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

15 Years of VR/AR in Education

A Personal Summary and Outlook

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Overview

- A Brief Personal History
  - Construct3D & Evaluations
  - PhysicsPlayground
- Challenges for Use in Mainstream Education
- Outlook
  - Augmented Reality in Education
  - Virtual Reality in Education

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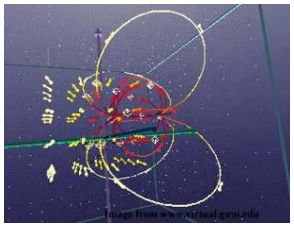
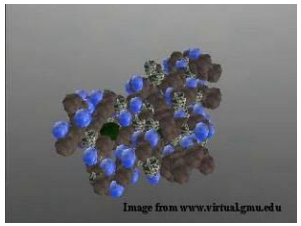
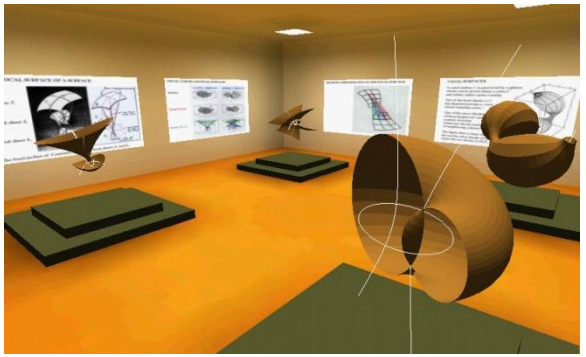
Kaufmann

Early Work





- Zengo Sayu (Rose H. et al., 1995)
- ScienceSpace (Dede C. et al., 1996)



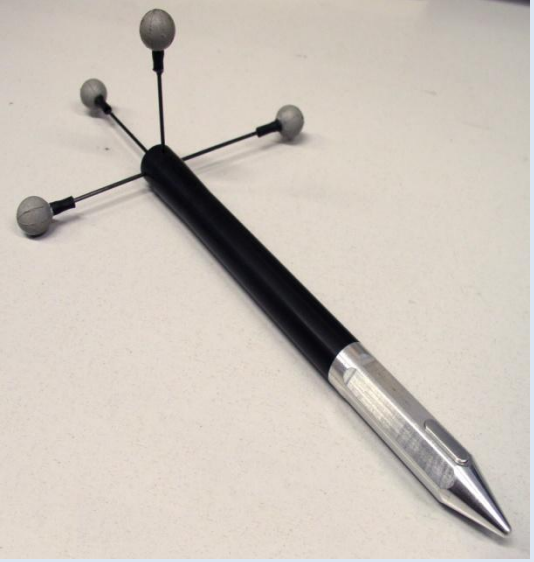
- NICE (Roussos M. et al., 1999)
- CyberMath (Taxen et al., 2000)

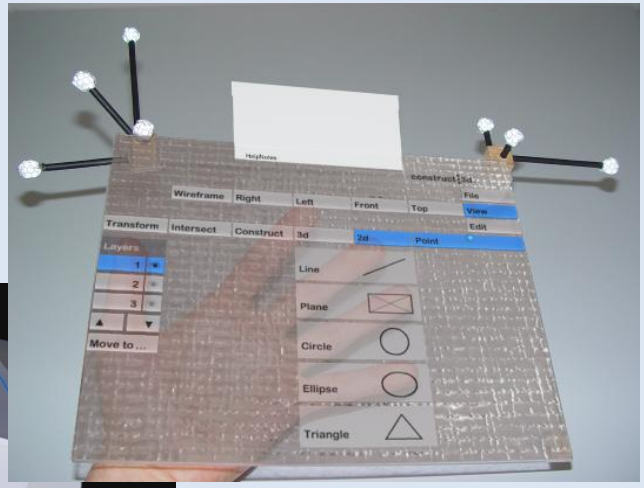
AR Education:

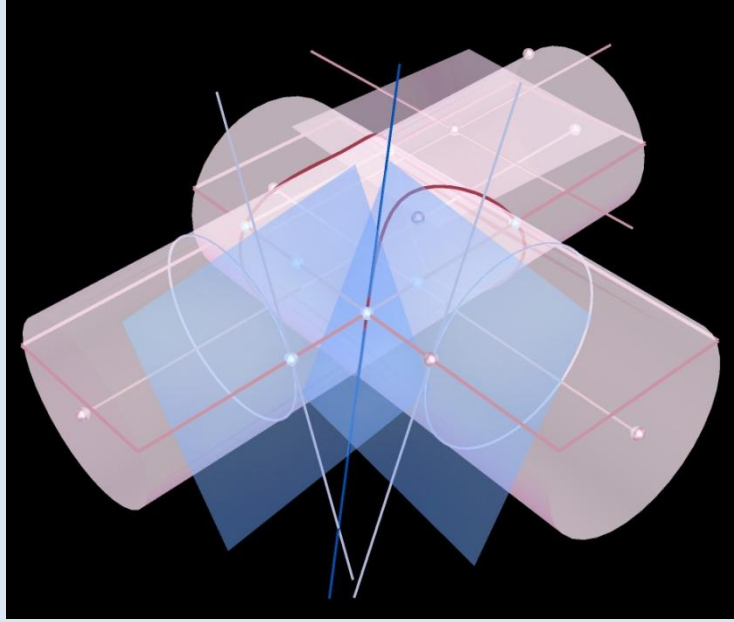
- MagicBook (Billinghurst et al., 2001)

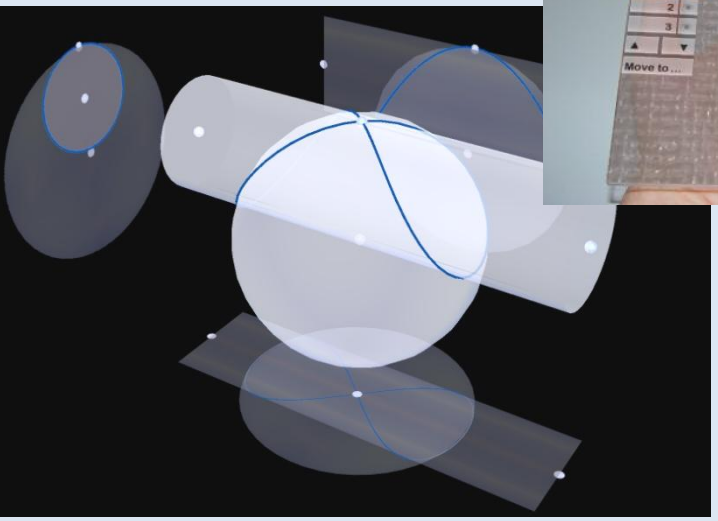
Construct3D

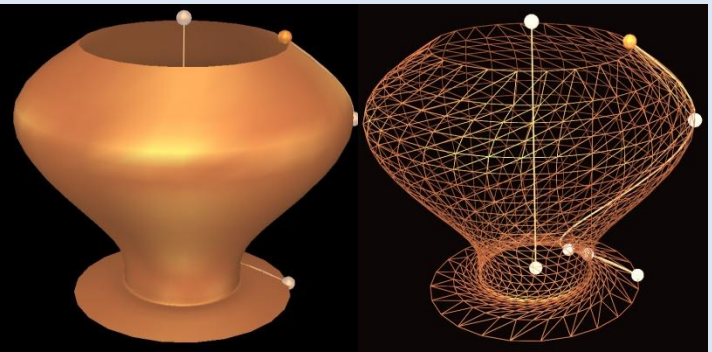
(since 2000)



