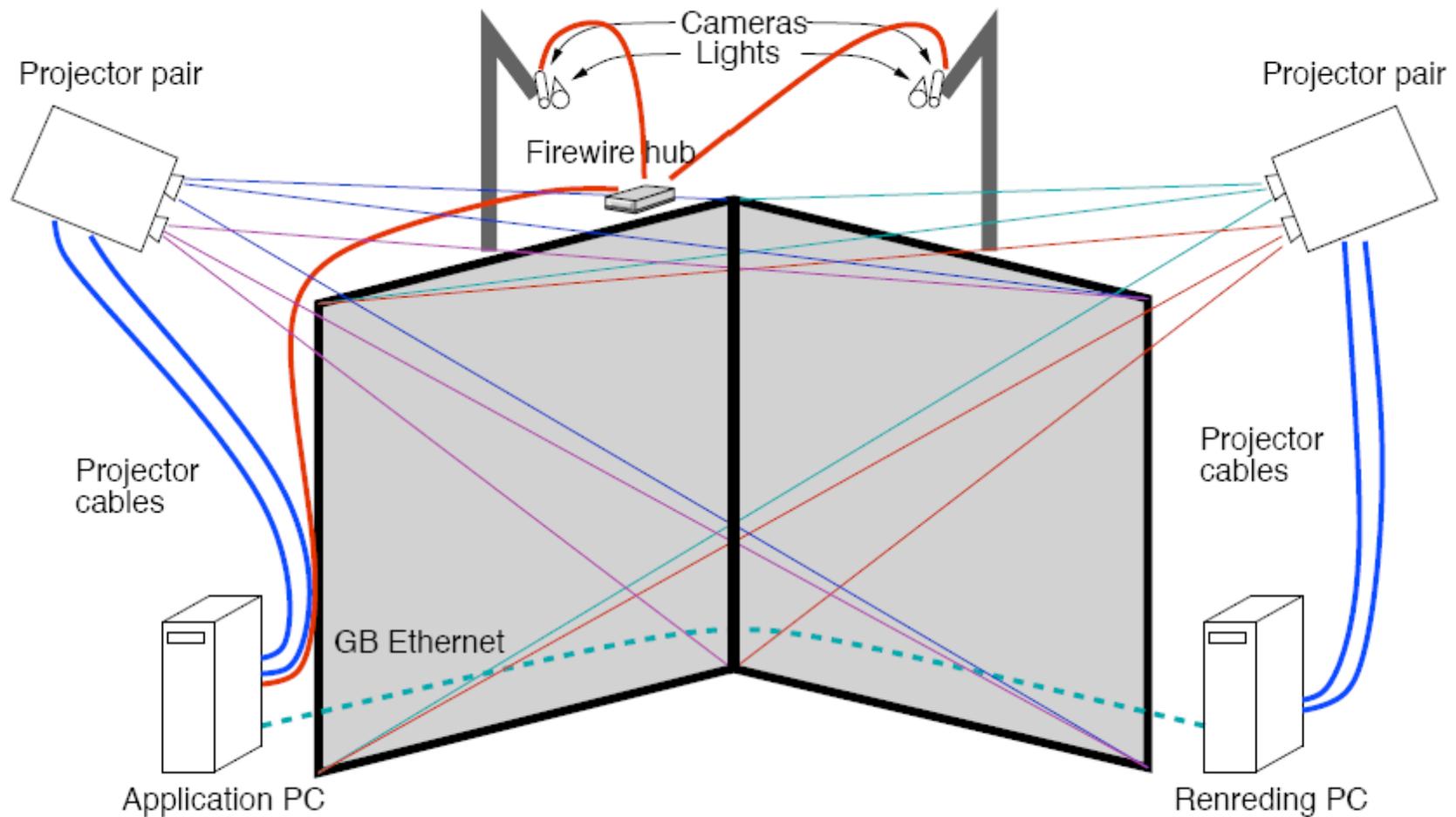


Drawing in the air

- Fine motor interaction methods for immersive free-hand expression
- a new art medium
- experiments with artists
 - ◆ exhibition at the Kiasma museum of modern art (2005)



