Human in the Loop and Ubiquitous Computing: Technologies for the Virtuality Continuum and Intelligent Environments
- State of the Art, Technology Trends, Roadmaps -

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Outline

- Actual Observations
- Development, Trends, Topics
- Roadmaps
  - Technology
  - Faculties
- Conclusion
Actual Observations
Video – Virtual Oceanarium
Observation 1: 
Standard User Interface: hardly changed in 20 Years

What hasn’t / has hardly changed:

- WIMP
  - Windows
  - Icons
  - Menus
  - Pointer
- Resolution
  (today: 1280 x 1024)
Standard User Interface...

... is a technology for a human with
- one eye
- one ear
- without mouth
- without body
- one hand
- one finger
The Complexity is Increasing ...

- Amount of available data
- Information worlds
- Networked systems
- Simulations
- Presentation methods
- ...

Human in the Loop and Ubiquitous Computing ...
Moore’s Law ...

Twice the Performance every 18 Month

What does that really mean:

- Computers in the future are
  - faster
  - more powerful
  - cheaper
  
as in the past
But ...

... the Capacity of the Human Brain is Constant!
Key Elements for further Development

- Mobility
- Ubiquity
- Multimodality
Mobility

User Support

- Everywhere
- Anytime
- For every task!
Ubiquity

Computer

- Everywhere
- Anytime
- For everyone!
Multimodality

We remember

- 10% of what we read
- 20% of what we hear
- 30% of what we see
- 50% of what we hear and see
- 70% of what we say
- 90% of what we do
Multimodality

Data types

- Text
- Image (static, dynamic)
- Video
- Music

Requirement

- Multimodal navigation and/or to experiment in computer generated worlds
Development, Trends, Topics
Today

Computer graphics is today

- Visualization
- Interaction with visual information
- Visual communication over networks

... where is the expected quantum leap?
The Evolution

- Leave the „desktop“
- Millions of users
- Web-based „visual“ services
- 2D und 3D „for all“
- Interactive video technology
- Interactive broadcasting
The Revolution needs a quantum leap

- "Rendering" for other senses has to be developed and consistently integrated into the "Rendering-Pipeline"

- Integration of our biological system with computers and other communication systems

- The man-machine interface becomes "fuzzy"

- Paradigm shift
  - Virtuality-Continuum
  - Human-Centered Computing and Interaction
  - Mobility and Ubiquity
Invitation to a concerted action:

- Ensure the progress of the evolution and be part of the leading groups
- Be prepared for a „non predictable Revolution“
Roadmaps
Human in the Loop and Ubiquitous Computing ...

Roadmaps

Applications

Technologies; Methods; Techniques; (R&D-Topics)

Faculties
Technology Roadmap

2001 / 2002

What are the topics we are working on today?
What are the „hot topics“ at the moment?

2003 / 2004

Which trends do we expect and should be funded?

2005 / 2006

Where do we want to go?
What are the visions?

R&D-Topics

2001 / 2002
- Tracking
- Interactive Broadcasting
- VR / AR
- Multimodal Interaction
- Mobility
- Agents
- Avatars
- Knowledge- “Mining” and - Visualization

2003 / 2004

2005 / 2006
What is Interactive Broadcasting?

It is more than

- Video Streaming and transmission channels
- Interactive television

It combines

- Contents, services, transmission channels
- Applications for different application scenarios

and supports the activity of the user.
Research- and Development Topics

Integration of broadcast content into online services

- Which content types – besides TV – are suitable?

Presentation of the content on different output devices

- A TV set is not a computer monitor!
- Mobile vs. stationary output devices

Which applications can be used in different context?

- When will the user be about to use the offered services (at home, in the office, during travel, ...)

[Logos]
Multimodal Interaction

- Gesture- and speech recognition
- Haptic Displays

New interaction metaphors

- Digital Assistants
- Avatar
Video – Avatar Programming
Avatar

Physical Avatar-Interface

➢ Fun / Attention

➢ Avatar will be controlled by internet users and visitors

➢ New forms of communication

➢ Design and usability
Video – Telebuddy
Mobility
Mobility

Wearable Computer

- Features
  - Wearable during the work
  - Hands remain free
- May include sensors
  - Registration of the physical environment
- Autonomous actions
  - e.g. may inform the user about incoming informations
- Operational all the time (24/7)
Tracking

