Ein paar Dinge vorab:

- Heute letzter Termin mit prüfungsrelevantem Stoff
- kommende Woche (15.7.) frei zum lernen
- 22.7. zum Vorlesungstermin: Fragestunde zur Klausur

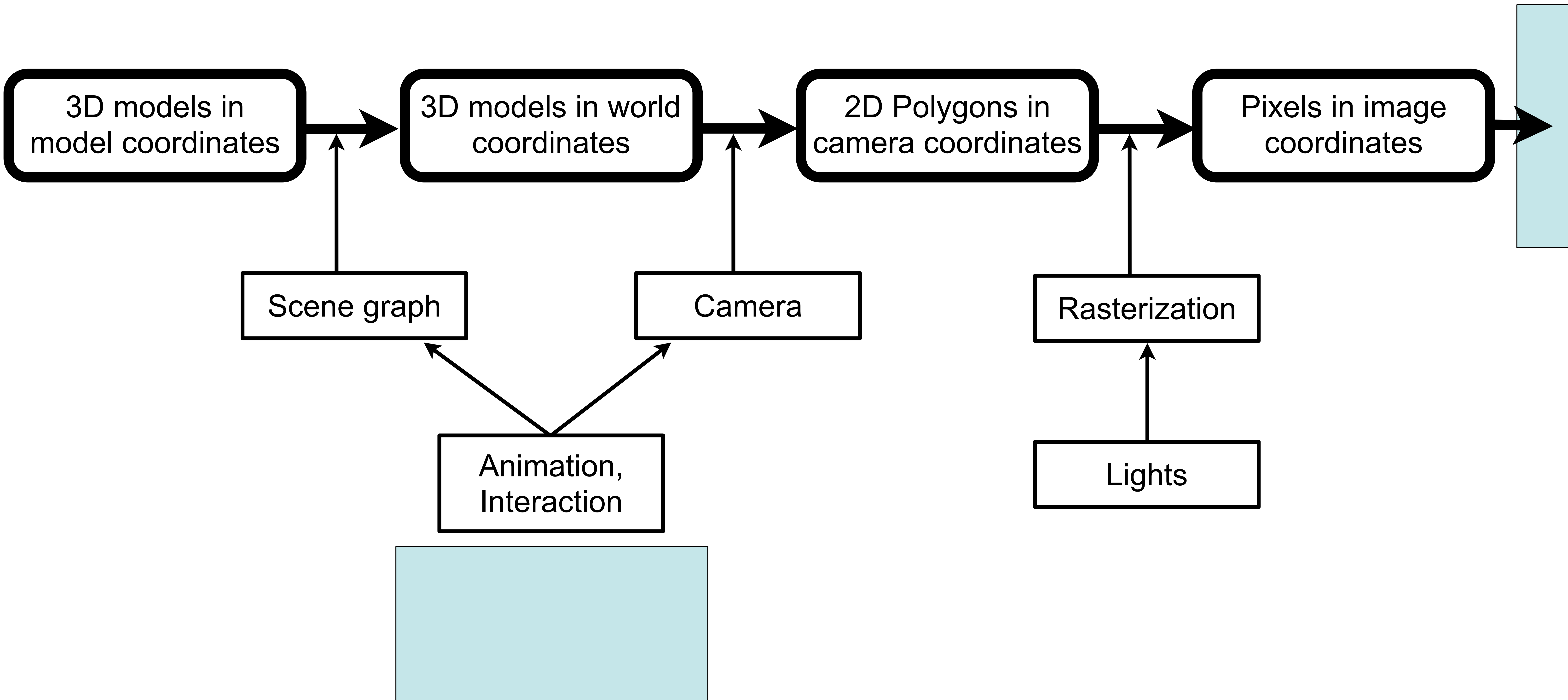
- Evaluation der Vorlesung
  - LMU-Evaluation: nach der Klausur
  - meinprof.de (optional!)

- Was ist mit der Fachschaft Medieninformatik?
  - Gestaltung der reformierten Bachelor-Ordnungen
  - Gestaltung der Master-Ordnungen
  - Gestaltung der Zulassungsordnung zum Master...
  - Modul persönliche und soziale Kompetenz...

Computer Graphics 1

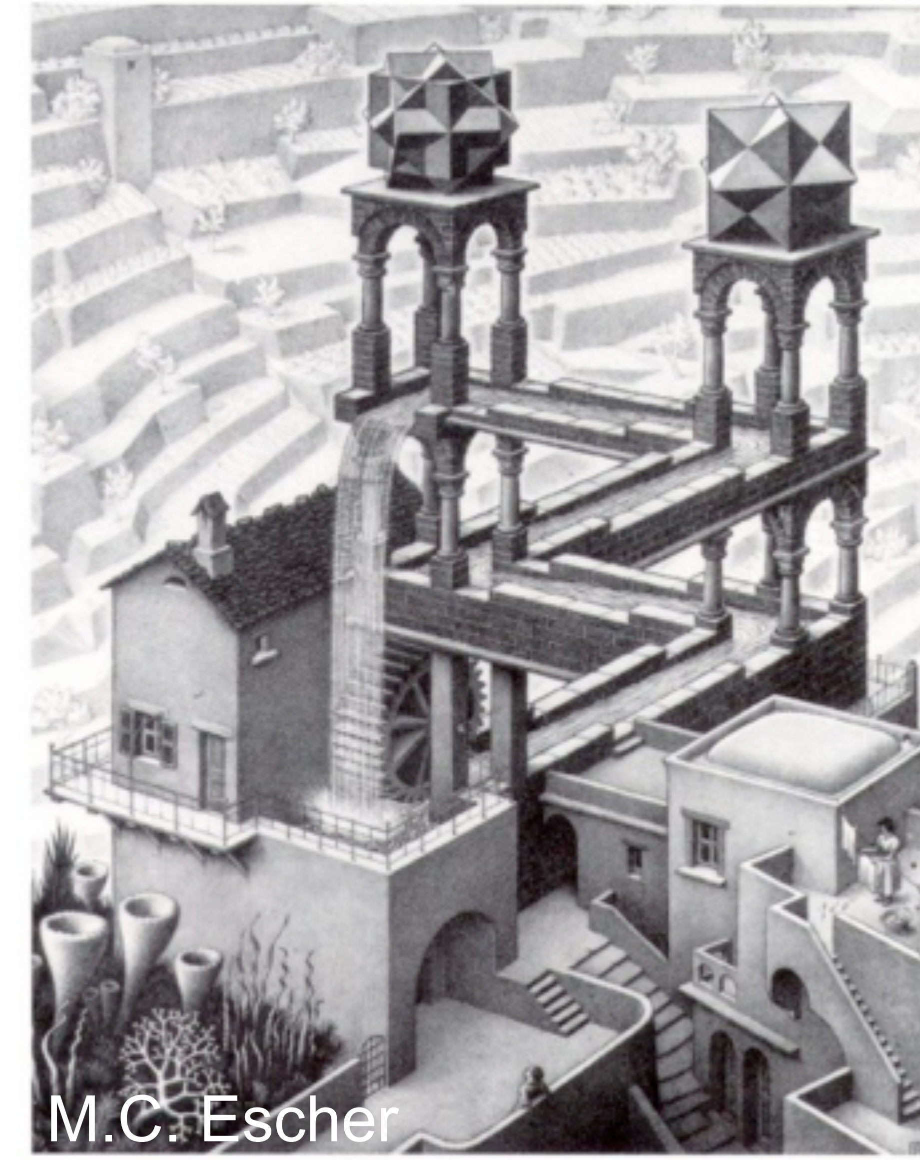
Chapter 10 (July 8th, 2010, 2-4pm):
3D input and output devices