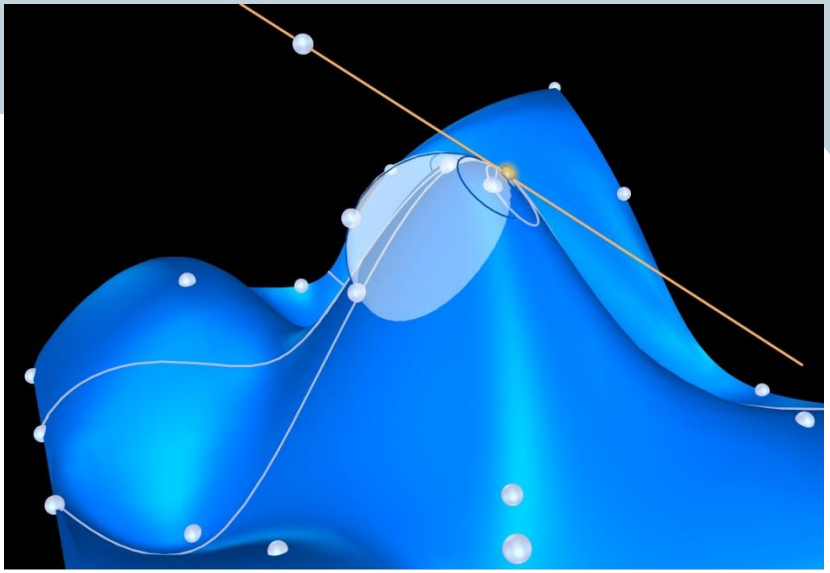




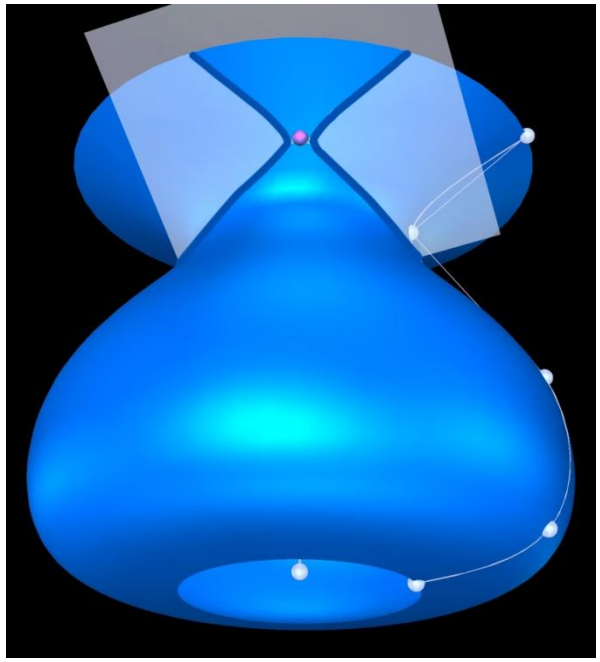




Features



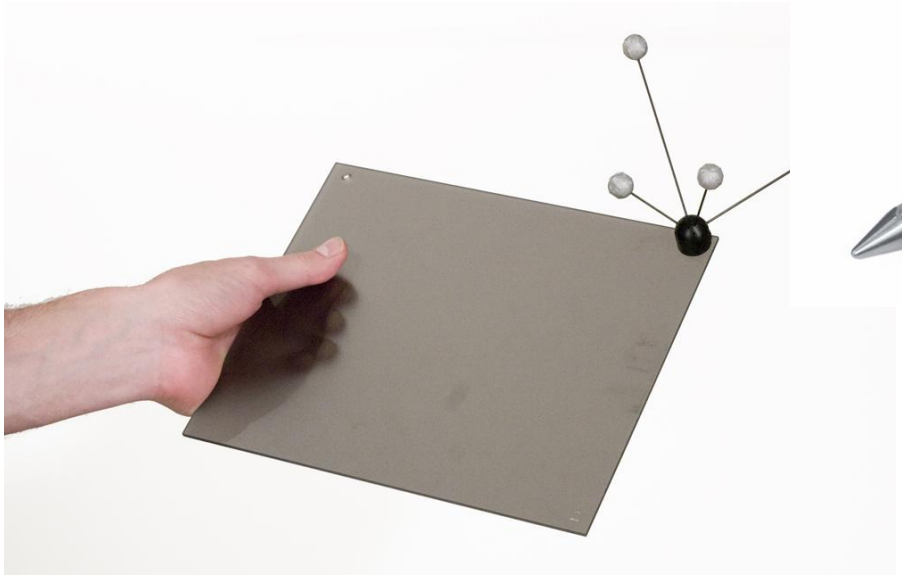
- Points, 2D primitives
- Basic 3D objects
- Intersections
- Boolean operations
- Normal, tangent, tangential plane
- B-Spline curves, NURBS-surfaces
- Surfaces of revolution
- Sweep surface, translation surface
- Transformations, measurements…
- Differential geometric objects

