Virtual and Augmented Reality for Edutainment

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Definition of Virtual and Augmented Reality

Definition of Virtual Reality

- Realtime rendering
- Interaction
- Immersion
- Mixing real and virtual images
What is Edutainment

Education
- Learning
- Training
- Knowledge

Entertainment
- Fun
- Games
- Storytelling
Movies & Games

Movies:

• No interaction

• Less immersive

Games:

• Less immersive

• Mostly standard input devices
Why should we use VR/AR for Edutainment?

New forms of teaching:

- Learning by experience
- Learning by doing
- ...

Problem

- The learning matter has to be experiencable
Why should we use VR/AR for Edutainment?

Virtual and Augmented Reality offer:

• Flexibility

• Direct experience

• Interactivity

• Interesting technology
Trends in learning and public education

Education as a recreational activity

- At Museums and science centers
- On vacations and study trips

Learning becomes more informal

Popular science programs top television ratings of pure entertainment formats in German TV

Understanding of science as an entertaining experience
Attractiveness of VR and AR

A lot of variations of the technology:
- Degree of immersion in the virtual world
- Interactivity
- Mobility
- Dynamic of the virtual world

A lot of different needs:
- Preservation and digital documentation of cultural sites
- Presentation worldwide
- Presentation on-site of disappeared constructions
- Exploiting the didactical potential of 3D graphics
Attractiveness of VR and AR

People are very interested in the technology
cybernarium days:

- Waiting time up to 4 hours
- All ages

<table>
<thead>
<tr>
<th>Age Group</th>
<th>%</th>
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<tbody>
<tr>
<td>Up to 15</td>
<td>5.6</td>
</tr>
<tr>
<td>16 – 25</td>
<td>41.2</td>
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<tr>
<td>26 – 35</td>
<td>22.0</td>
</tr>
<tr>
<td>36 – 45</td>
<td>7.9</td>
</tr>
<tr>
<td>46 – 55</td>
<td>9.0</td>
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Types of virtual learning environments

Training environments

- flight simulators
- driving simulators

Explorative worlds

- Virtual Cathedral of Siena

Experimental worlds

- Virtual Universe

Constructive worlds

- Virtual Gorilla Exhibit project
- ALICE
Learning Environments!

- Explore and interact with complex data and processes
Learning Environments!

- Be a hitchhiker to the virtual galaxy
- Get a better understanding of debris in space
Learning Environments!

- Be a virtual diver in a fascinating underwater world
Where to present it?

- Schools
- Universities
- Training centers
- Exhibitions
- Museums
How to do it

Creation of the presentation

• Preparation phase

• Models, textures, lighting, etc.

• Authoring

• Interaction

• Presentation
How to do it: Preparation phase

Data acquisition

- Background information
- Storyboard
- Plans, pictures, etc. of objects needed

Preparation

- Definition of Soft- and Hardware
- Definition of workflow
How to do it: Modelling

Hardware

• Scanner

Software:

• CAD Software
• Modelling tools
• Animation software
• Photogrammetry
• Converter
• ...
How to do it: Modelling

Problems:

• Polygonal models
  - Polygon count
• Special effects
  - Reflections
  - Shadows
• Data structures
  - Converters
  - Simulations
How to do it: Textures

Textures:

• Add realism
• Presentation of surfaces
• Reduce polygon count
• Animation
How to do it: Textures

Bitmap textures:

- Image sources:
  - Photographs
  - Scans of surfaces
  - Computer generated images
How to do it: Textures

Image processing steps:

- Perspective correction
- Cropping
- Colour correction
- Removal of disturbing objects

Hardware bottlenecks:

- Texture size should be a power of two (e.g. 1024x512, 128x512 pixels)
- Maximal textur esize (1024x1024 or 2048x2048)
- Limited texture memory
How to do it: Textures

Shaders:

- Algorithmic images
- Supported by the GPU
- Unlimited resolution
- Special effects
How to do it: Authoring

Scene composition / configuration

• Composition of complex scenes
• I/O devices
• Level-of-Detail
• Camera

Setup of dynamic components

• Interaction between objects
• scripts
How to do it: Authoring

**flow control system:**

- Controls the reactions of the system
  - Navigation
  - User interaction
  - Changes of system state

- Controls the learning process

**Depends on:**

- VR/AR system used
- Type of learning environment
- Learning matter
- etc.
How to do it: Authoring

Flow control system

• Navigation control

• Finite state machine

• ...

