Interactive Media Systems Group
Software Technology & Interactive Systems
Vienna University of Technology

Virtual- and Augmented Reality in Education

Intel Webinar

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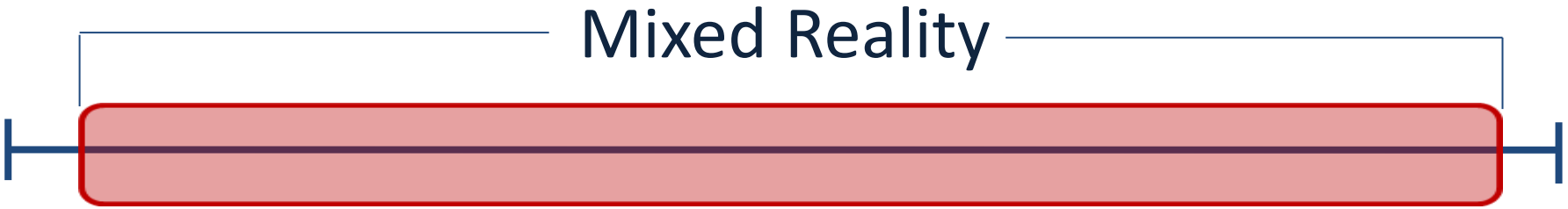
Overview

- 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)



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

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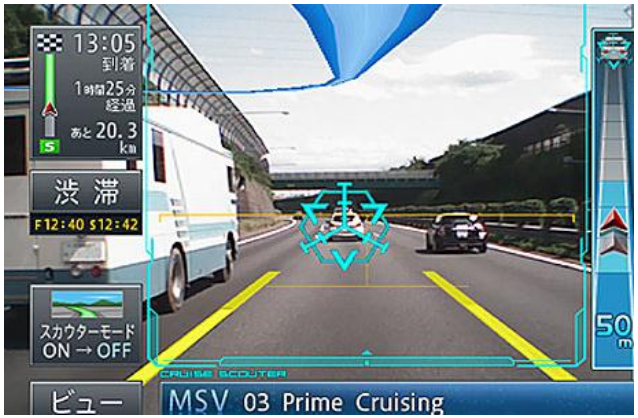
Augmented Reality (AR)



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

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AR/VR in Education: A Brief History

http://archive.ncsa.illinois.edu/Cyberia/VETopLevels/VR.History.html
http://www.bilawchuk.com/mark/history.html

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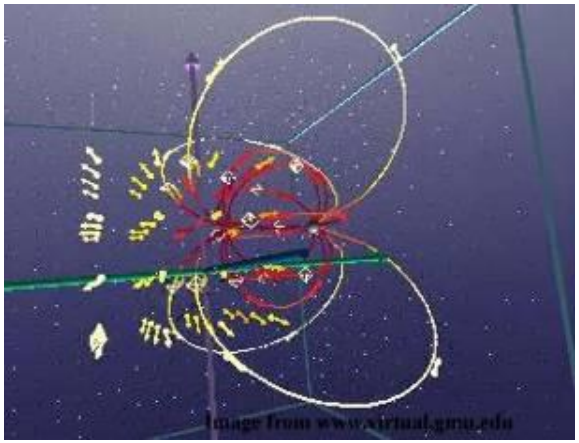
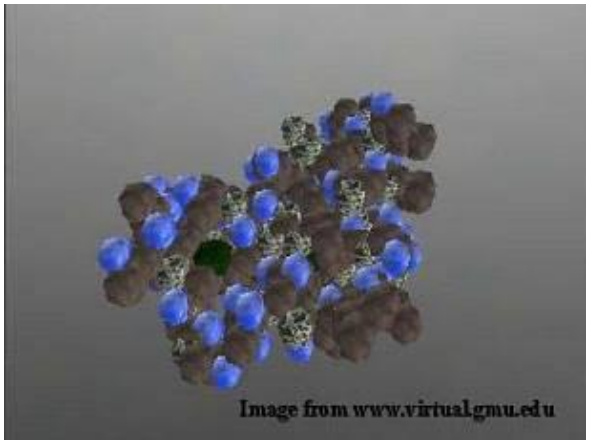
ScienceSpace (Dede C. et al., 1996) NewtonWorld, MaxwellWorld, PaulingWorld





- 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

Student uses head mounted display to interact

Courtesy Allison D., Georgia Tech University.