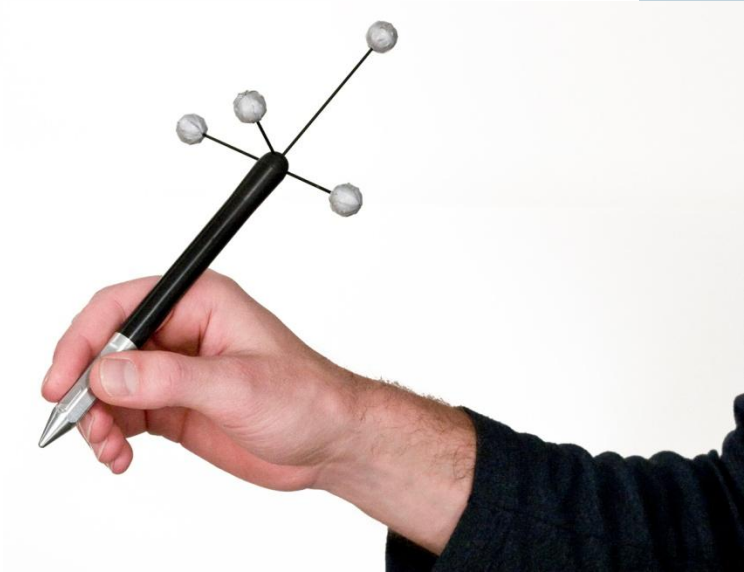


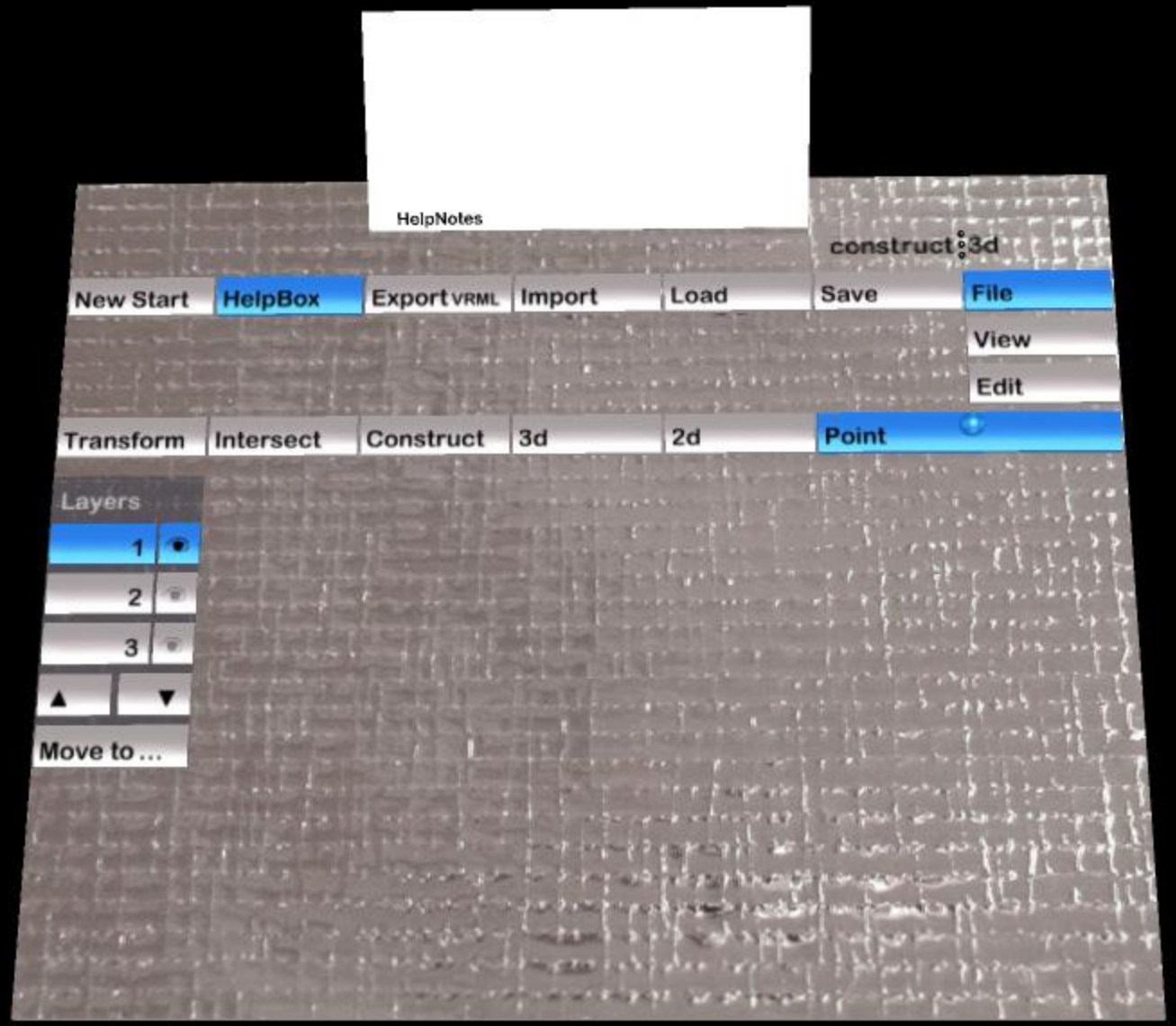
Dynamic modifications of points are possible at all times!