• Complex simulation system

• Learning management systems
Interaction

Interaction devices

• Intuitive use

• Robust

• Usability

Interaction

• Navigation with 6 degrees of freedom

• Interaction with the world

• Shouldn’t distract from the learning matter
Input devices

Classification of input devices

- Desktop device
- VR input devices
- Special devices
**Input devices**

**Classification of input devices**

- Desktop device
- VR input devices
- Special devices
Input devices

Classification of input devices

- Desktop device
- VR input devices
- Special devices

Advantages:

- Specialised for VR

Disadvantages:

- Expensive
- Problems with sizes (children)
Input devices

Classification of input devices

• Desktop device
• VR input devices
• Special devices

Advantages:

• Intuitive to use

Disadvantages:

• No standard
• Made for one purpose
Input devices

Desktop devices
(e.g. mouse, keyboard, joystick)

Advantages:

• Cheap
• Well-known

Disadvantages:

• No standard
• Not intuitive to use
Input devices

VR input devices
(e.g. spacemouse, data-glove, wand)

Advantages:

- Optimized for the use in VR
- 6D input

Disadvantages:

- Expensive
- Difficult to use
- Not for children
**Input devices**

**Special devices**  
(e.g. steering wheel, flashlight)

**Advantages:**

- Optimized for the application  
- Intuitive to use

**Disadvantages:**

- Sometimes expensive  
- Only usable for special applications  
- Only usable for a special task
Presentation

Virtual Reality:

• Projection based

  ♦ Computer-Monitor
  ♦ Largescreen Display
  ♦ CAVE
  ♦ HEyeWall

• Head-mounted Systems

  ♦ HMD
  ♦ BOOM

Zur Anzeige wird der QuickTime Dekompressor für IFF (Unkomprimiert) benötigt.
Presentation

Augmented Reality:

• See-through devices
  - See-through glasses
• Video-see-through
  - Video glasses
  - AR-Telescope

Zur Anzeige wird der QuickTime Dekompressor IFF (Unkomprimiert) benötigt.
Dunhuang Art Caves

• Virtual representation of the Mogao CAVES
  - 500 caves in the north of China
  - Only 30 are still open to the public

• Digital documentation of the site

• Preservation of vulnerable cultural assets

• Presentation to a large public
  - The virtual visit becomes a real experience
  - Appeal to the visitor emotions
Dunhuang Art Caves: Immersion

Not only watch but experience history
Dunhuang Art Caves

Involve the visitor by

- Finding the right interface
  - Flash light as input interaction device
  - Correct lighting and shadows
- 3D Sounds
  - Audio text information
  - Music
- “Exploring the caves”, “Being in China”
Video: Dunhuang Art Cave
Cathedral of Siena

- Challenge of content creation and complexity of the content creation
- Huge construction with a lot of details
- High realism is necessary to ensure the acceptance of the digital model
- Fidelity to the real building and real context must be respected
Cathedral of Siena

The „Making of“

- 5000 images
- 4 hours video-tape
- plans – books

- Modeling tools
- Constant update among the designers
Cathedral of Siena

Applying high resolution textures (300 MB)
Cathedral of Siena

High realism through physically correct light simulation

- 150,000 polygons
- 800 light sources
- Day light simulation

- Hierarchical light simulation to handle the model complexity
Cathedral of Siena: light simulation

Without light simulation

With light simulation
Cathedral of Siena: the user interface

Interface for large publics and groups presentation

• Touchscreen
• Metaphor of a historical book
• Intuitive navigation
• Realization over a web-based client/server architecture
Cathedral of Siena: virtual guide
Video: Cathedral of Siena
Zur Anzeige wird der QuickTime Dekompressor ⬩ UV420 codec ⬩ ⬩ ⬩.
Reliving destroyed sites (Bad Hersfeld)

- Virtual reconstruction of the church
- Presentation the evolution and history over time
- Museum presentation as well as creation of a video for visitors
Church Bad Hersfeld

Interior of the Church
Church „Bad Hersfeld“

Travel in time and space

- From the present, back to past
- From real to virtual
Church Bad Hersfeld

Switching between real and virtual for a better understanding of the historical evolution
Video: Church Bad Hersfeld
Presentation of historical ceremonies

- An animation presents the funeral ceremony
- Valorization of the site through supplementary information
- Implementation: projection on the floor
- Feeling to look into the grave
Presentation of historical ceremonies

Representation of the grave objects

- At the right place
- In 3D
- With zoom of details
Igartubeiti Farmhouse

- Virtual reconstruction of 16\textsuperscript{th} and 17\textsuperscript{th} century wooden architecture
- Scalable presentation from web to high immersive projection screen
Igartubeiti Farmhouse

- Bringing the building to life with virtual humans
- Telling the history using digital storytelling techniques
Peranakan Culture