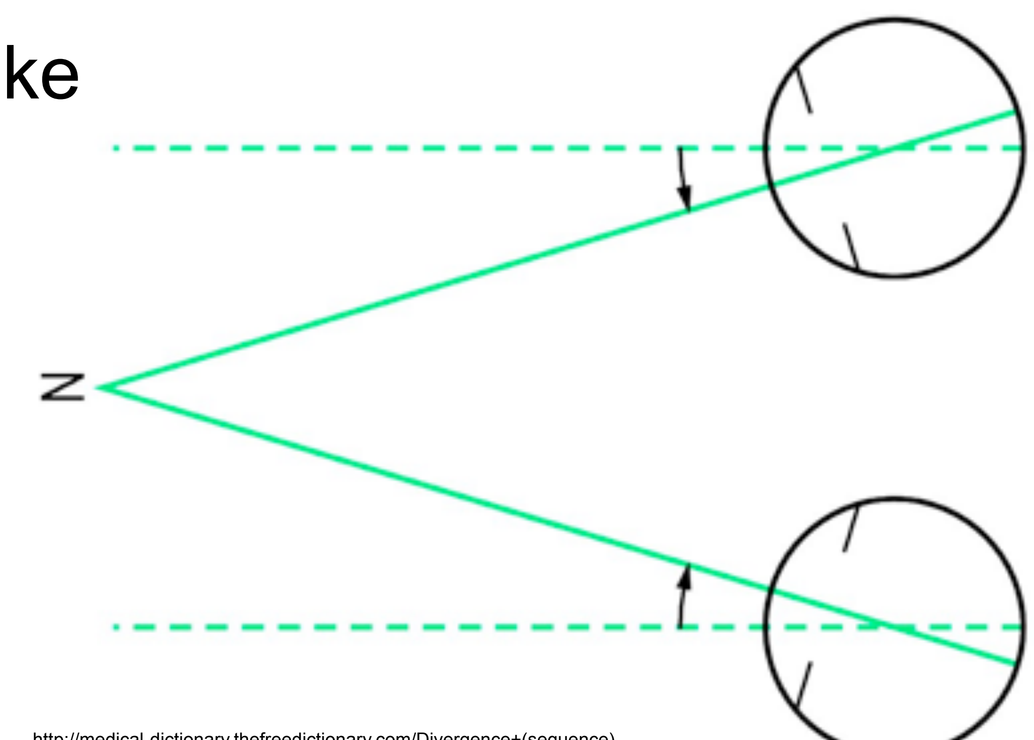
The 3D rendering pipeline (our version for this class)



Depth Perception in Human Vision

- The visual system derives spatial information from a number of cues:
- Monocular cues:
  - Occlusion: which objects cover up which other?
  - Size: the relative or familiar size of objects shows how far they are..
  - Perspective: assumptions about space and perspective communicate depth
  - Texture gradient: imagine a cobblestone pavement on the road before you...
  - Accommodation: the distance at which the eye lenses are focused
  - Motion parallax: moving the head left and right provides stereo-like depth perception with one eye only
- Binocular cues:
  - Stereopsis: different images seen by left and right eye
  - Convergence: the distance at which objects are in the same position for both eyes





http://medical-dictionary.thefreedictionary.com/Divergence+(sequence)

3D output devices + techniques

Anaglyphic stereo on conventional screens

- Overlays 2 images in different primary or complementary colors
  - mostly: left image in red, right image in cyan

- When rendering:
  - set conversion on main object
  - Set focus on main object (anyway ;-)
- When viewing:
  - convergence is on main object
  - accommodation is on screen
  - ideal: conversion in screen plane (i.e. focus = conv.)
- Cheapest way of achieving stereo vision
  - color stereo glasses for a few cents
- Unwanted effects on color
  - red/cyan: all colors there, but in different eyes...

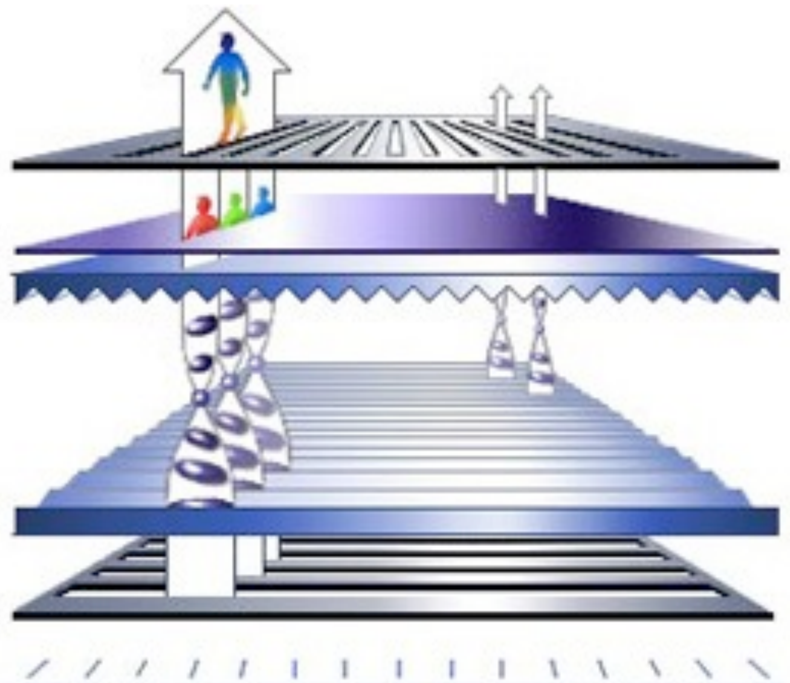
http://www.syndime.com/pics/Hulk.jpg

LCD Shutter Glasses

- Liquid crystals change polarization direction with electric current
- LCD element can be switched between transparent and opaque

- Each eye is covered by an LCD element
- Eyes are blinded alternatingly
  - left image is shown when right eye is blinded
  - right image is shown when left eye is blinded
  - light loss >= 50%
- Glasses need to be synchronized with screen
  - via cable or infrared

- Image frequency needs to be twice as high
  - can be a problem with projectors



http://www.beamer-freund.de/content/lcdelement.JPG

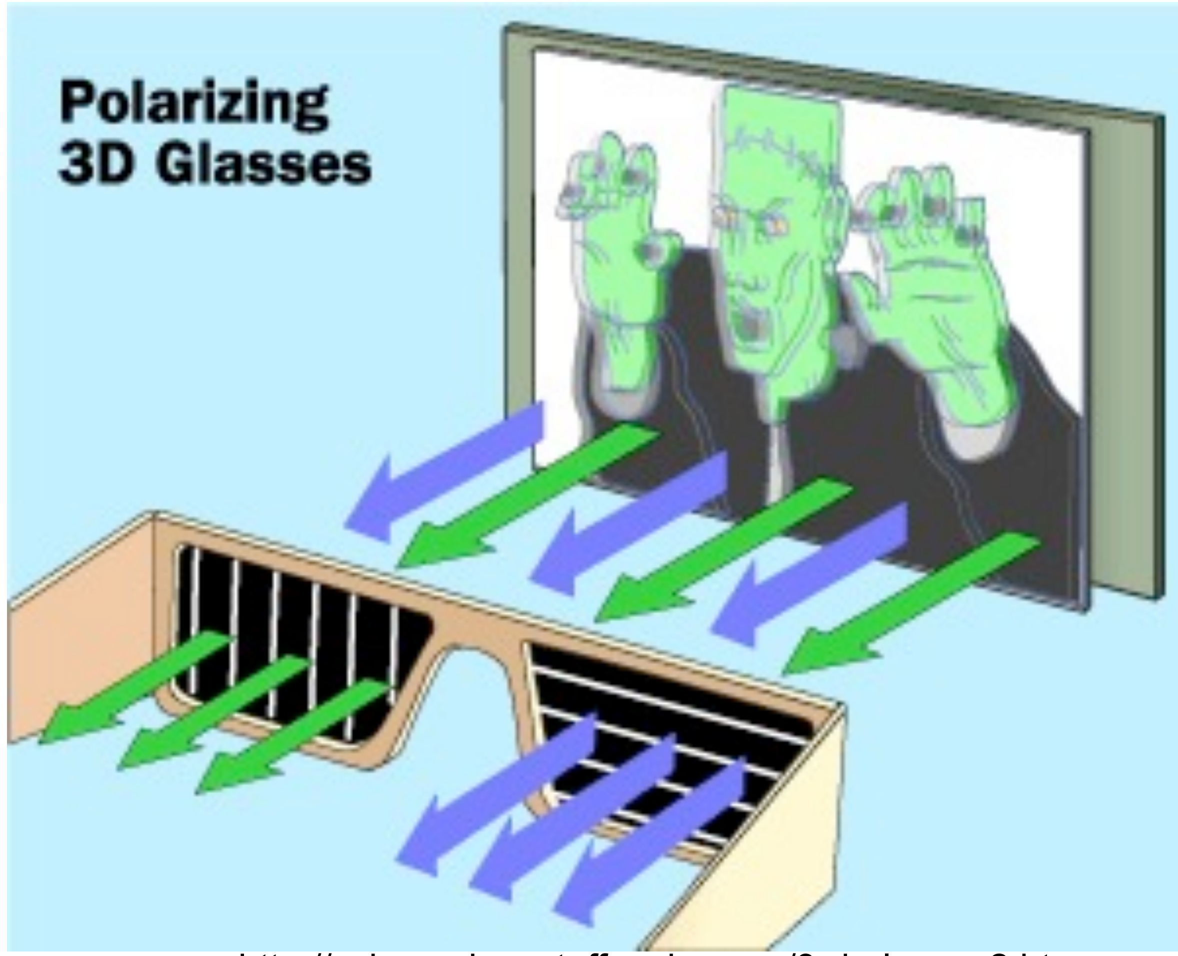
http://upload.wikimedia.org/wikipedia/commons/b/b6/CrystalEyes_shutter_glasses.jpg