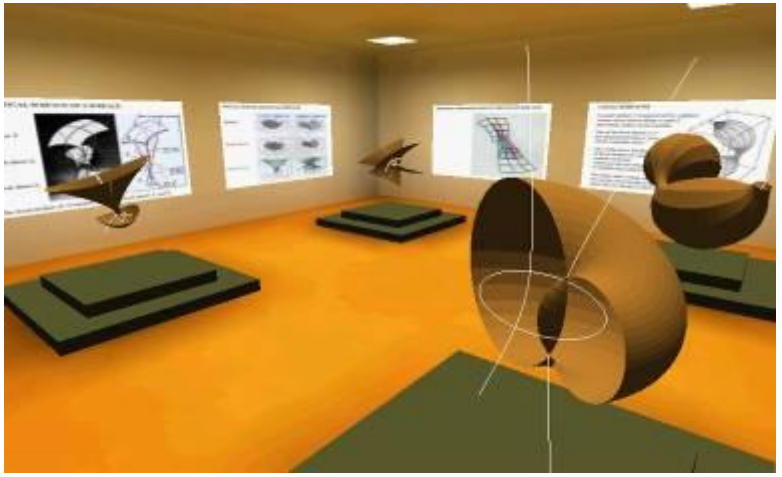
VR Education: NICE (Roussos et al., 1999)

Courtesy Maria Roussos, EVL, UIC.

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)



Courtesy Gustav Taxen, Center for User Oriented IT Design, Sweden.

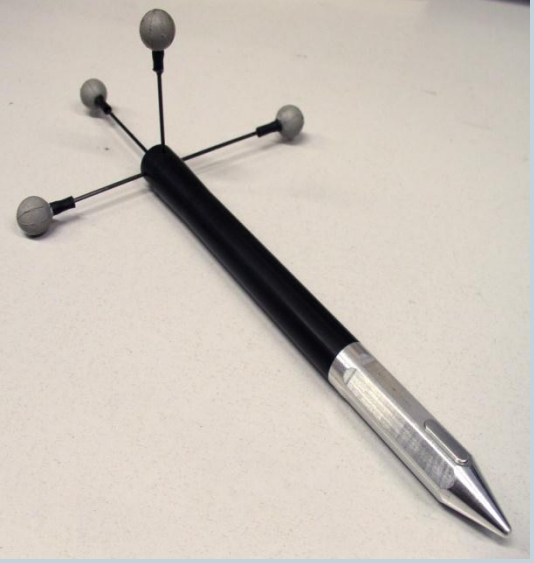
Area: Mathematics education

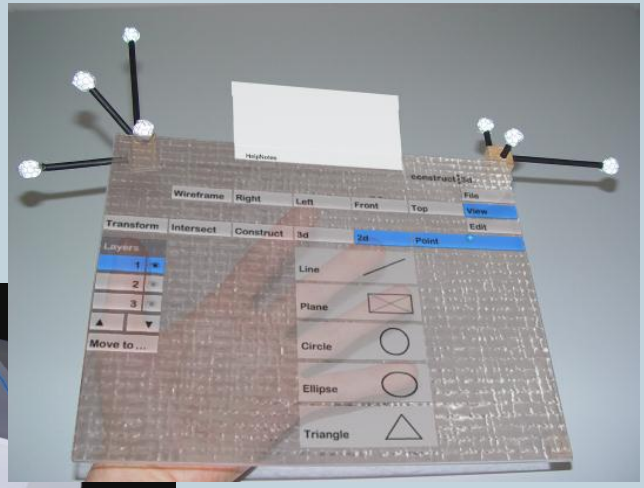
Goal: Exploring open issues in VR education

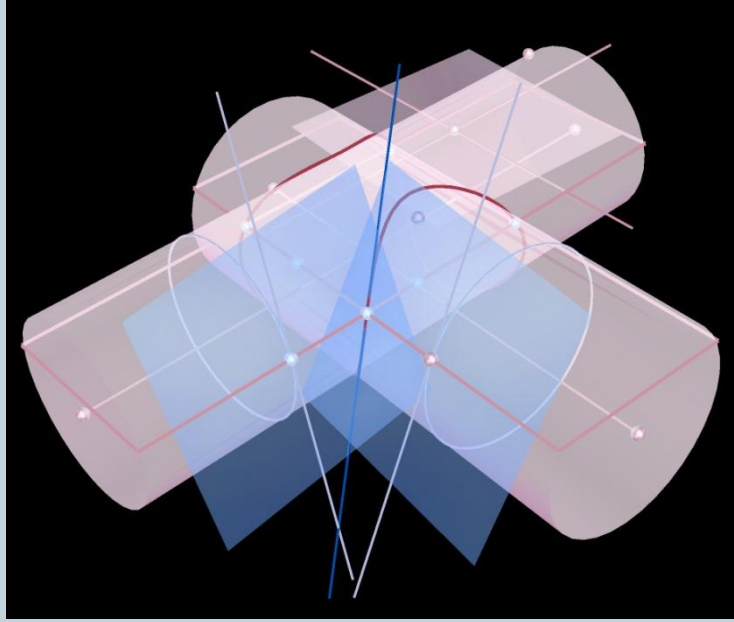
- 4 exhibitions on geometry and calculus
- Remote collaboration (CAVE, desktop)
- Supports teaching styles