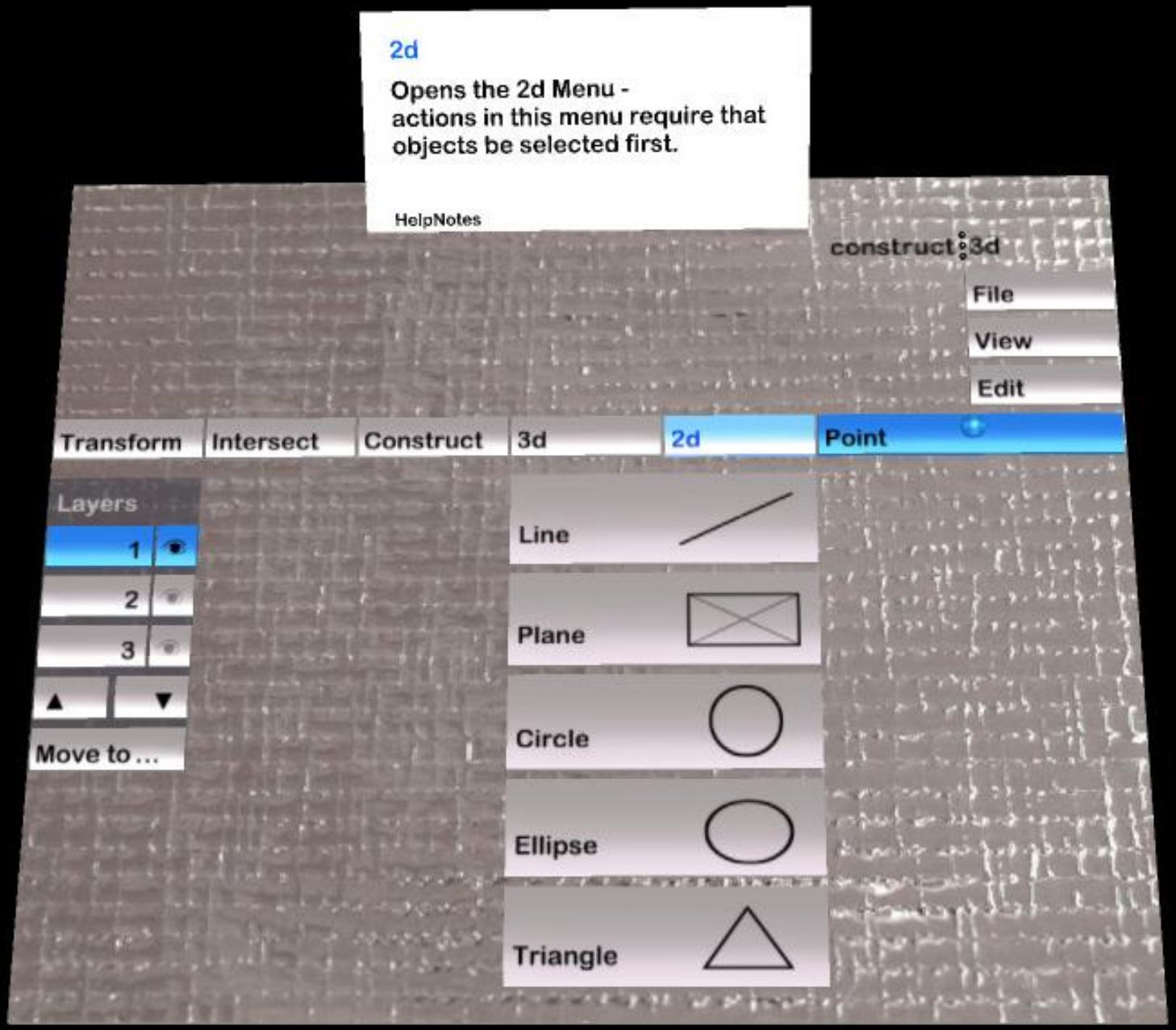
Interaction Devices

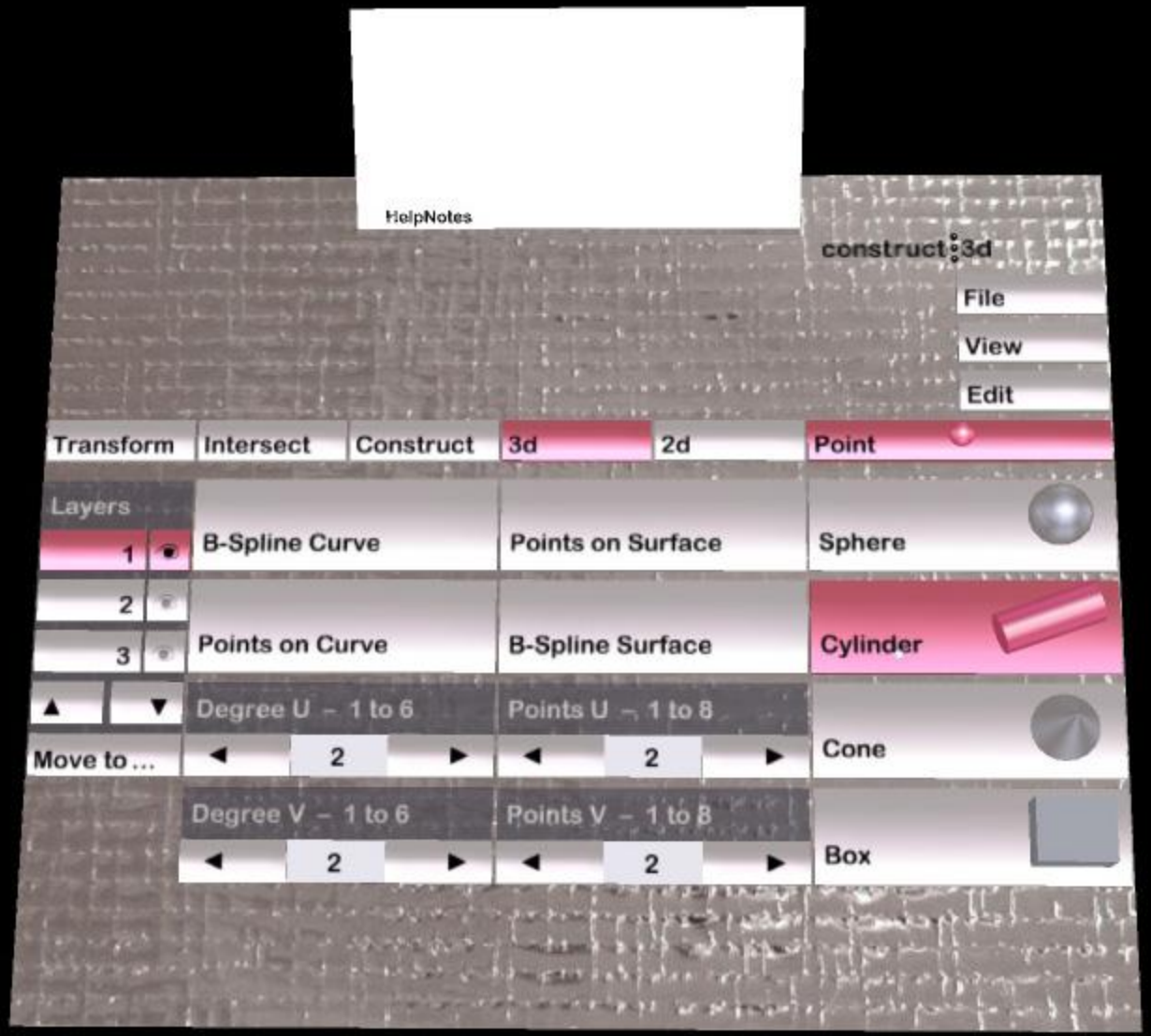
Pen & Tablet






HelpNotes
construct:3d
New Start
HelpBox
Export VRML
Import
Load
Save
File
View
Edit
Transform
Intersect
Construct
3d
2d
Point
Layers
1
2
3
Move to ...


2d
Opens the 2d Menu -
actions in this menu require that
objects be selected first.
HelpNotes
construct 3d
File
View
Edit
Transform
Intersect
Construct
3d
2d
Point
Layers
1
2
3
Move to ...
Line
Plane
Circle
Ellipse
Triangle

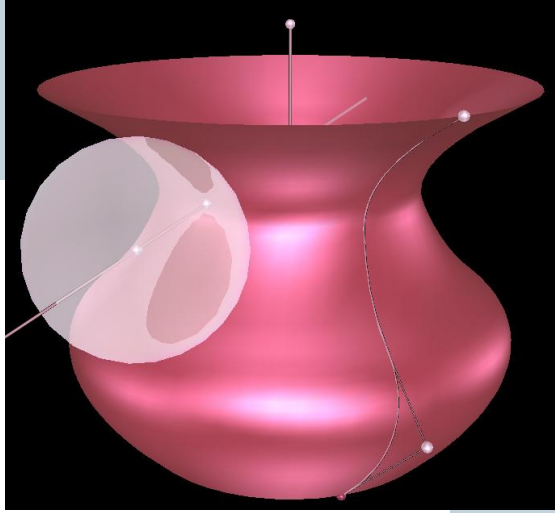

HelpNotes
construct:3d
File
View
Edit
Transform
Intersect
Construct
3d
2d
Point
Layers
1
2
3
B-Spline Curve
Points on Surface
Sphere
Points on Curve
B-Spline Surface
Cylinder
Degree U – 1 to 6
Points U – 1 to 8
Move to ...
2
2
Cone
Degree V – 1 to 6
Points V – 1 to 8
2
2
Box