Coarse tracking:
- Active badges, GPS

Precise tracking:
- Magnetic
- Ultrasound
- Mechanic
- Inertial
- Optic
- Laser

Trend: Combination
- Hybrid Tracking
Geographic Information System
Presentation of Traffic Routes – „Yesterday“
Presentation of Traffic Routes – „Today“ - Monomodal
Intermodal Personal Mobility Assistant

- „Knows“ (spatial) goals
- Usable in different locations
  - car, public transport, plane, ...
- Offers informative description of directions
- „Knows“ attractions in the area
- Is able to make online reservations in nearby hotels
Knowledge-“Mining” and -Visualization
Knowledge-“Mining” and -Visualization

- Visualization of data and structures
  - Show correlations (Infospaces)
  - New media (e.g. 3D-Models)
- Analysis techniques
  - Text correlations, image analysis
  - Topic-Map
  - (Automatic) metadata creation
Virtual Reality (VR)

Third Generation is in sight

- 3D graphic systems in PCs (also at home)
- Vivid attractive, virtual worlds
- Interactive knowledge imparting (history, nature, science, ...)
- Distributed virtual worlds (VR videoconferencing)
Video – Cathedral of Siena
Augmented Reality (AR)

- First real world applications available (ARVIKA)
- Registration of on-line data (especially for medical applications)
- Concepts for interaction with real and virtual objects
- “Breakthrough” relies on the next hardware generation (mobile computers and cell phones), which will be equipped with cameras
Technology Roadmap

R&D-Topics

2005 / 2006

Sensors; Feedback

Scalable Tracking

„Tangible“ Information

Digital Story Telling

2003 / 2004

Knowledge management in broadcasting applications

Mixed Reality (MR)

Task Modeling

2001 / 2002

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Knowledge management in broadcasting applications

- Automatic video hyperlinks

- New forms of interaction

  "Off-Screen Hyperlinking"
Broadcasting Applications

Presentation of **Product Information**

- Server
  - X,Y-coordinates, frame, profileID, movie name
  - Additional information, web page

- Client
  - Product Information

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Broadcasting Applications

Authoring tools

- **Object definition**
- **Automatic tracking using key-frames**
Video – Interactive Broadcasting
Definition Mixed Reality (MR)

_Virtuality continuum_ (Paul Milgram)

Several classes of existing hybrid display environments can be found, which could reasonably be considered to constitute MR interfaces according to the ‘virtuality continuum’
Mixed Reality (MR)

Different aspects for the distinction between Reality and Virtuality:

- Real vs. virtual objects
- Direct vs. Indirect viewing
- Real vs. virtual images
Mixed Reality Applications: Production, maintenance, ...

Supporting

- Development
- Production
- Training
- Service

by superposition of 3D instructions
Mixed Reality Applications: Medicine

- Education and training
- Support for minimal invasive surgery
- Operation scheduling
Mixed Reality Applications: Guidance and Information Systems

Main Tasks

- Navigation
- Information imparting
Mixed Reality Applications: Entertainment

- Multiplayer Entertainment in Mixed Reality Environments

- Users interact „directly“ with the avatar
Personal Ubiquitous Assistance

Task Modeling

➢ For personal ubiquitous assistance

Sensors

➢ Registration of the physical environment
➢ Feedback in „online“ mode
Personal Ubiquitous Assistance

Facts about everyday life:

- **Complex** spatial and temporally widespread tasks/activities (e.g. maintenance)
- **Diverse** parallel activities
- **Frequent context switches** from one task to another

What is the right way to support the user here?
Personal Ubiquitous Assistance

Necessary Technologies

- **Situation and event tracing** (sensor technology)
- **Task models** (description of tasks)
- **Prediction methods** (determination of action alternatives)
- **Presentation and interaction mechanisms** for „synchronisation“
Task Modeling

Personal Assistance

Everyday Life
- requires
  \- Complex task management
    \- requires
      \- Selection of suitable action alternatives

Ultra portable mobile computer
- enables
  \- Availability in "all" situations
    \- requirement for
      \- Usage of situation knowledge for prediction

Sensor technology
- enables
  \- Situation awareness
    \- requirement for
      \- Task model
Digital Storytelling (1)

Integration of multimedia “fragments”

- Computer graphics: images, animations, 3D worlds
- Real recording: photo, video
- Syntheses and recording of: music, spoken text, noise
- Multimodal user centered interaction
- Immersive or mobile environment
- Network based presentation and cooperation

to a comprehensive experience
Digital Storytelling (2)