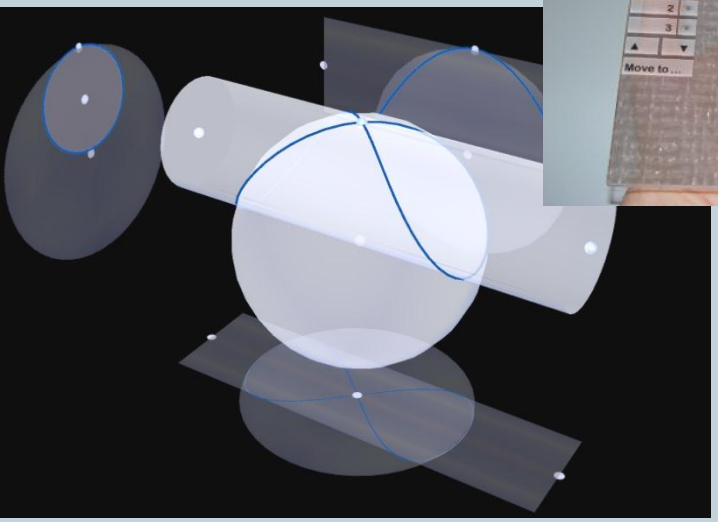
Construct3D

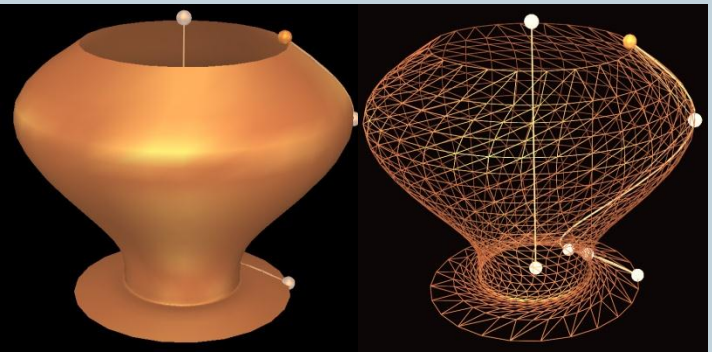
in [1], Computers&Graphics, 2003









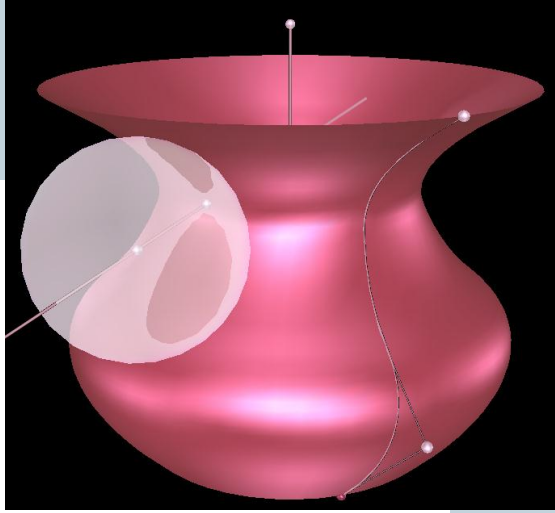


Summary in [2], HCI 2007, LNCS Springer

Usability Evaluation (2004)