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

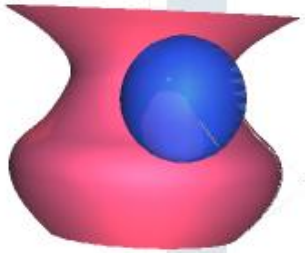
- ISONORM 9241 Usability questionnaire

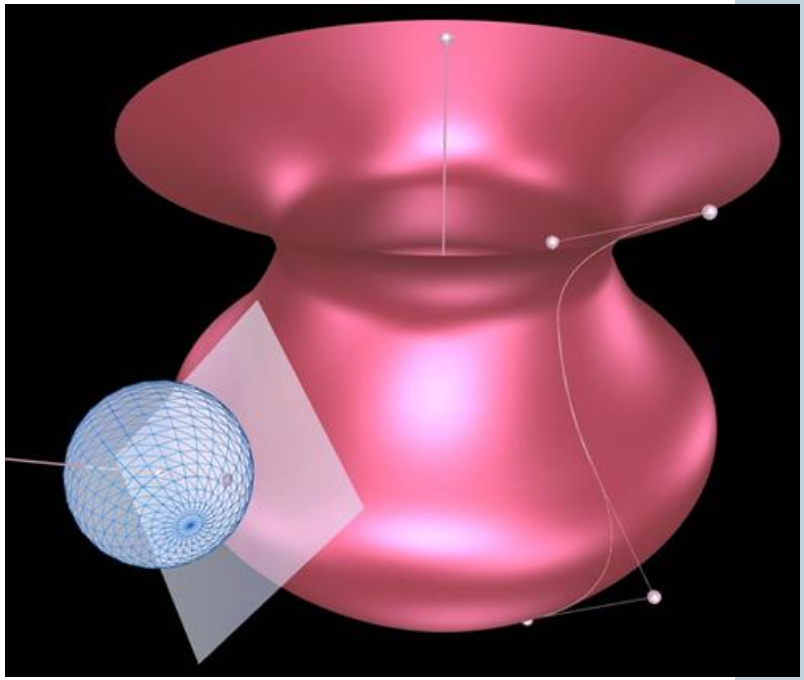


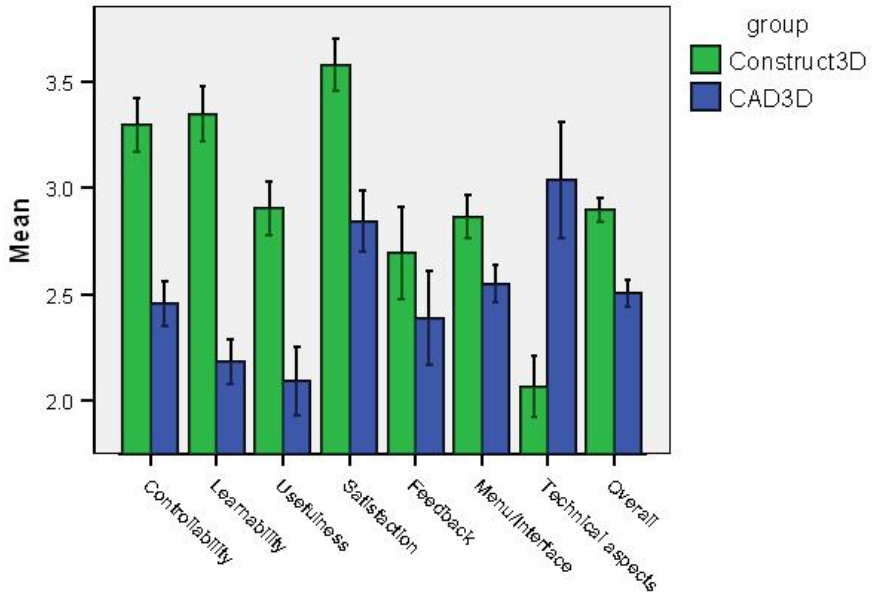
Milling Cutter

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

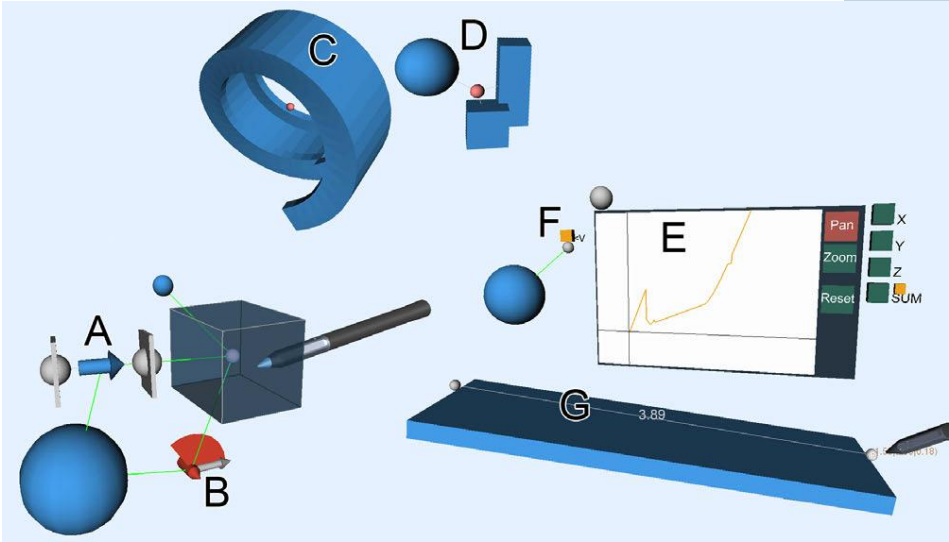
Key Strengths

- 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

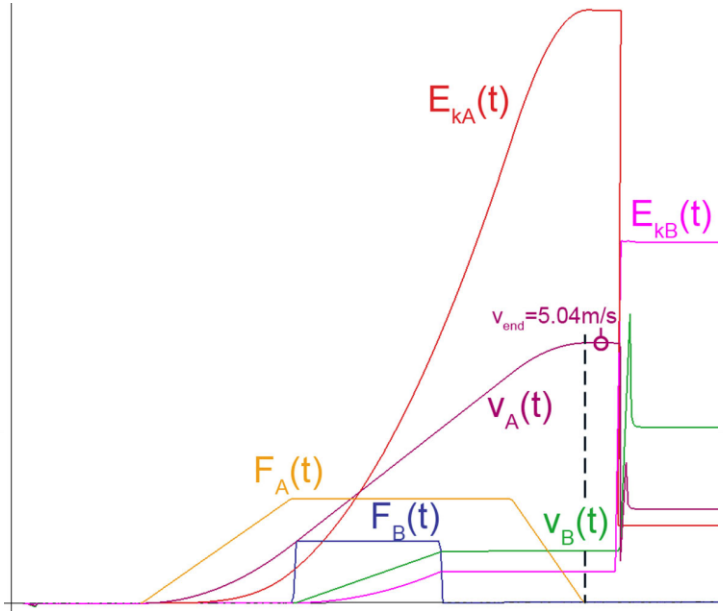
PhysicsPlayground

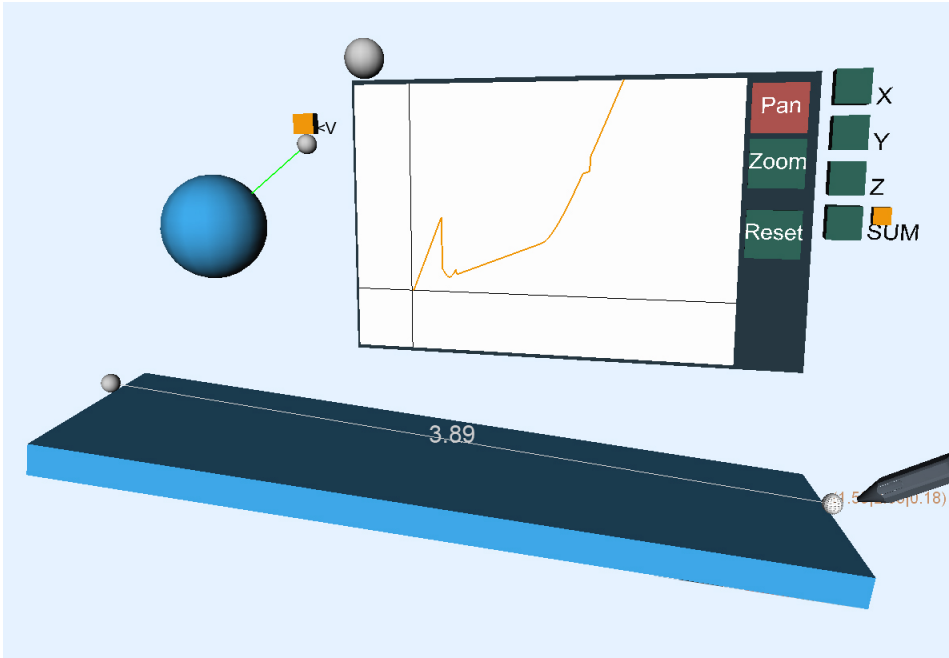
- Basic building blocks:
  - 3D shapes / actors
  - Joints
  - Interaction adapters
    - Force adapter
    - Analyzer adapter
- Simulation mode
- System control (load/save)