Polarized Projection

- Project left and right image with different polarization
  - used to need 2 projectors for that
  - now available in 1 device for $6K
  - preserves full color

- Special projection screen needed to preserve polarization

- Cover eyes with orthogonal polarizers
- Polarizer glasses absorb light (>50%)
- Full color is preserved
- Focus + convergence on the projection plane



http://science.howstuffworks.com/3-d-glasses2.htm

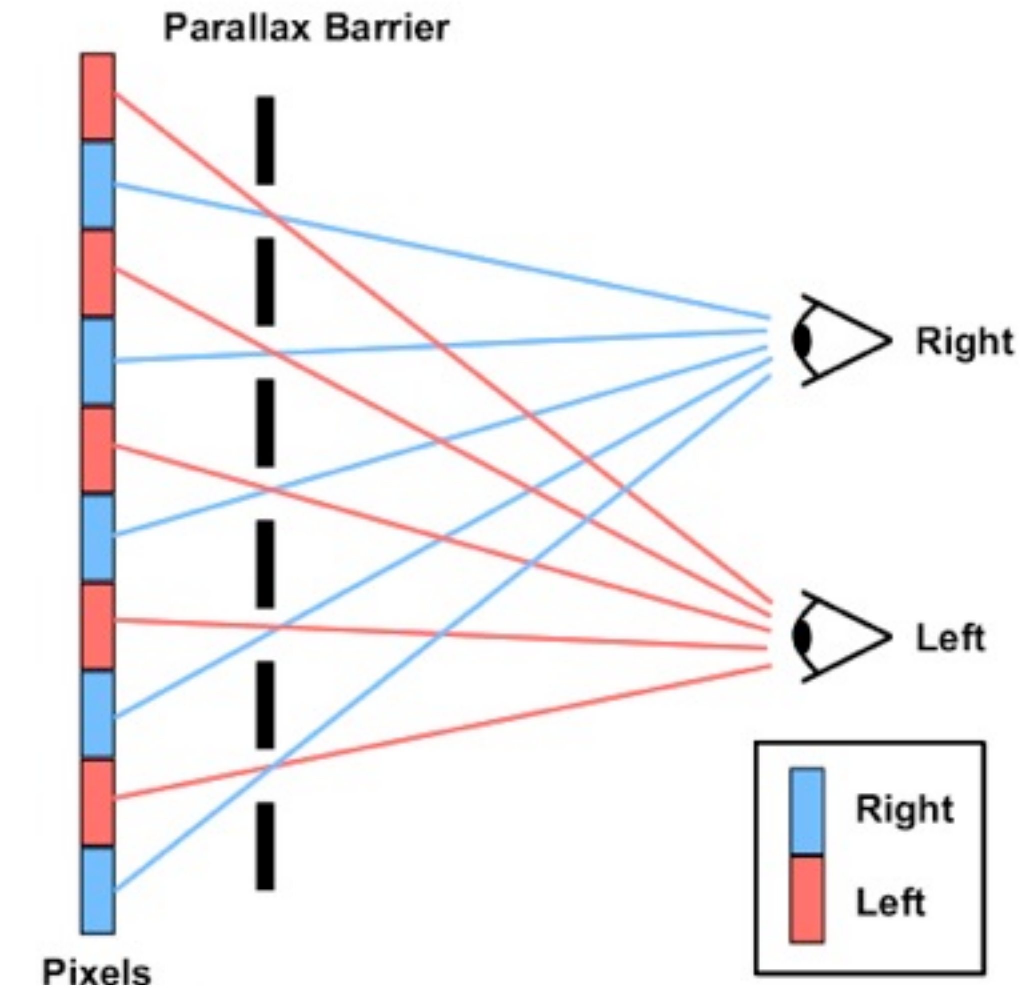
http://www.edimensional.com/popup_extra_images.php?peiID=389

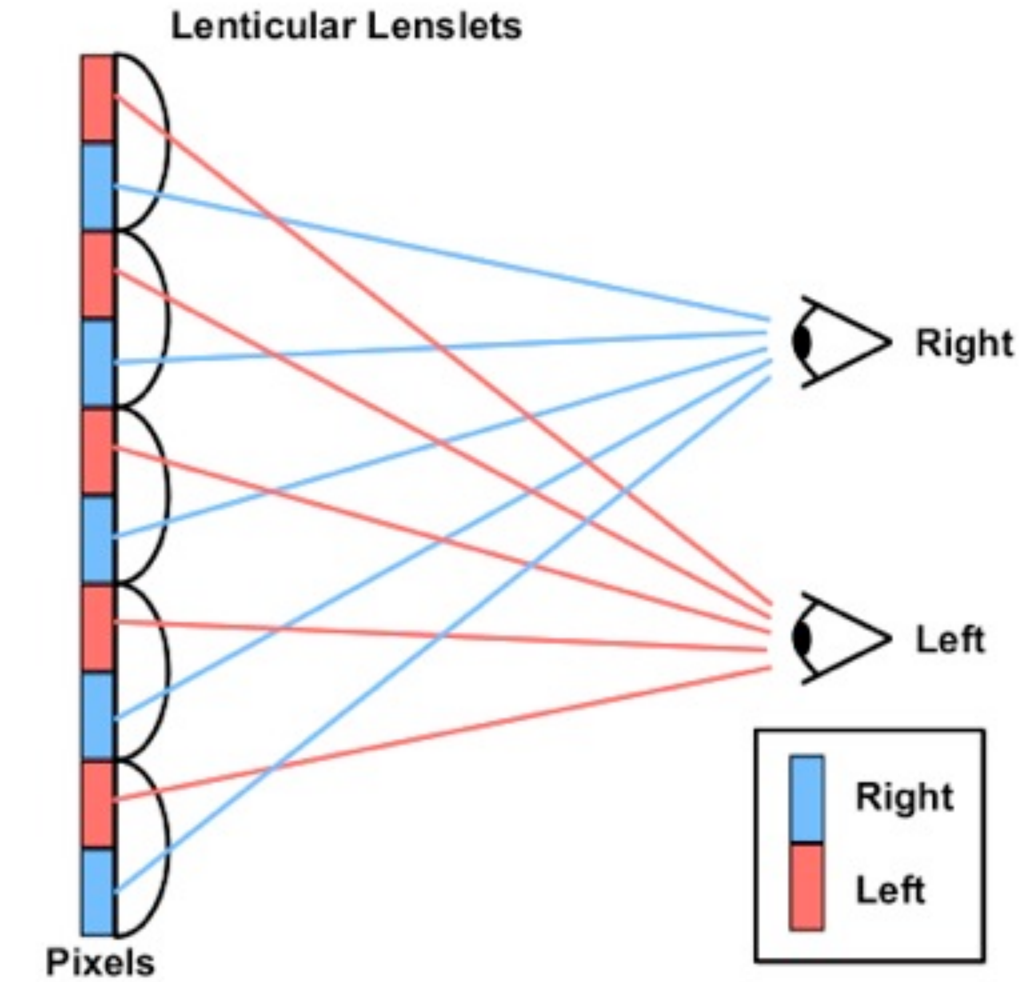
Autostereoscopic displays

- Provide different images to both eyes depending on their position
- Very sensitive to head motion
  - what about motion parallax?
- Different optical constructions exist
  - parallax barrier
  - lenslets, prisms