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

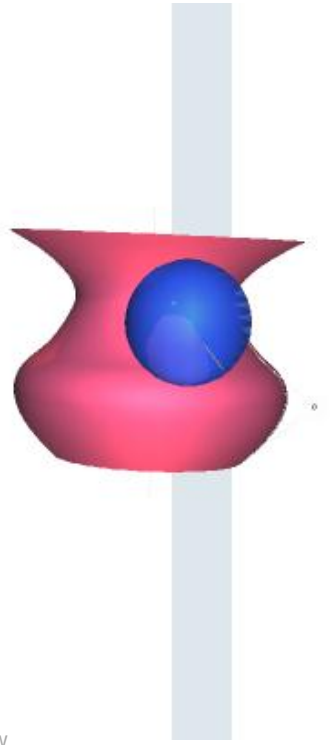
- ISONORM 9241 Usability questionnaire

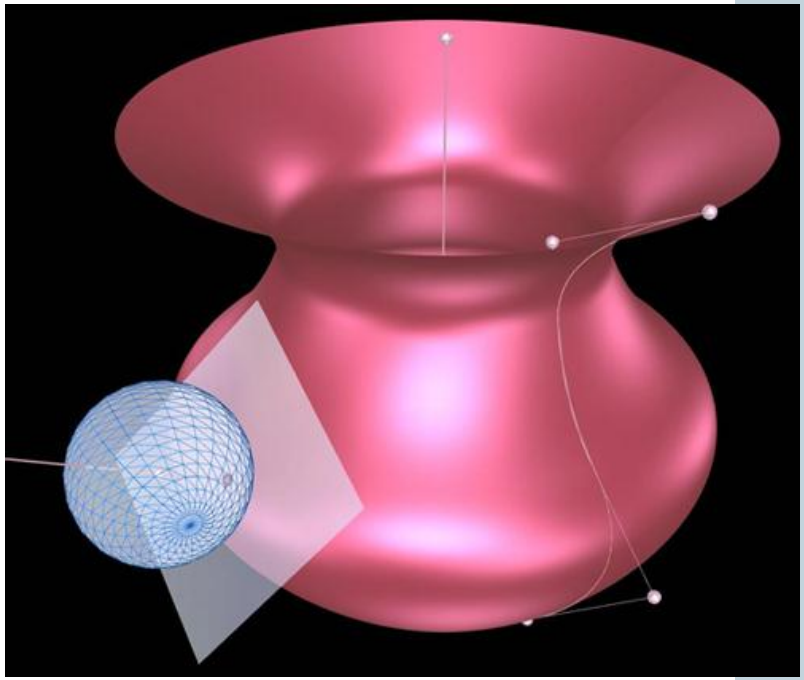


Milling Cutter

Given: Surface of revolution

Find diameter of spherical cutting tool





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

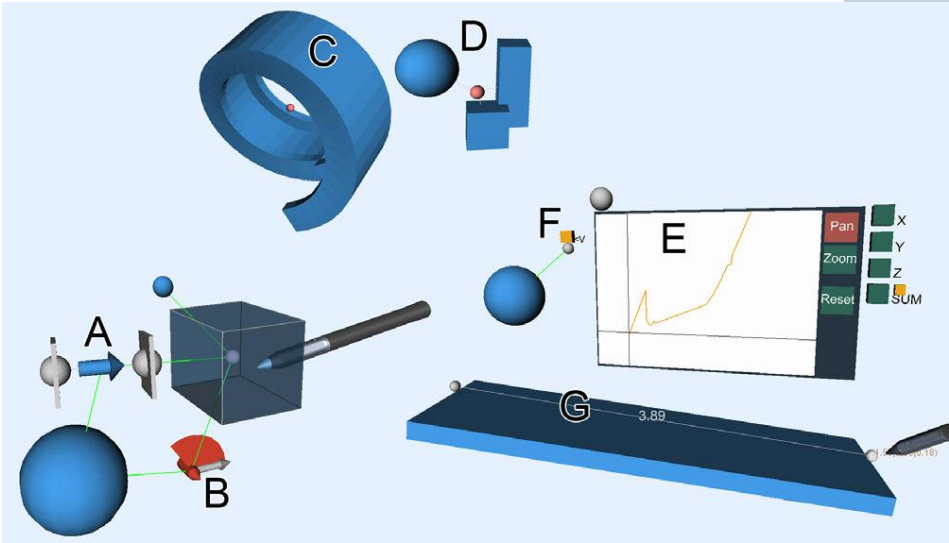
→ Ideal content: Highly dynamic examples which encourage modifications and visualize abstract problems