Interdisciplinary teamwork

➢ Writing as programming

➢ High-Level-API for "Non-Programmers"
Video – Gari’s Game
Digital Storytelling
System view
GEIST

Experience a historic context in an urban environment by using a mobile AR information system and digital storytelling

Mobile Augmented Reality
- Historic information for pedestrians
- Application for Tourism and Training

Research topics
- Video based, mobile tracking system using wearable computers
- Historic knowledge database
- Automatic, animated presentation through interactive story engine
Interactive Storytelling within the GEIST Project

Magic Equipment:

- Interface is part of the story!
- Seemless integration with AR sensors: ghosts “show up”
- User is protagonist of the story

R&D-Topics

2005 / 2006

“Intelligent” Environments  
“Perceptual” Computing

Human in the Loop  
Virtuality Continuum  
UMTS

2003 / 2004

2001 / 2002

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Human in the Loop

Alternative platforms (embedded processors, smart cards, etc.)

Interactive Appliances

Multimedia Workspace

Interactive Internet

Broadcasting and Networking

New Interaction paradigms

Human in the Loop and Ubiquitous Computing...
Human in the Loop and Ubiquitous Computing...

**Virtuality Continuum (VC)**

Applications

- App-1
- App-2
- ...
- App-n

Application Programming Interface (new API's)

- VR
- VK
- AR

Product definition → Design → Analyses → Production planning → Production → Operation → Maintenance → Recycling

Mixed Reality Driver

I → O → I/O

New I/O-Devices (incl. Sensors, Tracking, etc.)

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UMTS
UMTS (Universal Mobile Telecommunications System)

- Users are „24 hours“ online
- Using UMTS we will use only one universal device for several applications
  - Video over the internet
  - Download of software, video and music
  - Infotainment
  - etc.
- Research topic
  - „WAP (Wireless Application Protocol) for graphical objects“
WAP for Graphical Objects

- Platform independent transmission of complex, dynamic 3D graphics
- Availability on "arbitrary" output devices
- Dynamic adaptation of the data based on the available network capacity will make the distinction between stationary and mobile devices obsolete
WAP for Graphical Objects

- Progressive transmission of 3D data between different devices
- Integration of mobile devices through WAP
- Animation and interaction on distributed systems
„Intelligent“ Environment

Goal Oriented Interaction

- User will define goals and will no longer use commands to control the computer
- Challenge
  - The system has to organize the collaboration of the available devices by itself
  - The system has to „understand“ the goals of the user within the multimodal interaction of the user
  - The user has to spot the potential of the environment
- No general problem solver possible
  - The system needs „location und situation awareness“, in order to reduce the users target area
Perceptual Computing

- Recognition and consideration of the user emotions
- Recognition and consideration of physical reactions
- Context-“Awareness”
- Address new users (elderly and handicapped persons) through „ability-awareness“
Video – Baby
Roadmap

Faculties
Roadmap Faculties (2)

2007 / 2009

2004 / 2006

Human-Centered Multimodal Interfaces

Knowledge Engineering, Mining and Visualization

Video Technology and Interactive Broadcasting

2001 / 2003
Roadmap Faculties (3)

- **2001 / 2003**
  - Perceptual Computing
  - Situation and Task Awareness Computing

- **2004 / 2006**
  - Usability Engineering

- **2007 / 2009**
  - Perceptual Computing
  - Situation and Task Awareness Computing

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Roadmaps of New Faculties
Roadmap: Usability Engineering

2001 / 2003
- Task Models
- Interactive Task Modeling
- Qualitative usability tests
- Usability Frameworks
- User modeling
- New Usability Methods
- User behavior tracking
- Eye tracking
- Human related sensors
- Speech Analysis
- Quantity based analysis
- Affective Computing
- Knowledge-based Usability Engineering

2004 / 2006
- Interactive Task Modeling
- Qualitative usability tests
- Usability Frameworks
- User modeling
- New Usability Methods
- User behavior tracking
- Eye tracking
- Human related sensors
- Speech Analysis
- Quantity based analysis
- Affective Computing
- Knowledge-based Usability Engineering

2007 / 2009
- Interactive Task Modeling
- Qualitative usability tests
- Usability Frameworks
- User modeling
- New Usability Methods
- User behavior tracking
- Eye tracking
- Human related sensors
- Speech Analysis
- Quantity based analysis
- Affective Computing
- Knowledge-based Usability Engineering
Roadmap: Situation and Task Awareness Computing

2001 / 2003

Mobile Multimedia

Environment Sensors

Mobile Interaction

Interactive Task Mgmt

Situation Models

User Modeling

2004 / 2006

Monitoring Architectures

Mobile Assistant Architectures

Situation Inference

Situation and Task Aware Assistance

2007 / 2009
Conclusion
Conclusion

➢ Ensure the progress of the evolution

➢ Be prepared for a „non predictable revolution“

➢ Personal view from José L. Encarnação
Human in the Loop and Ubiquitous Computing...