- accommodation on screen
- convergence on main object

- Principle was known since the 80s
- Still no wide adoption





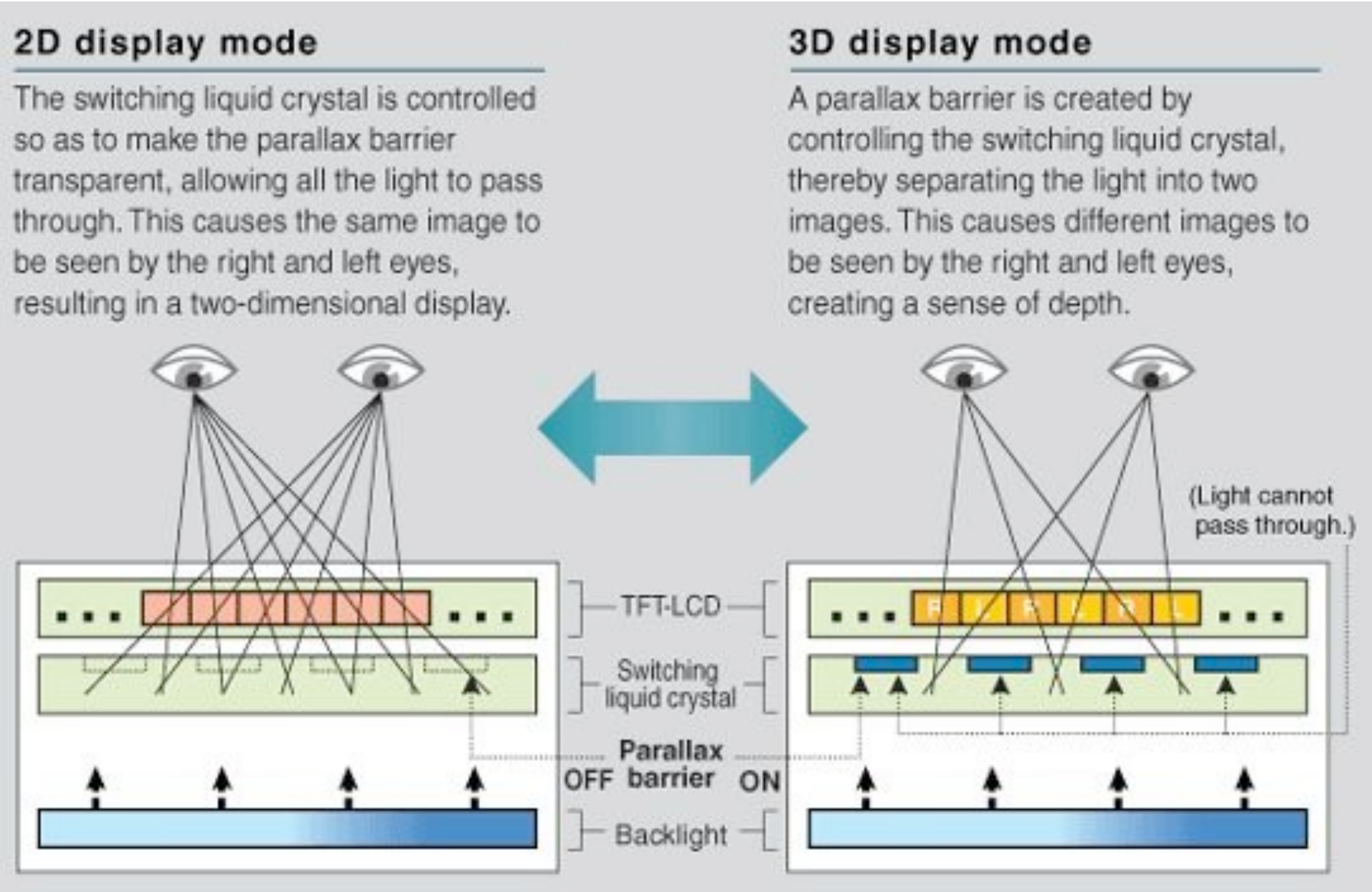
Excursion: 3D-TV

- No clear technology favourite for 3D TV yet, different systems in use:
  - Stereoscopy with shutter glasses (see there), works everywhere
  - stereoscopy with polarizer glasses (see there), no batteries needed
  - autostereoscopic screens (see there): works only in a sweet spot.

- Interesting technology proposed by SHARP:
  - switchable parallax barrier
  - can be used for 3D
  - can display 2D without loss

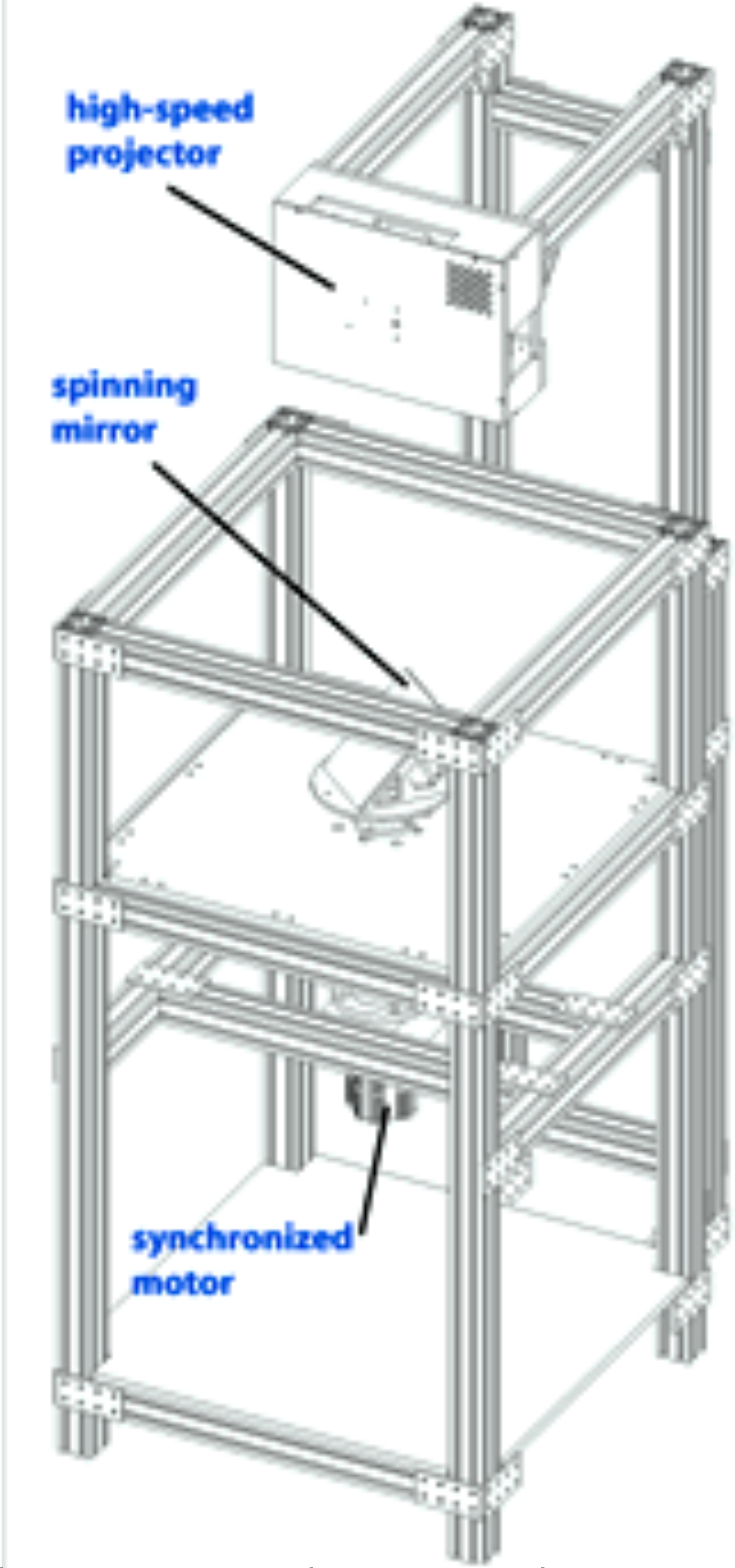
- very active development

http://www.thinkdigit.com/TVs/How-3D-TV-works-Part-II-_3602.html



Volumetric Displays

- Active field of research
- Several approaches exist
- Video: siggraph 2007 exhibit
- Discussion: How does this work?