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

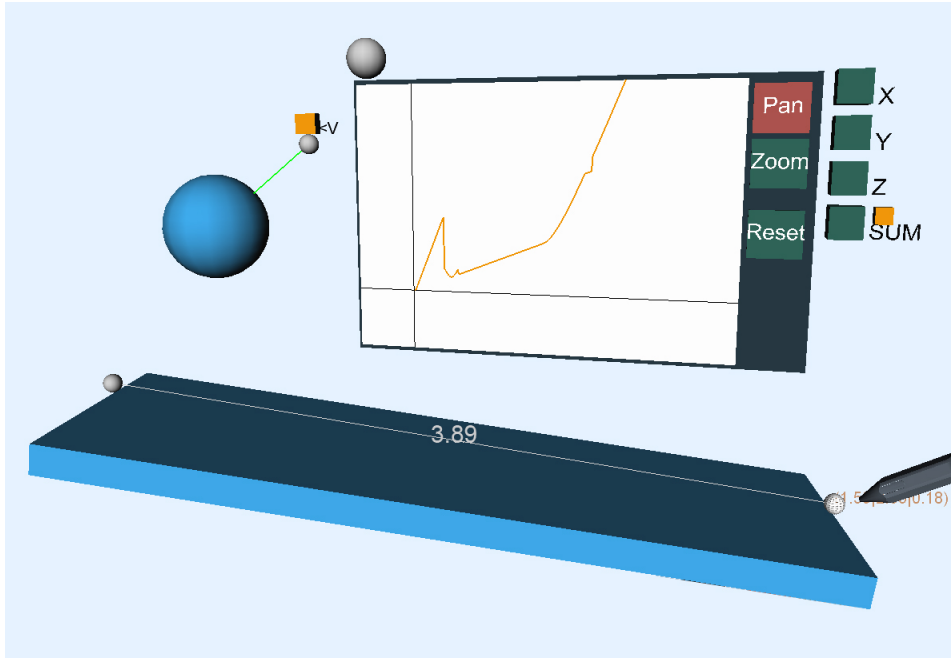
PhysicsPlayground

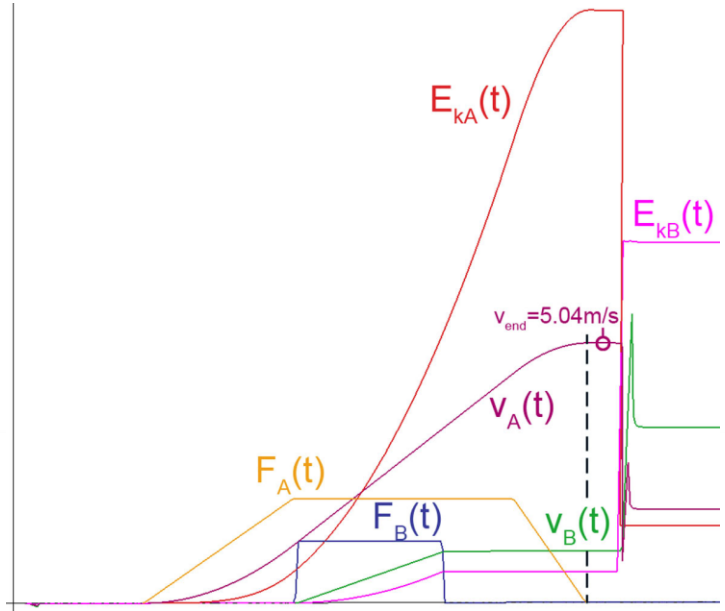
- Basic building blocks:
  - 3D shapes / actors
  - Joints
  - Interaction adapters
    - Force adapter
    - Analyzer adapter
- Simulation mode
- System control (load/save)