PhysicsPlayground - Analyzer

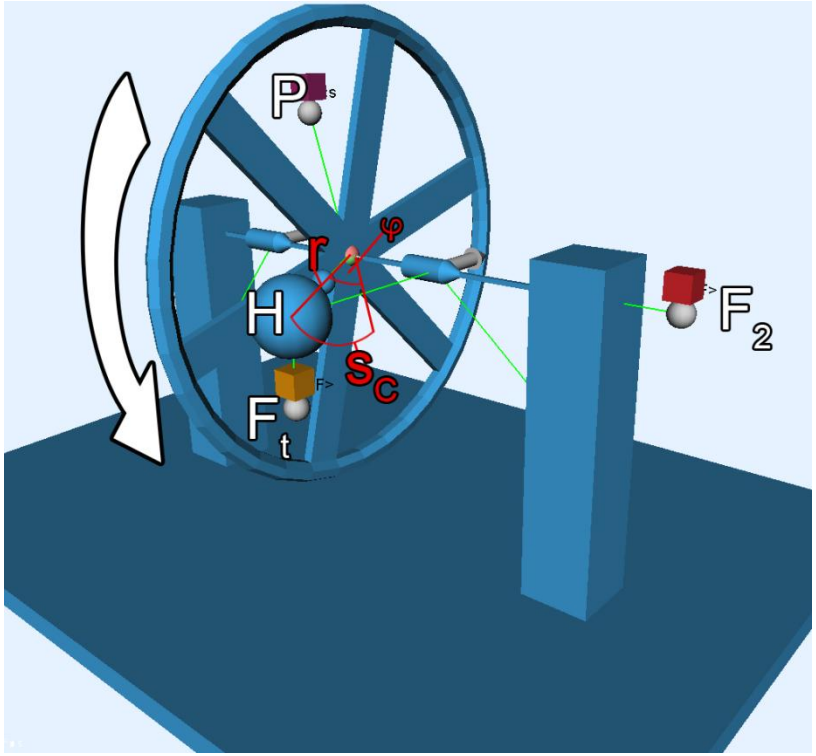
- Allows to monitor physical behavior and properties
  - Real time logging
  - Multiple connections between adapters and analyzer inputs possible





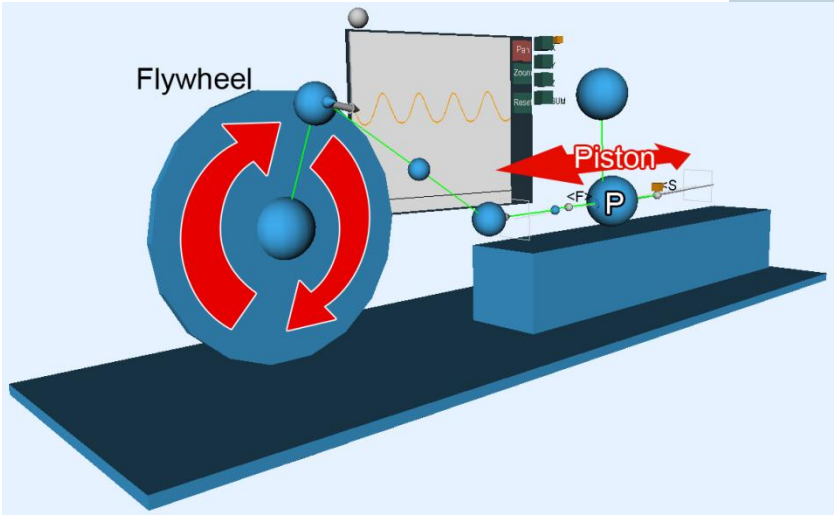
Teaching content – Torque

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



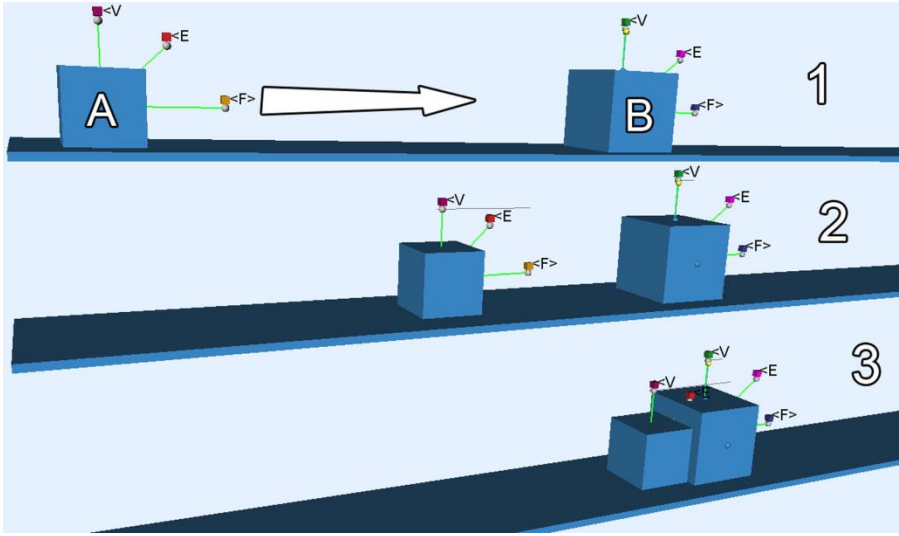
Teaching content - Crankshaft

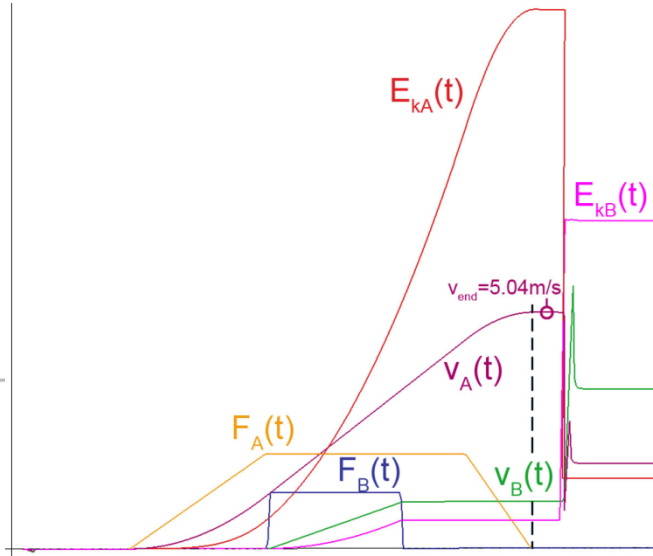
- Piston is moved by exerting force on flywheel
- Motion of the piston is analyzed
  - Path of movement is recorded
  - Analyzer shows acceleration and deceleration
  - Rotational motion transforms into sinus wave



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?

Proof of VR/AR‘s effectiveness is difficult!