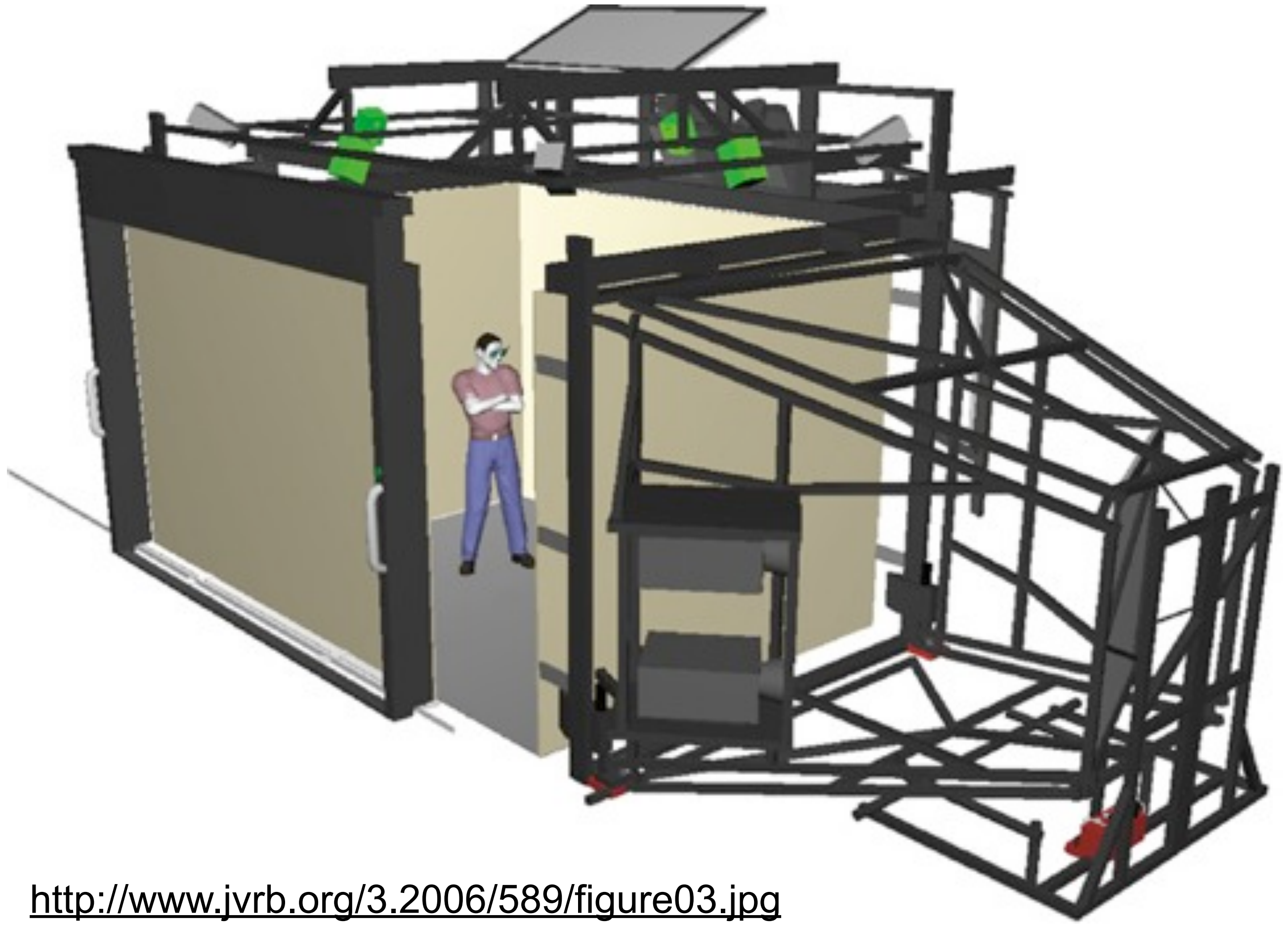
http://gl.ict.usc.edu/Research/3DDisplay/

CAVE

- CAVE Automatic Virtual Environment
- User is surrounded by back projection
- Minimum 3, maximum 6 sides
- stereo projection for space impression
- head tracking for correct perspective
- user can walk around (well, a bit ;-)

- Usually quite a big architectural effort
- LRZ is currently planning to build one
- http://www.badw.de/englisch/forschung_e/inf_e/e_22_informatik/index.html

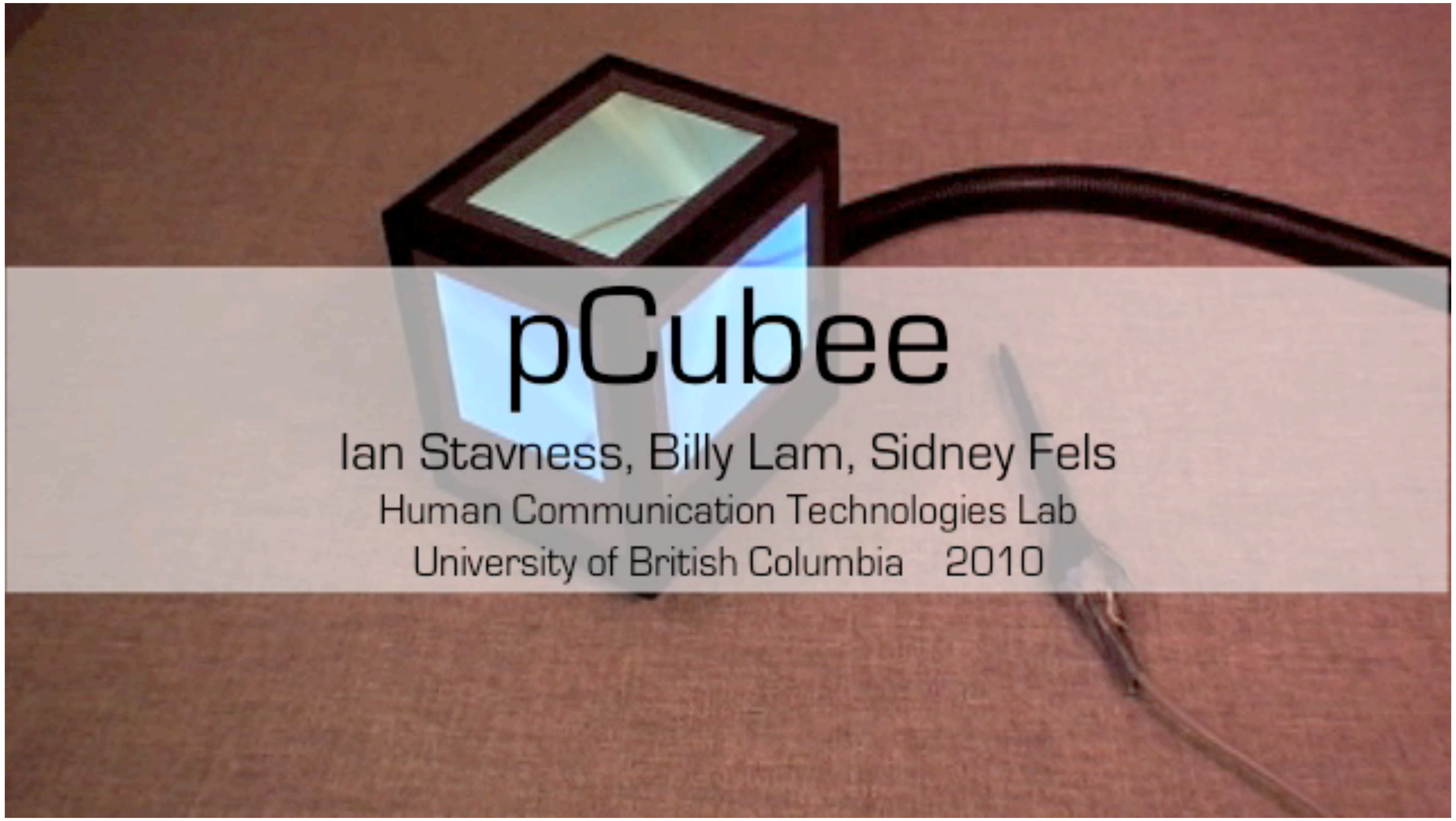
http://en.wikipedia.org/wiki/Cave_Automatic_Virtual_Environment



http://www.jvrb.org/3.2006/589/figure03.jpg

Head-tracked 3D and motion parallax

- Stereo rendering assumes a known head position
- Motion parallax needs head movements to work
- „Fishtank VR“ really needs head tracking to work properly
- If the display is moved, additional tracking is needed.



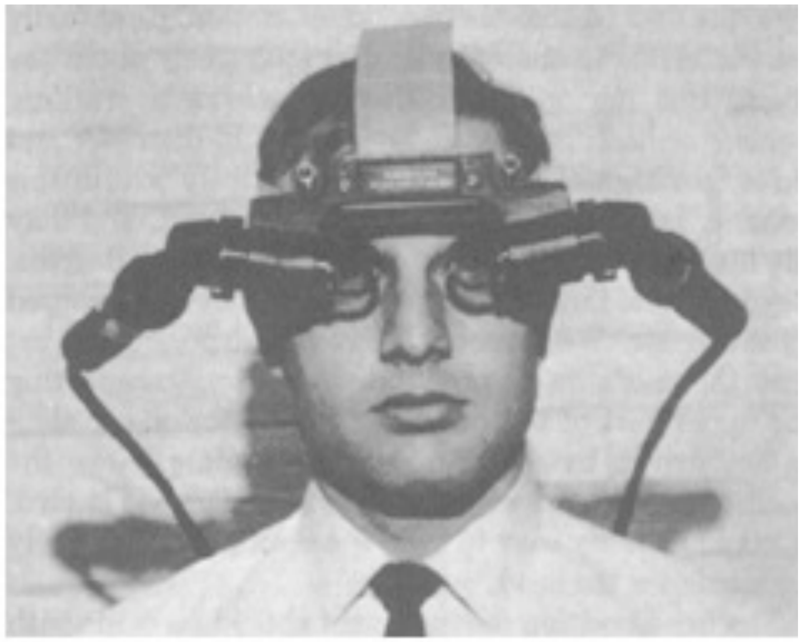
http://hct.ece.ubc.ca/research/pcubee/

Head-Mounted Displays

- Concept first presented by Ivan Sutherland 1965
- Large developments, but still no wide adoption

- Idea: have a small screen with optics for each eye
- stereopsis works well
- accommodation is usually fixed to a few meters
- convergence depends on rendering

- HMDs need fast tracking of the head
  – Discussion: why???