PhysicsPlayground - Analyzer

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

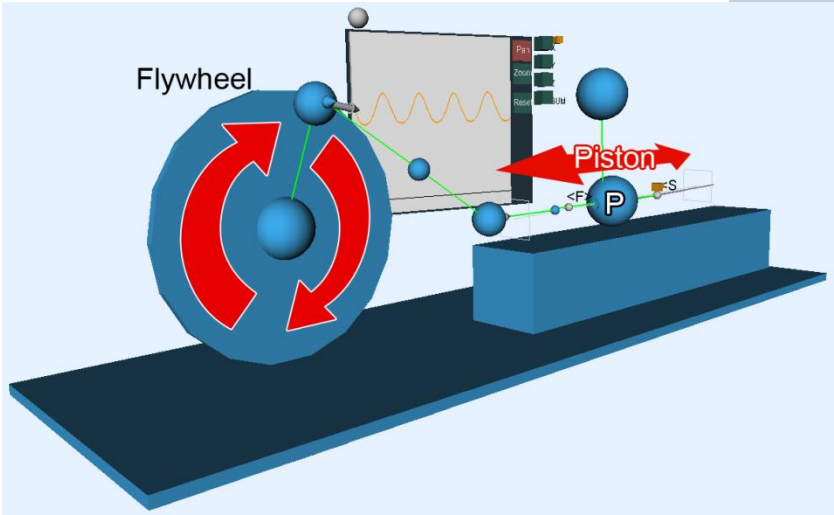




SIGGRAPHASIA2008
NEW HORIZONS

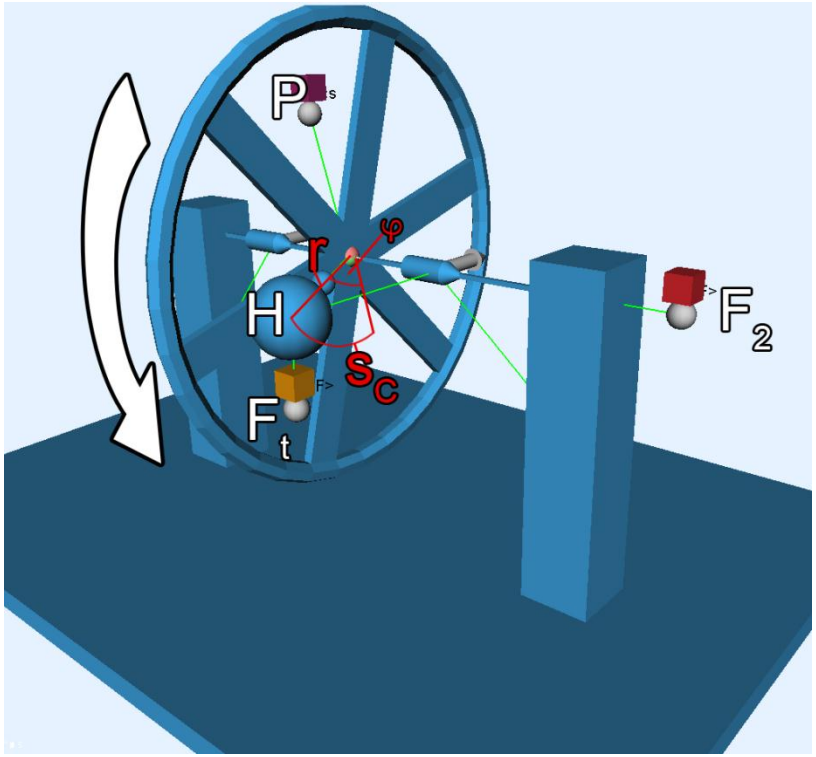
Teaching content - Crankshaft

- 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



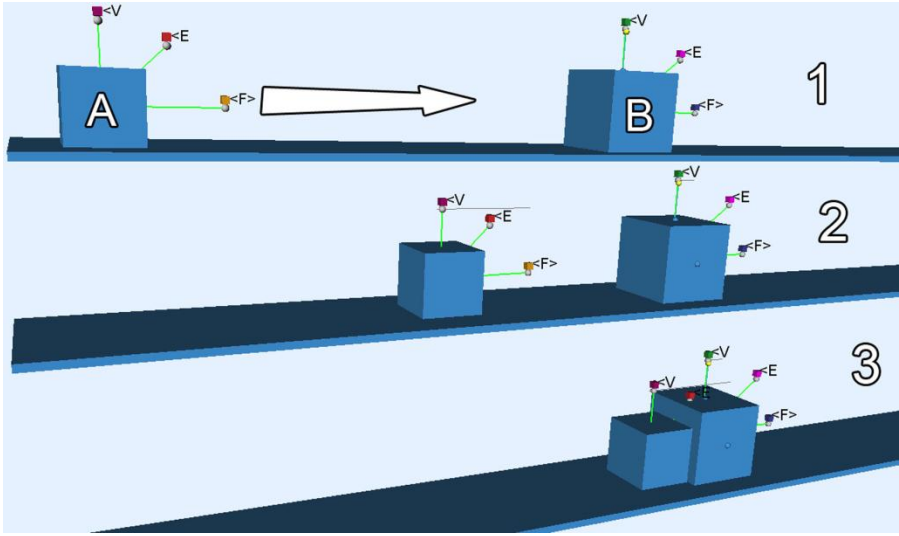
Teaching content – Torque

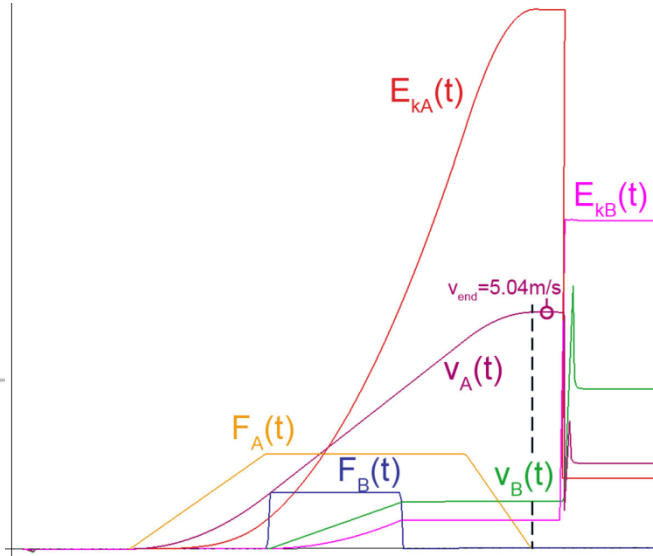
- Flywheel is spinned by exerting force on the handle
- Torque depends on length of handle
  - longer handle, larger torque
- Friction causes deceleration: exponential factor