1. Didactical Aspects
2. Organizational Aspects

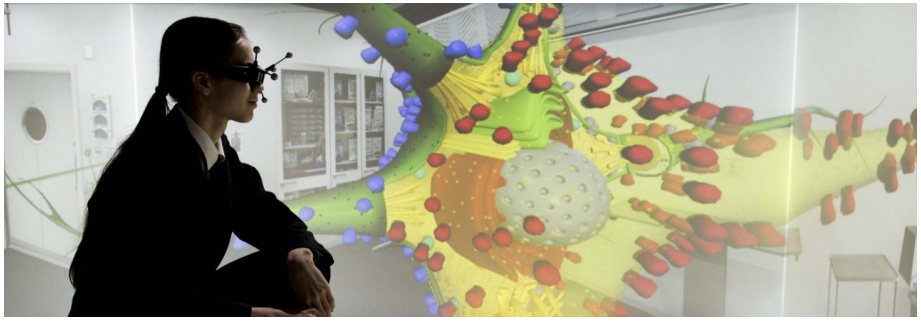
Didactical Aspects

- 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.

Variety of Hardware Setups

Stereo Projection (EON Reality)

Wii Controller + Auto-stereoscopic screen



Projection Environment (EON Reality)

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

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

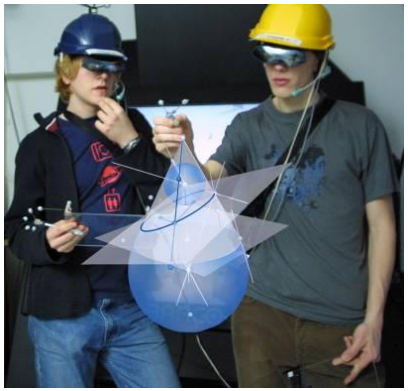
- Access to infrastructure
- Ease of use of AR/VR infrastructure

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

  - Sponsoring of companies 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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Technische Universität Wien
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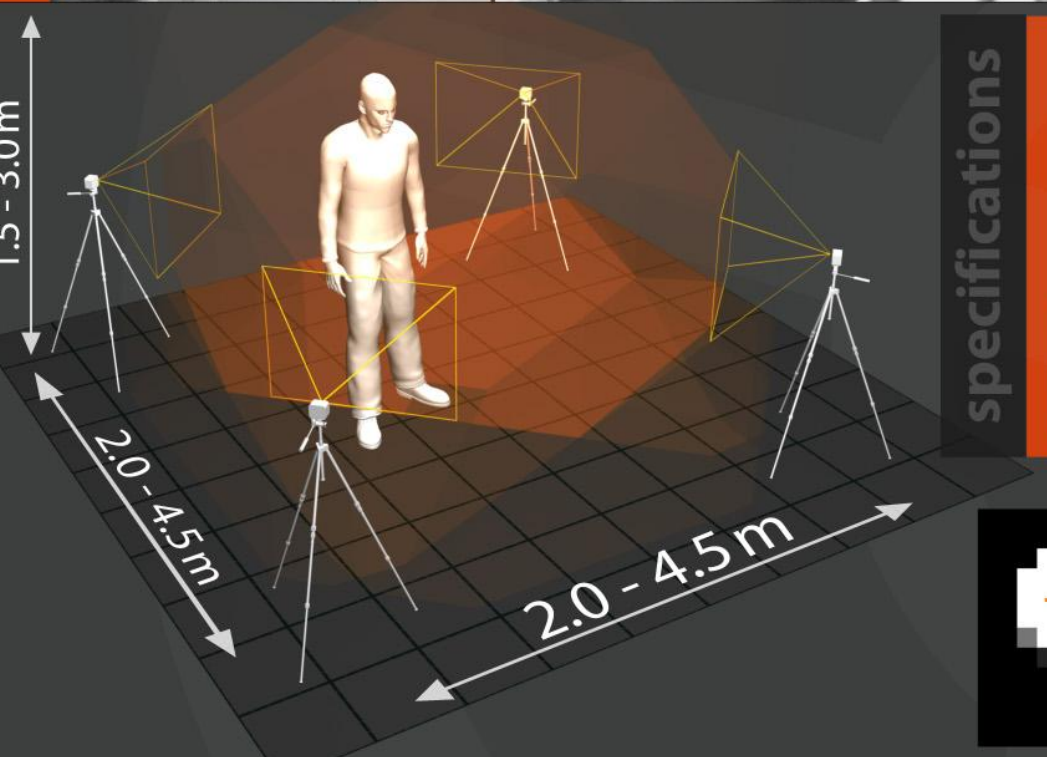
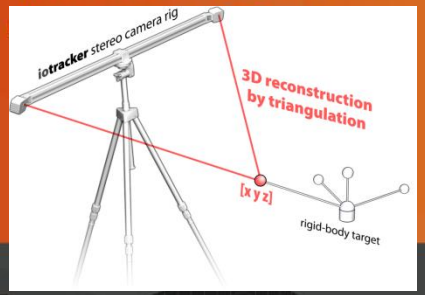
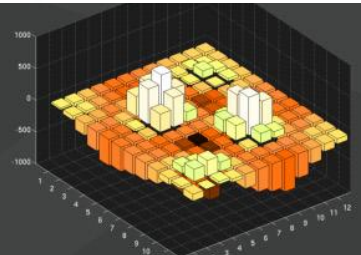


specifications

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





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: Augmented Reality in Education

Use of Available Hardware in Schools

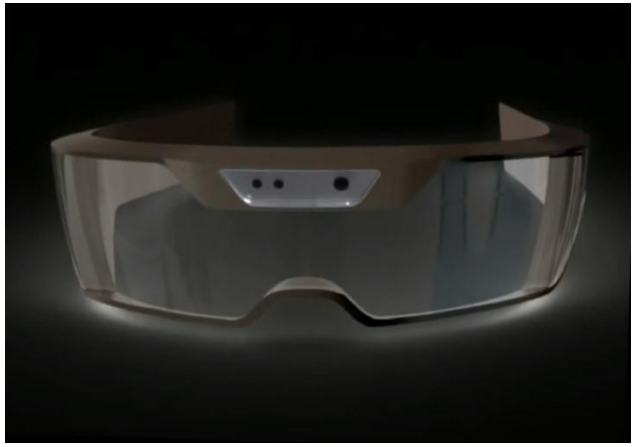
Interactive Books

Re-writeable
holographic Display

BooksComeAlive.co.uk

New AR Devices Coming…

- Spaceglasses (Jan 2014)



- Cast AR (Sep. 2014)

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State of the Art & Outlook: Virtual Reality in Education

EON Reality

Why don‘t we turn movie theaters into

VR learning environments in the mornings?