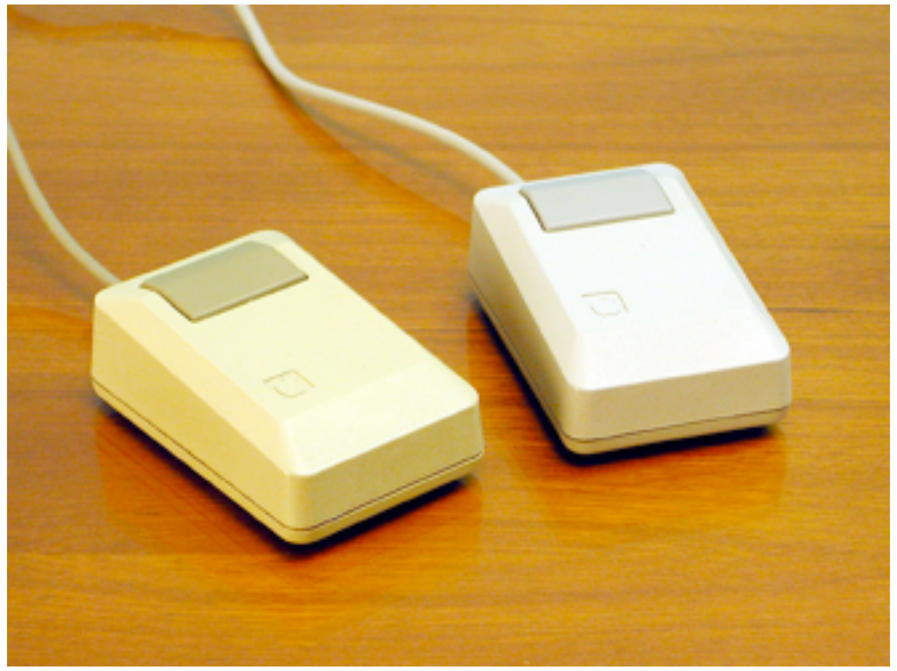
http://design.osu.edu/carlson/history/lesson17.html

http://www.vrealities.com/hmd.html

3D Input devices

2D mouse ;-)

- No real 3D interaction device, but still the one most often used for 3D interaction!
- Dimensionality is the same as 2D screen
  - similar problems result
- Substitute 3rd dimension by various means
  - input modes, e,g. by pressing buttons
  - interaction techniques (see last lecture)

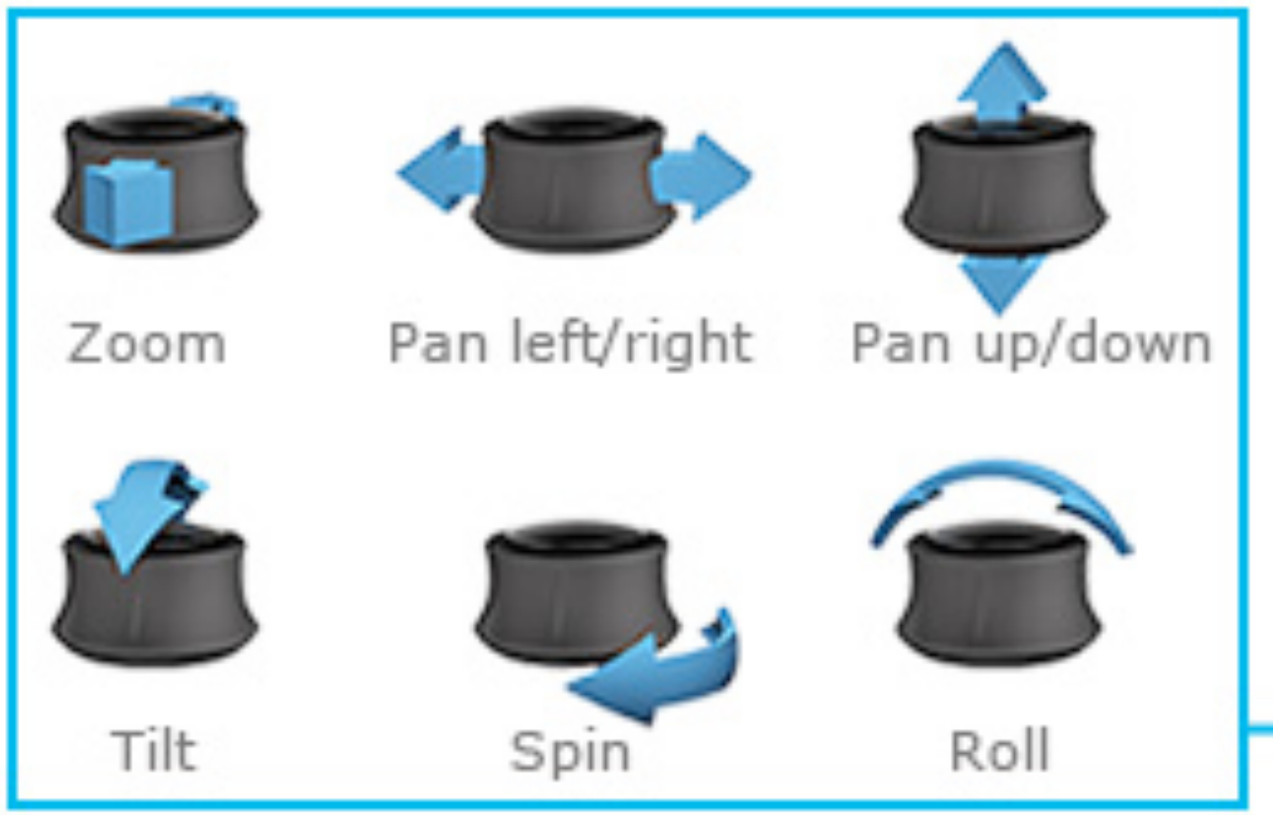


http://en.wikipedia.org/wiki/Mouse_(computing)

Space mouse

- Provides true 6 DOF input
  - 3x translate, 3x rotate
- Not an absolute and direct mapping as with 2D mouse
  - rather joystick-like mapping

- Various designs and manufacturers exist



http://www.3dconnexion.com/

Data Gloves

http://www.vrealities.com/glove.html

- Track the angles of the fingers
  - at various levels of exactness
- Some are also tracked in space (3-6 DOF)
- Models with force feedback exist
- Usually used with a virtual hand in the 3D scene