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

in International Journal of Virtual Reality, 2007

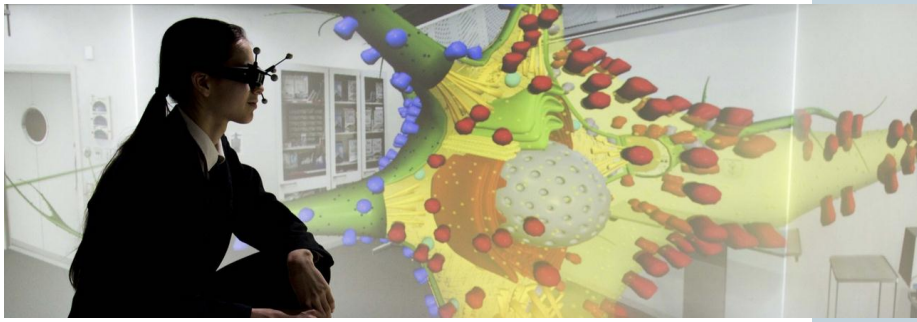
- 6 wireless HMDs attached to one consumer graphics card (using TripleHead2Go)
- Rendering 6 stereo views on 1 PC; interactive frame rates
- Private screen + private view for each user
- Personalized output: Context-sensitive views

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

Costs of an Immersive HW Setup (2003)

1 PC w	~~~2.500 EUR~~
1 Heac	~~~5.000 EUR~~
1 wirel	~~~1.000 EUR~~
1 Plexi	~ 10 EUR
1 optic	~~~50.000 EUR~~ ?
	~58.510 EUR

iotracker

affordable infrared-optical pose tracking

IEEE Virtual Reality 2007
VR2007
March 10-14, 2007 Charlotte, North Carolina USA

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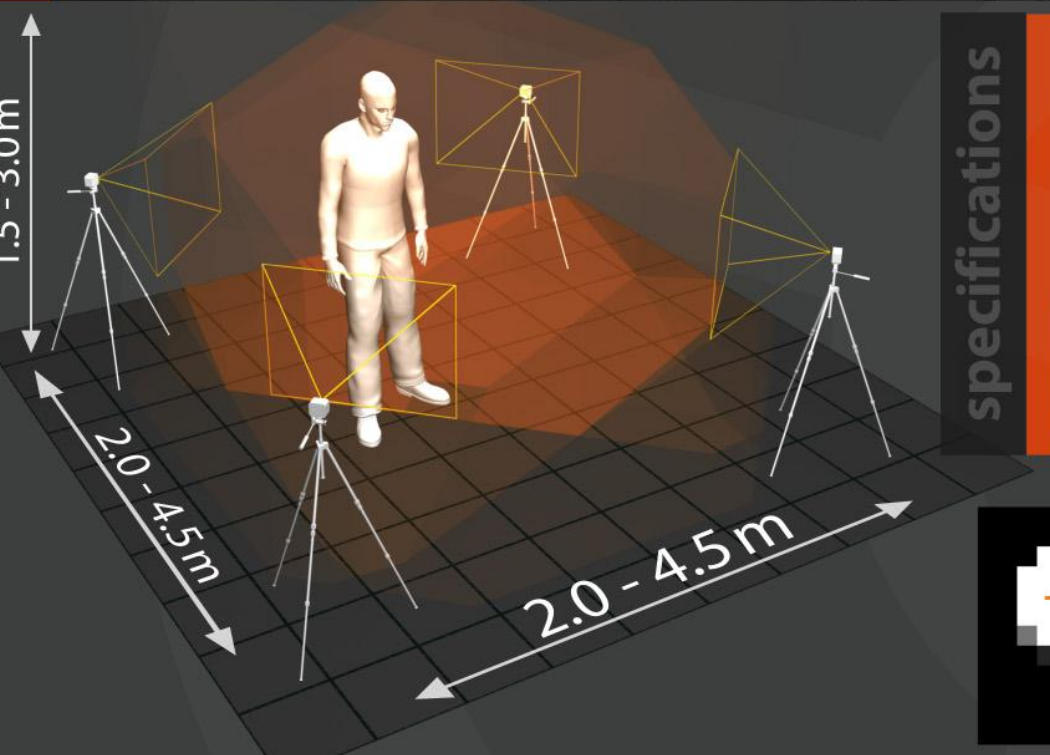
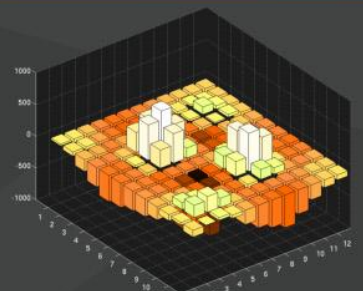