Upponurkka: a cheap two-wall display



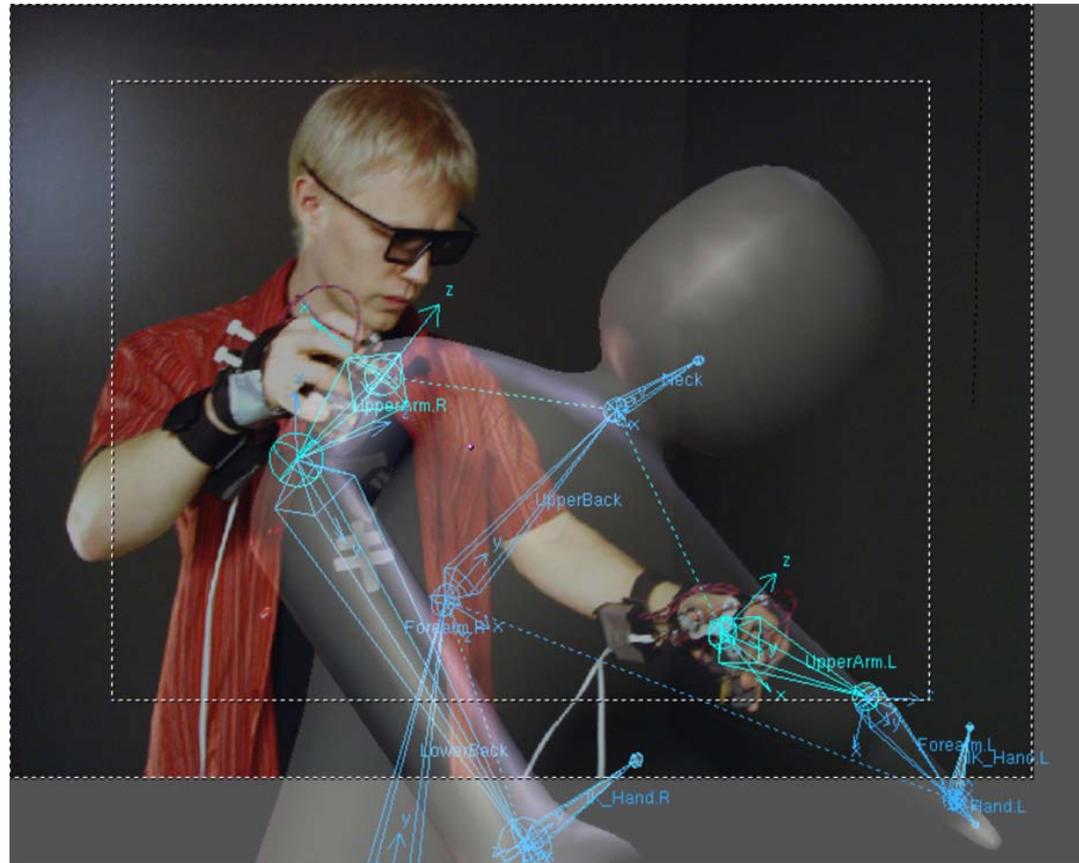
Open software platform for VR (2010–)

- RUIS (Reality-based User Interface System)
- based on Processing
 - ◆ physical modeling included
- using off-the-shelf hardware (Wiimote)



Embodied Interaction

- **HandsOn:**
connecting a CAD system with 3D immersive display and wireless hand-tracking



DIVA virtual orchestra (1997)

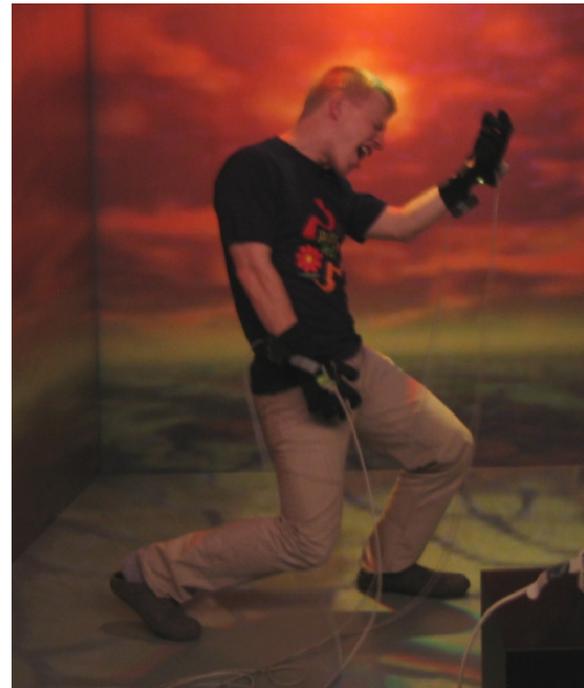
- animated musicians playing MIDI encoded music
 - ◆ automatically computed grips on the instruments
 - ◆ physically based sound synthesis



- sound reverberated according to virtual concert hall
- music conducted with a baton
 - ◆ neural networks trained to follow the motion
 - ◆ mapping from motion samples to relative timing between beats
- also recognition of conductor's emotional intent
- performance at Siggraph'97 Electric Garden
- **video sample...**

Virtual instruments

- new user interfaces for synthesized sound
- started with ALMA project (EU) 2002–2004
- more degrees of freedom than with a keyboard
- mappings to control parameters of physically based synthesis algorithms
- free configurability
 - build your instrument
- examples
 - ♦ xylophone
 - ♦ drum plate
 - ♦ virtual air guitar
 - <http://airguitar.tml.hut.fi/>
- violin modeling (2007)
 - ♦ sound model + playable interface