- Promotion of Singapore’s unique heritage
Peranakan Culture

- Virtual Tour Guide

<table>
<thead>
<tr>
<th>Base</th>
<th>Blink</th>
<th>Smile</th>
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</thead>
<tbody>
<tr>
<td>Walk</td>
<td>Climb Up Stairs</td>
<td>Turn Right</td>
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Peranakan Culture

- Interaction with context-sensitive cursors, on-screen menus, and the virtual tour guide
The Interactive Museum Exhibit

Idea

• to confront the museum visitor with interactive exhibits

• to provide informal learning through interactive exploration

• to overcome the „do-not-touch“ caution

• to offer an interactive environment to complementarily present art works „in stock“
The Interactive Museum Exhibit

Requirements

• "... novel combination of intuitive interaction techniques and the presentation of multimedia content ..."

• "... digitized paintings on projection screens ..."

• "... novel experience during an exhibition visit ..."

• "... invisible computer ..."

• "... no special physical device like a mouse or pointer shall be needed to interact with a system ..."
The Interactive Museum Exhibit

Scenario

➤ museum exhibit installation
➤ as intuitive as possible => usable without training
➤ pointing gesture based interaction

➤ large scale screen
➤ video-based interaction

➤ 2d digitized paintings
➤ 3d VRML sculptures
The Interactive Museum Exhibit

Pointing at predefined areas

Selection of

- images
- artists
- thematic areas
- help buttons
- interaction tools
The Interactive Museum Exhibit

- laser pointer

- magnifying glass

- torch light
The Interactive Museum Exhibit

Magnifying Glass
The Interactive Museum Exhibit

Torch Light
Video: Interactive Museum Exhibit
Interactive Museum Exhibit
ZGDV
The Virtual Gallery Exhibit

Idea

- to offer museum visitors a personalized exhibition

- to combine a virtual exhibition in a real setting

- to offer an interactive environment to complementarily present art works “in stock” first evaluation results
The Virtual Gallery Exhibit

Requirements

• “... novel combination of innovative visualisation techniques and the presentation of multimedia content ...”

• “... digitized paintings in real picture frames...”

• “... novel experience during an exhibition visit ...”

• “... intuitive interaction similar to a traditional visit of an exhibition ...”
The Virtual Gallery Exhibit

Scenario

➢ virtual gallery exhibition
➢ personalised exhibition
➢ look and feel similar to real exhibition
➢ as intuitive as possible
➢ combining virtual world and real setting
➢ takes place in a real exhibition room
➢ provision of additional information
The Virtual Gallery Exhibit

Scenario

- visitor moves from one frame to the other
- detection of location is based on hidden features
- superimposition of images into the frames
- location aware audible explanations
The Virtual Gallery Exhibit

program logic

camera view

detected feature

visitor view
Virtual Graffiti

• Getting famous – legally
Video: Virtual Graffiti
Mixing Real and Virtual Objects
„Virtual Showcase“

Enrich real objects with virtual information with help of the „Virtual Showcase“

• small objects are magnified on monitors
• Missing parts are added virtually
**Stereo „Virtual Show Case“**

- Projection-Based Augmented Reality
- Allows interactive presentation of a mixed content
- Supports multiple users
- Stereoscopic (3D) viewing
- Realistic combination of virtual and real objects
  - high resolution graphics
  - matching illumination
  - correct occlusion
  - matching depth perception
  - animations
Packing and Presentation

muscle

registration and calibration

muscles, sinus, bony ring

skin
Video: Raptor
RAPTOR: Towards Augmented Paleontology

Oliver Bimber and Miguel Encarnação
Fraunhofer Center for Research in Computer Graphics, Providence (RI), USA, {obimber,me}@crcg.edu

SIGGRAPH 2002
ICAT 2004

Ferrum Exhibition

- Virtual showcase in Ferrum Exhibition
- Virtual reconstruction of damaged or non-existent parts of artworks that cannot be shown otherwise
Mobile Travelling in Time & Space
ArcheoGUIDE - Vision (Olympia)

Resurrect the past...

... with the help of modern AR technology
Text

Sound

Mixed-Reality Views
PDA Approach

- The right information at the right time and at the right place through:
  - location-based information selection
  - Personalization of the presentation through profiling of the visitor (expert, interested, ...)
- Use of augmented reality images to enrich view of the surrounding
  - Better understanding
  - Making the most of the visit
ArcheoGUIDE – Screenshots

Philippeion

Zeus

Heraion

ICAT 2004
Mobile augmented reality: high end solution
Markerless Tracking

Database with calibrated images and virtual information

Live-Image  Image-selection  Registration  Augmented-View
Video: ArcheoGUIDE