Virtual- and Augmented Reality in Education

Intel Webinar

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Overview

- AR/VR in Education: A Brief History
  - Construct3D & Evaluations
- Challenges for Use in Mainstream Education
- Outlook
  - Virtual Reality in Education
  - Augmented Reality in Education
Milgram’s Reality-Virtuality Continuum (1994)

Mixed Reality

- Real Environment
- Augmented Reality (AR)
- Augmented Virtuality (AV)
- Virtual Reality (VR)

Adapted from Milgram, Takemura, Utsumi, Kishino. Augmented Reality: A class of displays on the reality-virtuality continuum
Augmented Reality (AR)

Definition (Azuma, 1997)
1) Combines real and virtual world
2) Interactive in real time
3) Registered in 3-D:
   Real and virtual objects are in a 3D relation to each other
Collaborative VR / AR

• Users share the same virtual space
• Assists social interaction / cooperation
  – natural communication (language, gestures)
  – supports working in teams
AR/VR in Education: A Brief History

http://archive.ncsa.illinois.edu/Cyberia/VETopLevels/VR.History.html
http://www.bilawchuk.com/mark/history.html
ScienceSpace (Dede C. et al., 1996)

NewtonWorld, MaxwellWorld, PaulingWorld

- NewtonWorld: Kinematics and dynamics of one dimensional motion
- MaxwellWorld: Electrostatics
- PaulingWorld: study of molecular structures

- Evaluation studies: Learners’ engagement, usability issues
Virtual Gorilla Exhibit Project (Allison D. et al., 1997)

Area: Zoology, Biology
Goal: Learning about Gorilla behavior

- Model of Atlanta Zoo Gorilla habitat
- Combination of desktop 3D-modeling and immersive VR
VR Education: NICE (Roussos et al., 1999)

Area: Biology, especially for children (age 6-10)
Goal: Testbed for the exploration of virtual reality as a learning medium
CyberMath (Taxen G. et al., 2000)

Area: Mathematics education

Goal: Exploring open issues in VR education

- 4 exhibitions on geometry and calculus
- Remote collaboration (CAVE, desktop)
- Supports teaching styles
Construct3D
in [1], Computers & Graphics, 2003

- 16 students (age 16-19) working in teams of two
- One teacher supervises each team
- 5 training sessions
- Basic dual-user evaluation setup
- ISONORM 9241 Usability questionnaire

Summary in [2], HCI 2007, LNCS Springer
Milling Cutter

Given: Surface of revolution
Find diameter of spherical cutting tool

View in 3D with Deep View
Free at
www.righthemisphere.com/dv
Main Results

Construct3D is

- Easy to use, requires little time to learn
- Encourages learners to try new functions
- Can be used consistently
  - Designed in a way that things you learned once are memorized well
Key Strengths

- Dynamic 3D geometry - nearly haptic interaction with geometric objects
- Students can walk around objects. Active relationship between body – object
- Strength to visualize abstract problems

**Ideal content:** Highly dynamic examples which encourage modifications and visualize abstract problems
Training & Education

• Unlimited possibilities to re-try/learn
• Supports active participation – active learning! (in contrast to educational video)
• Increased interest and motivation of students
• New, better ways of training and learning
• New learning medium
• New, innovative learning content possible
Physics Playground

- Basic building blocks:
  - 3D shapes / actors
  - Joints
  - Interaction adapters
    - Force adapter
    - Analyzer adapter
- Simulation mode
- System control (load/save)
Physics Playground - Analyzer

- Allows to monitor physical behavior and properties
  - Real time logging
  - Multiple connections between adapters and analyzer inputs possible
Teaching content - Crankshaft

- Piston is moved by exerting force on flywheel
- Motion of the piston is analyzed
  - Path of movement is recorded
  - Analyzer shows acceleration and deceleration
  - Rotational motion transforms into sinus wave
Teaching content – Torque

- Flywheel is spun by exerting force on the handle
- Torque depends on length of handle
  - longer handle, larger torque
- Friction causes deceleration: exponential factor
Findings

• Simulation very robust for experiments with rigid bodies
• Accuracy of the Nvidia PhysX engine is sufficient for educational purposes
• Variety of teaching content
• Very motivating for students
• Real time simulation and monitoring of experiments possible
Constructivist Theory

• Knowledge is actively built by learners
  PhysicsPlayground: Active construction, real time simulation

• Knowledge construction (learning) is a collaborative process
  PhysicsPlayground: Collaborative Learning in AR

• Learning is contextual
  Adaption of old knowledge to new experience - integrate known types of information

• Motivation is a key component

• Support different learning styles/modes
Challenges:
Why is it not used in schools yet?