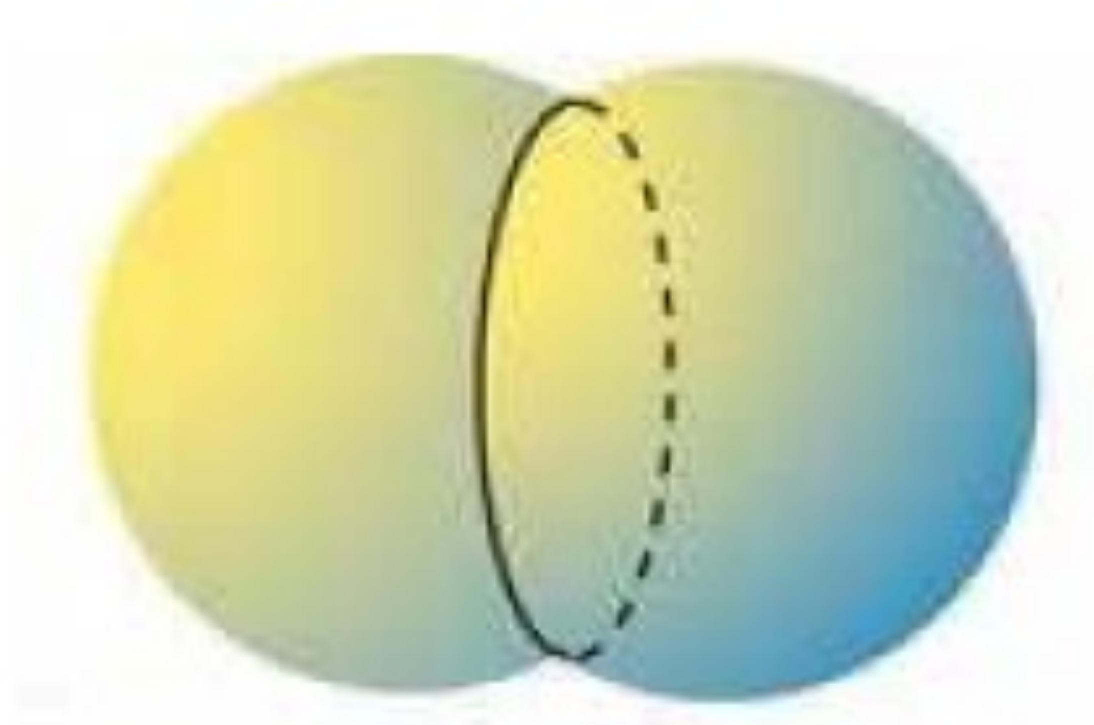
Tracking

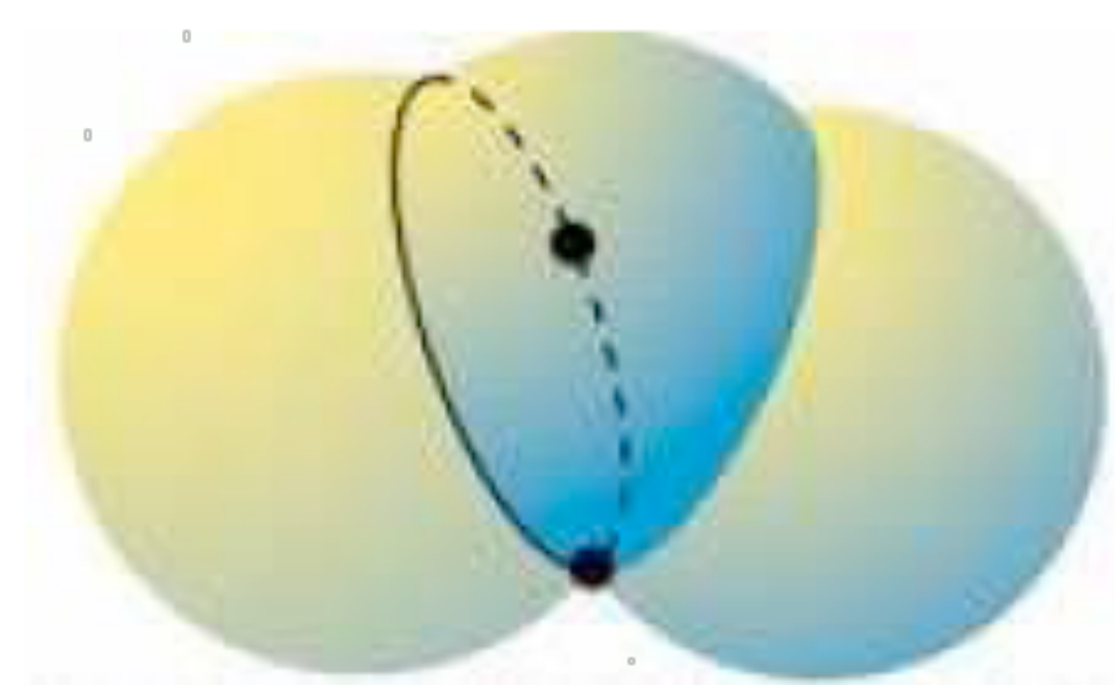
- Acoustic: 3D position
- Magnetic: 3D position + orientation (6 DOF)
- Inertial: 3D orientation and relative position

- other technologies and combined systems exist
  - beyond the scope of this lecture

Acoustical Tracking: Working Principle

- The tracking target is a known sound source emitting e.g. ultrasonic pulses
- 3 or more Microphones determine the time it takes for the signal to arrive. This is directly proportional to the distance (speed of sound = 330m/s)
- Time t to a microphone means the source is on a sphere with radius t/330
- 2 spheres define a circle, 3 spheres define 2 points
- 1 point can often be excluded logically
- Hence 3 mics can determine the 3D position of a sound source





[Bishop et al. 2001]

Magnetic Tracking: Working Principle

- Big stationary Coils create a known magnetic field in space
- This magnetic field induces a current in small coils, depending on their orientation and distance
- Three small coils can identify 3D position and orientation (=6 DOF)
- Two main principles:
  - low frequency AC, all metallic objects around influence the field
  - pulsating DC, only influenced by ferromagnetic objects
- Magnetic tracking is hard to calibrate and influences other devices

[Ascension Flock of Birds, DC]

[Polhemus FastTrak, AC]