Costs of an Immersive HW Setup (2013)

?

in 2007: ~14.040 EUR

Hannes
Kaufmann

Oculus Rift

- Stereoscopic
- Large FOV: 110° diagonal
  90° horizontal
- Weight: 220 grams
- Resolution (HD version):
  960x1080 per eye
- Price ~300 USD
- The best existing low cost immersive HMD

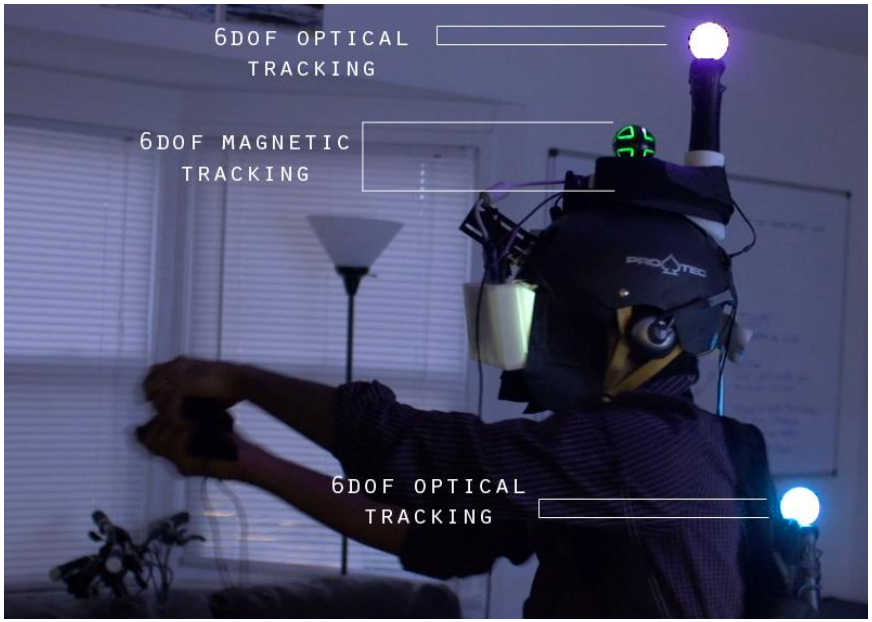
Hannes
Kaufmann

Sony MOVE Motion Controller

- Inertial sensor – measures orientation (gyroscope, accelerometer, magnetometer)
- 60 Hz camera used for optical tracking of colored sphere
  - High accuracy (cm/mm)
  - Controller can change colors (eases segmentation)

New Immersive Setup:

Oculus Rift + 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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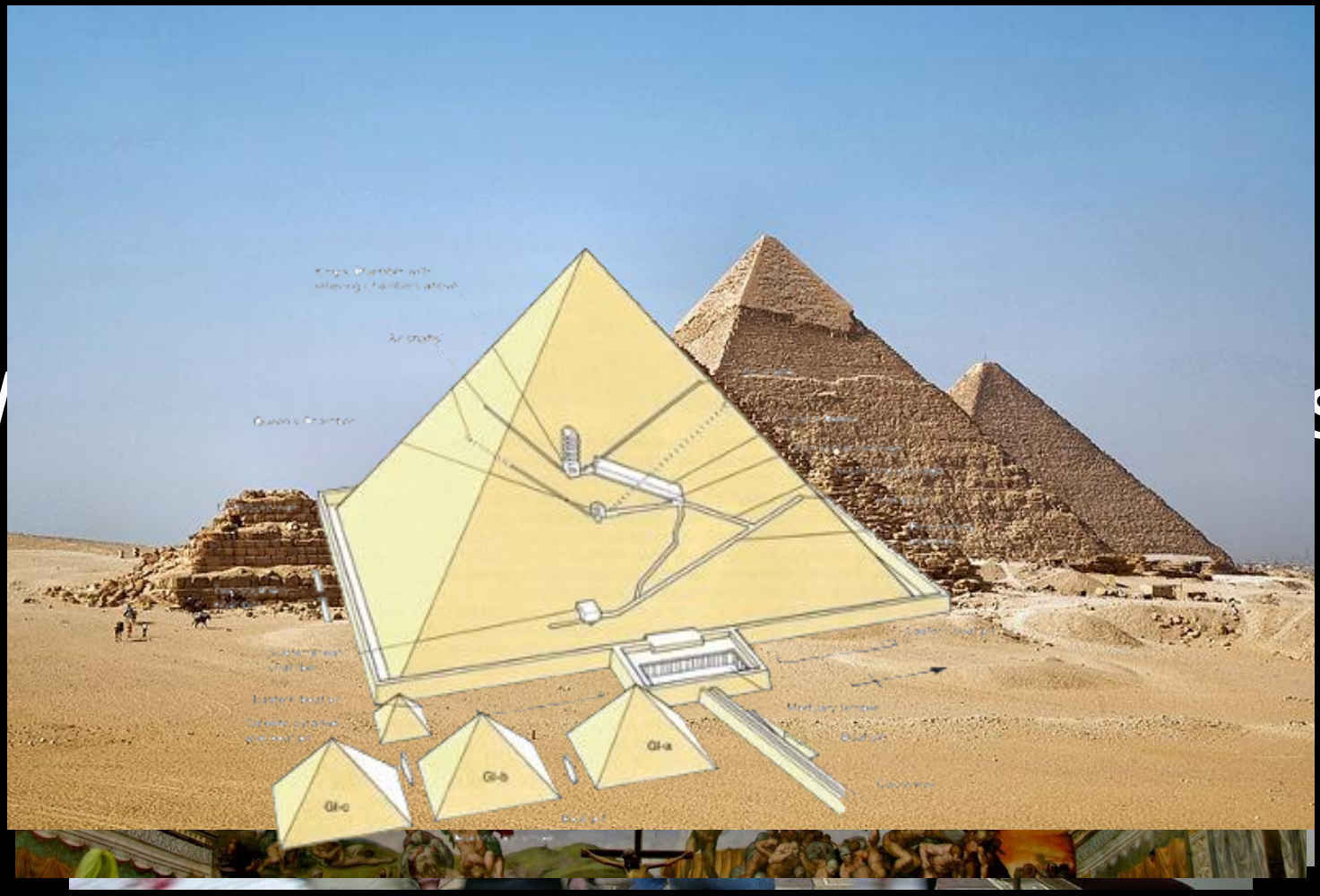
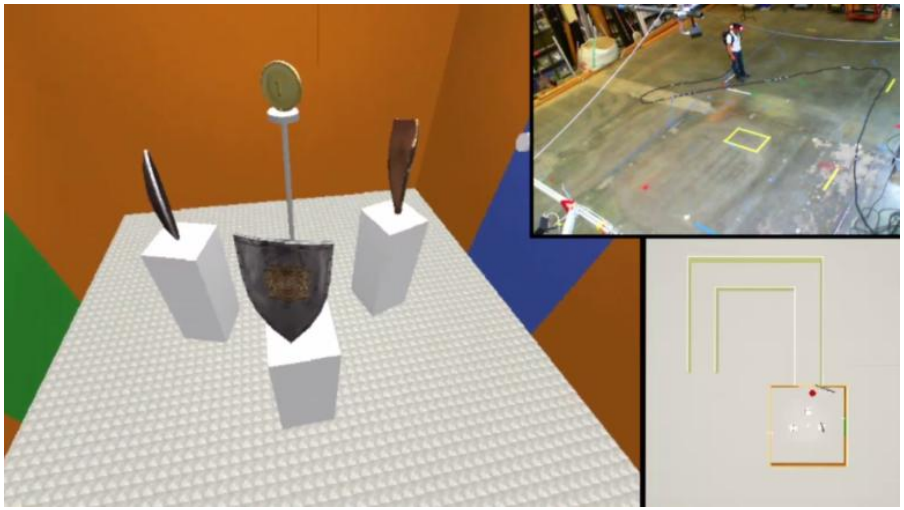
The Future of Immersive VR in Education ?


Air shafts
Queen's Chamber
Mortuary temple
Causeway
Gl-a
Gl-b
Gl-c

Flexible Spaces



- Real world rules do **not** apply
- Real walking
- Natural constraints
- Focus on virtual content
- Bigger distance between the rooms – more overlap
- Procedural layout generation

Summary

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

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Thank you!

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