1. Didactical Aspects
2. Organizational Aspects
Didactical Aspects

- Teaching in AR/VR very similar to current computer-supported teaching
- Tasks needed that actually engage learners and require their active involvement.
- Teaching in smaller groups
Multi-User Support

- 6 wireless HMDs attached to one consumer graphics card (using TripleHead2Go)
- Rendering 6 stereo views on 1 PC; interactive frame rates
- Private screen + private view for each user
- Personalized output: Context-sensitive views

in International Journal of Virtual Reality, 2007
Variety of Hardware Setups

Stereo Projection (EON Reality)

Wii Controller + Auto-stereoscopic Screen

CAVE

Projection Environment (EON Reality)
Didactical Aspects

• Teaching in AR/VR very similar to current computer-supported teaching
• Tasks needed that actually engage learners and require their active involvement.
• Teaching in smaller groups

• Time needed for adjustment and adaptation of teaching material
• Lack of ICT-competence of teachers
Organizational Aspects

- Access to infrastructure
- Ease of use of AR/VR infrastructure

- Costs!!! - missing financial means
  - Hardware & Software
  - Maintenance / Repair?

- Sponsoring could be an option

1 PC with high-end graphics card ~2.500 EUR
1 Head mounted display ~5.000 EUR
1 wireless pen ~1.000 EUR
1 Plexiglas tablet ~10 EUR
1 optical tracking system ~50.000 EUR

Total: ~58.510 EUR
ioTracker
affordable infrared-optical pose tracking

specifications
Update rate: 60 Hz
Latency: 18 - 40 ms
Jitter: < 0.05 mm / 0.02°
Accuracy: ± 0.5 cm

IEEE Virtual Reality 2007
VR 2007
March 10-14, 2007
Charlotte, North Carolina, USA
Costs of an Immersive HW Setup (2007)

1 PC with high-end graphics card  ~1.500 EUR
1 Head mounted display         ~1.500 EUR
1 wireless pen                 ~30 EUR
1 Plexiglas tablet             ~10 EUR
1 optical tracking system      ~11.000 EUR

in 2003:                      ~58.510 EUR
in 2007:                      ~14.040 EUR

→ Successful change of the market situation
State of the Art & Outlook: Virtual Reality in Education
EON Reality
Visenso: Cyber-Classrooms

Why don’t we turn movie theaters into VR learning environments in the mornings?
Oculus Rift

- Stereoscopic
- Large FOV: 110° diagonal
  90° horizontal
- Weight: 220 grams
- Resolution: 640x800 per eye
- Price ~300 USD
- The best existing low cost immersive HMD
Sony MOVE
Motion Controller

• Inertial sensor (gyro, accel., magnetom.) – measures orientation

• 60 Hz camera used for optical tracking of colored sphere
  – High accuracy (cm/mm)
  – Controller can change colors (eases segmentation)
PS Move Controller used for Tracking
Costs of an Immersive HW Setup (2013)

1 PC with good graphics card ~1.500 EUR
1 Oculus Rift head mounted displays ~300 EUR
1 Razer Hydra Controller ~150 EUR
1 PSMove for optical tracking ~ 50 EUR

in 2003: ~58.510 EUR in 2013: ~2.000 EUR

Prototype, no professional maintenance.
Nobody uses such a VR setup for education yet.
Outlook:
Augmented Reality in Education
Use of Available Hardware in Schools
Interactive Books

Re-writeable holographic Display

BooksComeAlive.co.uk
Spaceglasses
Summary

- VR/AR: High potential for teaching & learning
- Content can be taught differently (in 3D)
  - New teaching material can be taught
- Technological advances lower costs!
  - New display technologies
  - Flexible input devices
  - Work in small and large groups possible, depending on hardware setup
- Content development expensive & time consuming
- Organizational issues remain
Thank you!
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