Inertial Tracking: Accelleration sensors

- Built from piezo elements and weights
- Integrated circuit

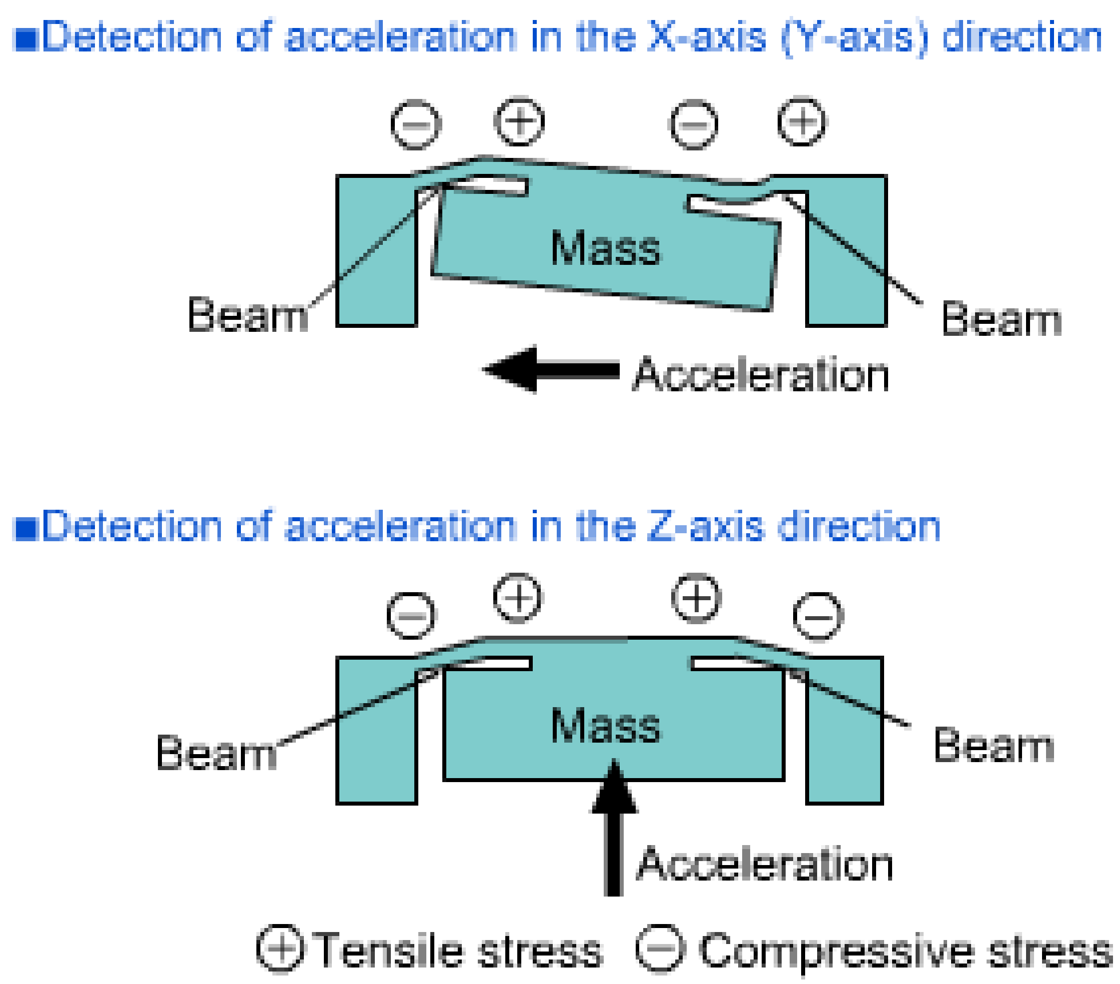
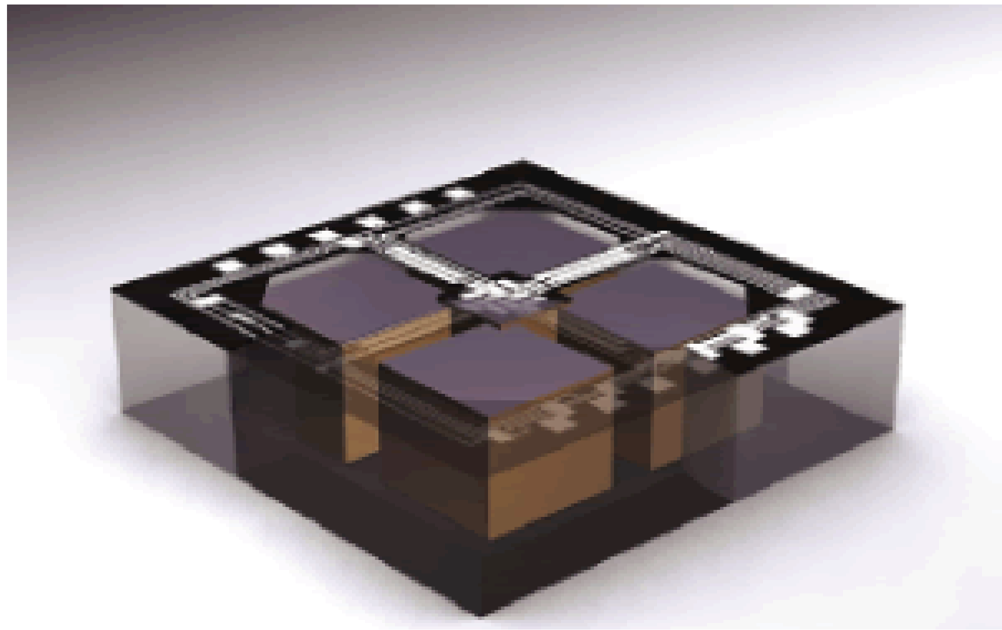
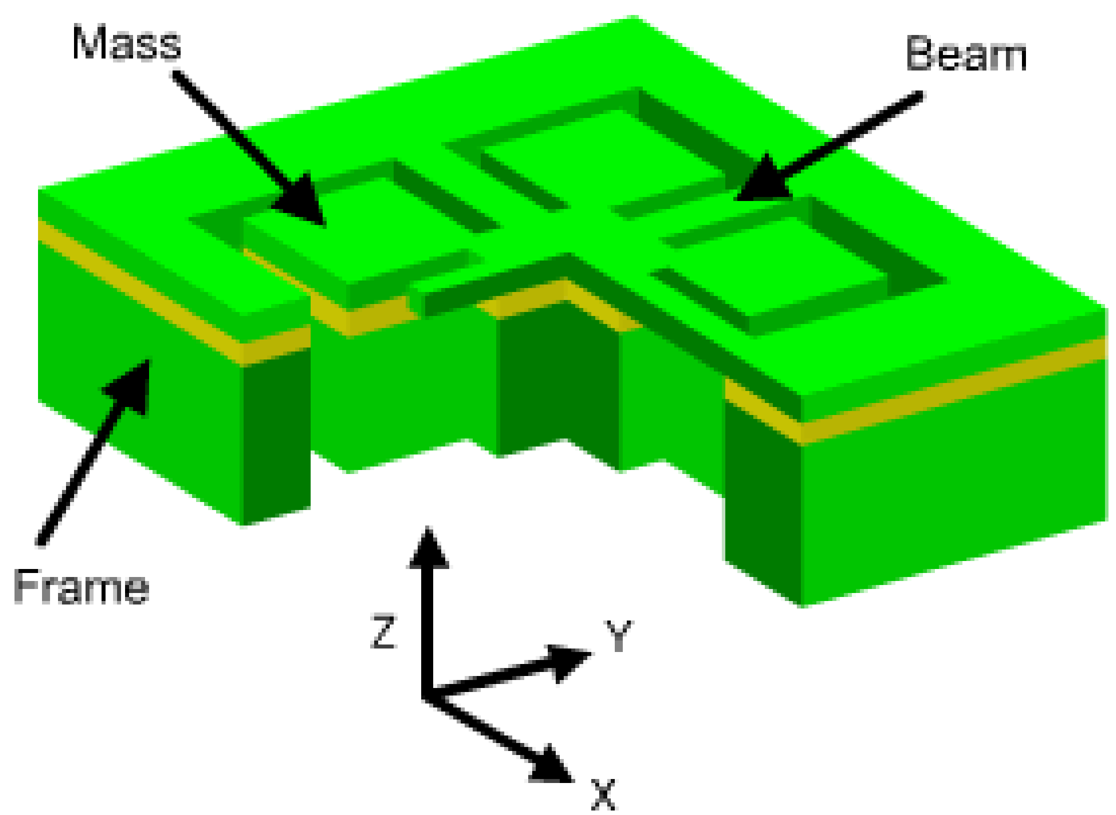
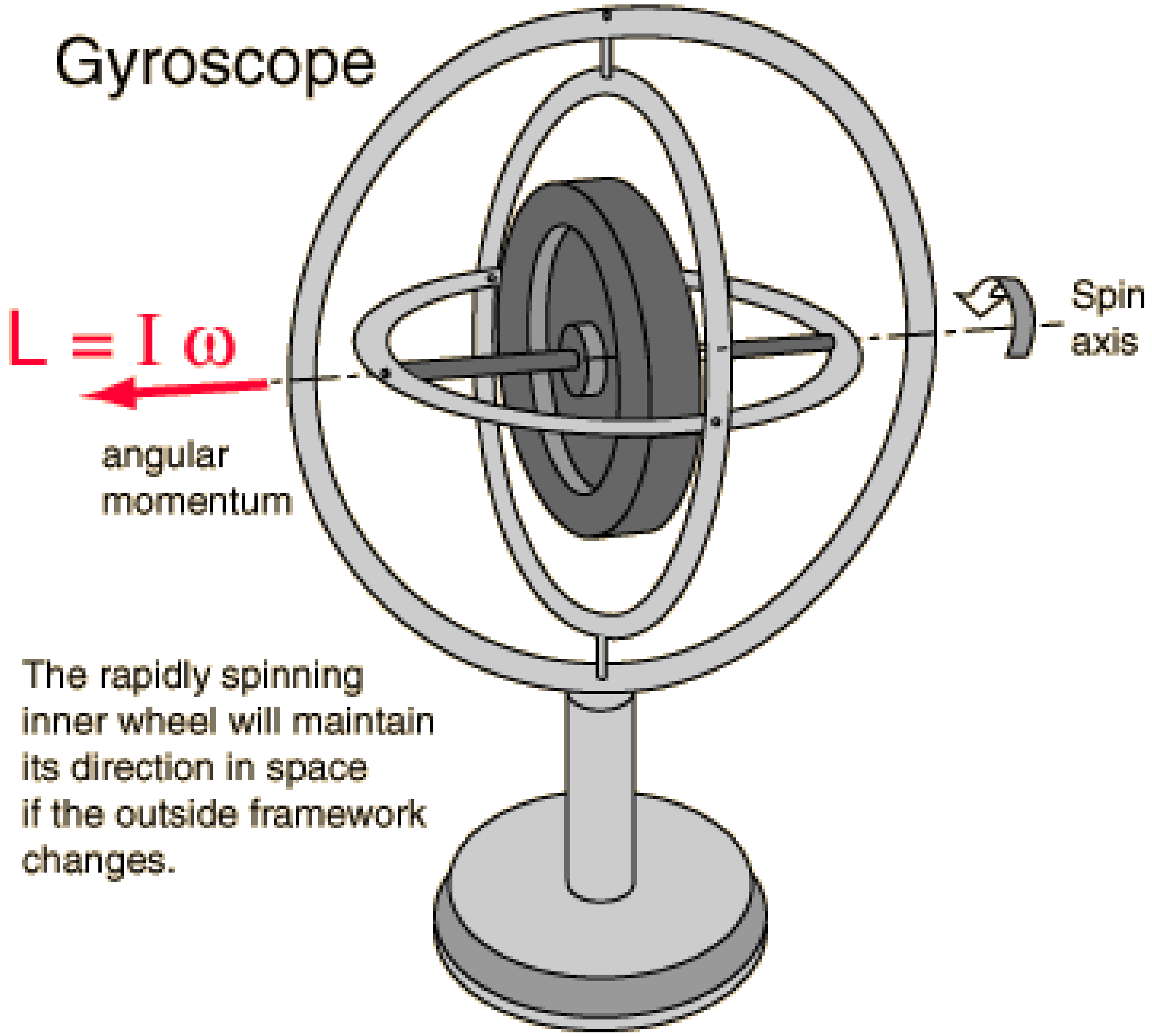


Figure 1 MEMS sensor chip in the GS3





Inertial Tracking: Gyroscopes



see also http://www.mikrokopter.de/ucwiki/GyroScope