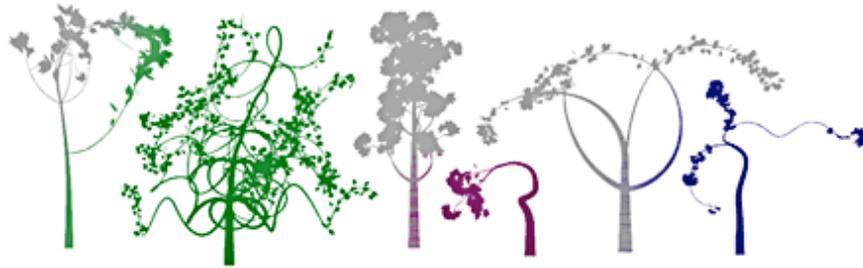
Motion-based entertainment and games

- hand gestures and sound effects
 - ♦ virtual aquarium
 - ♦ virtual snow fight
- camera based tracking of full body movements
 - ♦ games for children
 - ♦ Kick Ass Kung-Fu



Installations (student work)

- esimerkkejä taidenäyttelyistä (niitä jotka olleet myös muualla julkisesti esillä)
 - ◆ Kylä, Metsä, Elämän joki, Vangittu tanssija



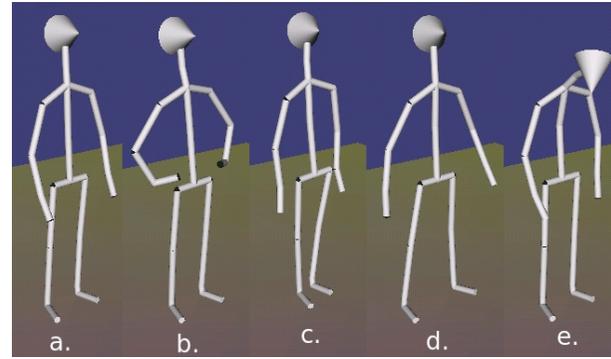
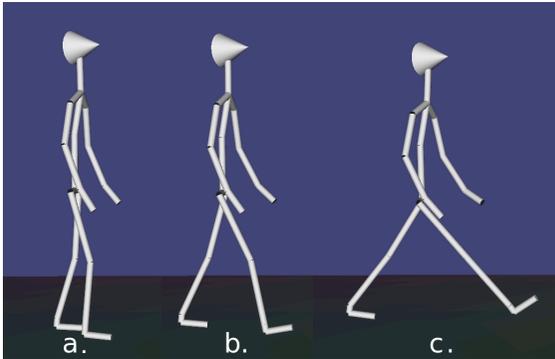
Enactive media

- emotion research (affective computing)
 - ◆ two-way communication with facial expressions
 - ◆ recording brain responses with fMRI
 - ◆ narrative development of feelings
 - ◆ eye tracking as a means of communication



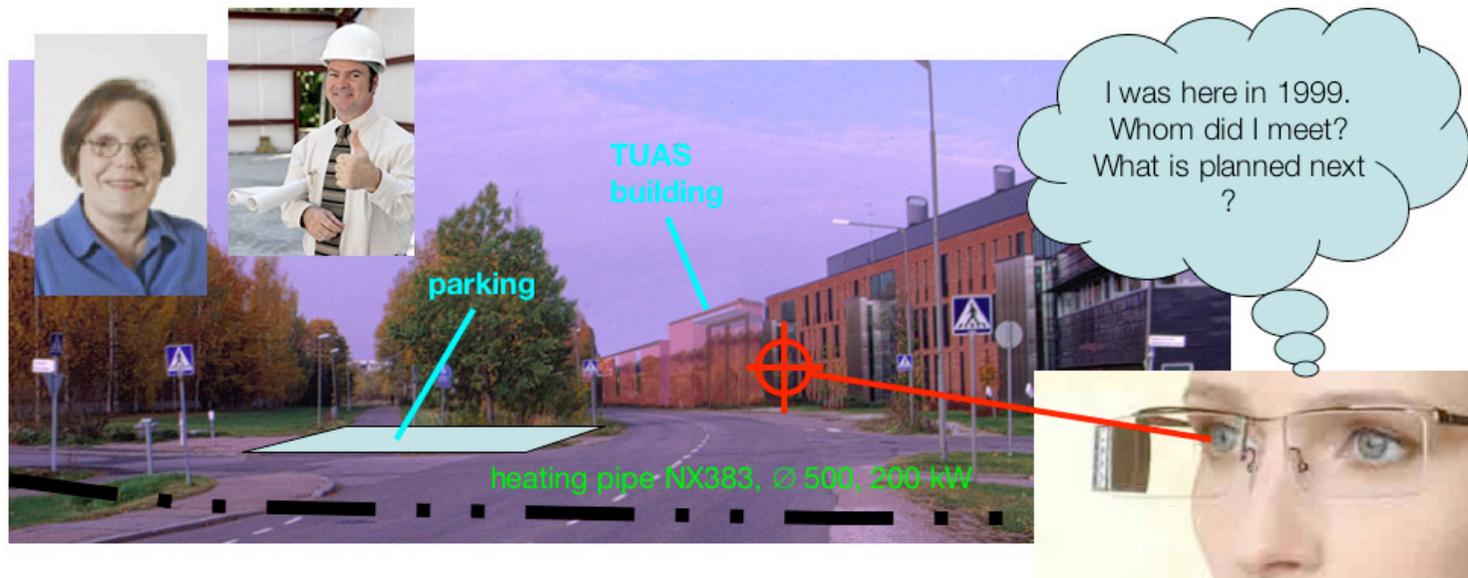
Enactive media (cont...)