**Technology Roadmap**

2001 / 2002

- Interactive Broadcasting
- Tracking
- Sensors; Feedback
- Knowledge-management in Broadcast Applications

2003 / 2004

- VR / AR
- Scalable Tracking
- Mixed Realities (MR)

2005 / 2006

- Mobility
- Agents
- Avatars
- UMTS
- Human in the Loop
- "Intelligent" Environments
- "Perceptual" Computing
- "Tangible" Information
- "Knowledge" "Mining" u. - Visualization

"Virtuality Continuum"

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Applications (Markets)

New Application Areas

➢ Multimodal, multimedia networked Service Engineering and Providing (MM-ASP)

➢ Appliance Techniques; Mobility Computing

➢ eLearning; Life-long Learning

➢ Visualization, Simulation und Modeling in den Life-Sciences
Roadmap Applications

2001 / 2003
- Telecommunication, Networking and Services
- Mobile Information Systems
- Education & Training

2004 / 2006
- Art and Cultural Heritage
- New Media Online and Broadcasting Services
- Edutainment
- IT-Security; Engineering and Systems

2007 / 2009
- Multimodal, multimedia networked Service Engineering and Providing (MM-ASP)
- eLearning; Life-long Learning
- Visualization, Simulation and Modelling in the Life-Sciences
- Computer Aided Engineering

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Roadmap Faculties

2007 / 2009
- Usability Engineering
- Perceptual Computing
- Situation and Task Awareness Computing

2004 / 2006
- Human-Centered Multimodal Interfaces
- Knowledge Engineering, Mining and Visualization
- Video Technology and Interactive Broadcasting

2001 / 2003
- Faculties - Today
Key Technologies for the Future of the Information and Communication Technology

- Digital representations and the real environment are growing together (virtuality continuum)
- Levels of abstraction are becoming more flexible (ubiquity; mobility)
- Perception and interaction with digital representations lead to new requirements (human in the Loop)
Vision (1)

Visualization in the future stands for:

- Eliminate existing weak spots
  - High quality visualization for everyone, anytime, everywhere
  - Provide more than a tool

- Innovative human-computer-interface
  - Leave the „desktop metaphor”

- Human centered
Vision (2)

➢ "Rendering" for other senses has to be developed and consistently integrated into the "Rendering-Pipeline"

➢ Integration of our "biological system" with computers and other communication systems

➢ Self-controlled visualization

➢ Establish standards
Goals and Objectives

„When setting goals, it’s important to be realistic. But we have to go beyond that if we want to accomplish anything. We have to aim at advanced and achievable goals and objectives that result from an evolutionary approach, but opens opportunities to follow an unexpected revolution“
Video – ACM SIGGRAPH
... and finally my personal vision:

Cybernarium
Cybernarium: the Idea ...

Using VR and AR we have a technology

- With an enormous didactic potential
- That makes a new experience possible
- Transfer know-how in a new and attractive way
- That has to be presented to a broad audience
- That allows the user to be immersed in virtual worlds
- That offers fun, attraction and learning
Cybernarium: a VR technology park

Cybernarium:
- “not another” multimedia oder science park
- “Exploratorium” for VR and AR technologies
- Accessible for the public
- Will transfer contents about culture, history, space, biology etc. through attractive and often changing exhibits and the opportunity to “experience” the information

www.cybernarium.de
Cybernarium: the Concept ...

- Museum part: simulators (e.g. flight simulator) and technology
- Experience part with high-end installations (CAVE, projections)
- “Cyberdome” with changing presentations
- VR service company
- Budget for several extraordinary new exhibits per year
Cybernarium Days 2002

- First public presentation of the idea in Darmstadt
  - 15 exhibits; 6 days opened
  - We hoped for 6000 visitors
- The Reality
  - 10,000(!) visitors
  - Waiting time up to 3 hours
  - Overall positive feedback
Our Goal

Official Opening in Summer 2004!
Thank you for your attention!