specifications

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

FireWire



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

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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?

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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

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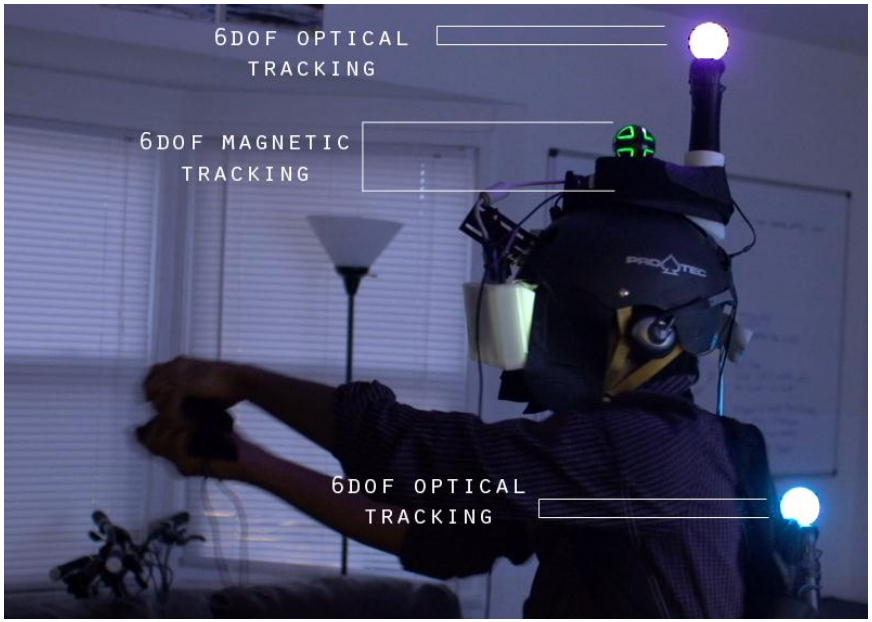
Sony MOVE Motion Controller

- 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.

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Outlook:
Augmented Reality in Education

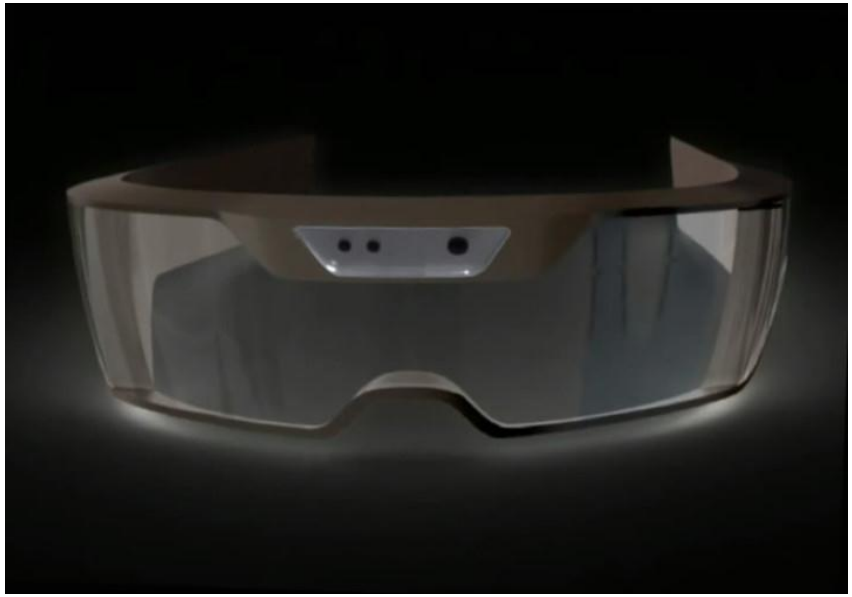
Use of Available Hardware in Schools

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

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Thank you!

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