- Animation and motion editing
 - ◆ modifying posture and limb motion of human characters to change emotional expression
 - ◆ CASA 2011



Augmented Reality

- **UI-ART:** visual and auditory augmented reality in urban environments
 - ◆ recognition and identification of 3D environment
 - ◆ eye tracking for detecting attention
 - ◆ associative access to public data, and personal memories

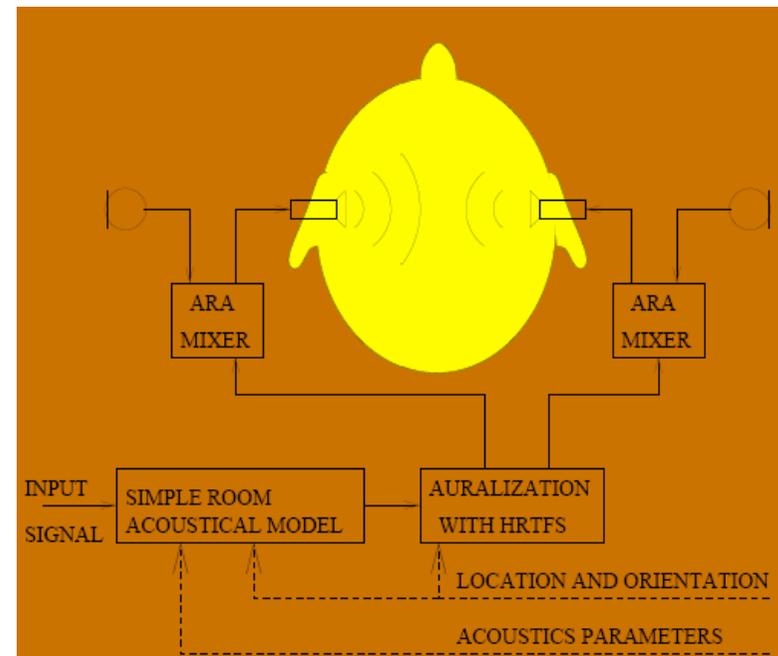


Augmented Reality (cont...)

- Markerless tracking for AR
 - ◆ ISMAR'10 tracking contest
- Sparse 3D reconstruction from images (kuvia Timolta!)

Virtual/augmented audio

- Mobile and augmented reality in audio
 - ◆ Binaural IP–telephone
 - ◆ Binaural audio networking
 - ◆ Location–based audio
 - ◆ Warnings
 - ◆ Navigation aids
 - ◆ Virtual tourist guides
 - ◆ Auditory traffic signs
 - ◆ etc.



Virtual opera (2005–2011)

- joint project with Sibelius Academy opera class students singing arias
 - ◆ digital visual and acoustic effects
- virtual 2D/3D sets in the background
 - ◆ animation partly controlled by music (MIDI piano) and singers' motion
- singing voice reverberated in 3D
 - ◆ artificial acoustics by 24 loudspeakers
- implemented using PD
 - ◆ events controlled with laptop during performance
- **productions**
 - ◆ SibaFest 2006, 2008
 - cooperation with SibA and HIIT
 - ◆ TKK anniversary opera 2009
 - ◆ next performance in 2011



What next???

- embodied interaction
 - ◆ gesture recognition technology
 - ◆ applications in games and sports
 - ◆ low cost installations
- augmented reality (AR)
 - ◆ matching virtual to real environment (position, lighting...)
 - ◆ multimodal interaction (visual, audio, gestures)
- user experience
 - ◆ joint research with psychologists, neuroscientist, and usability experts, for understanding emotions, etc.
 - ◆ applications in games and design
- growing cooperation with artists/designers
 - ◆ University of Art and Design

Thank you.
