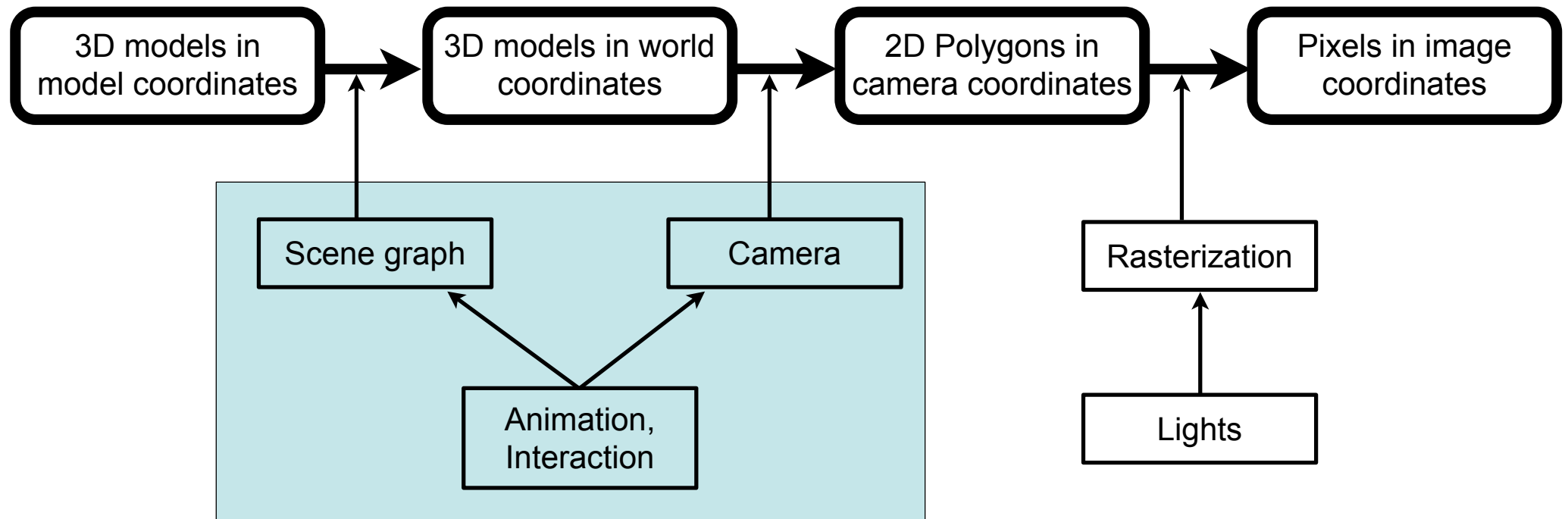


Chapter 10 - Interaction in 3D

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



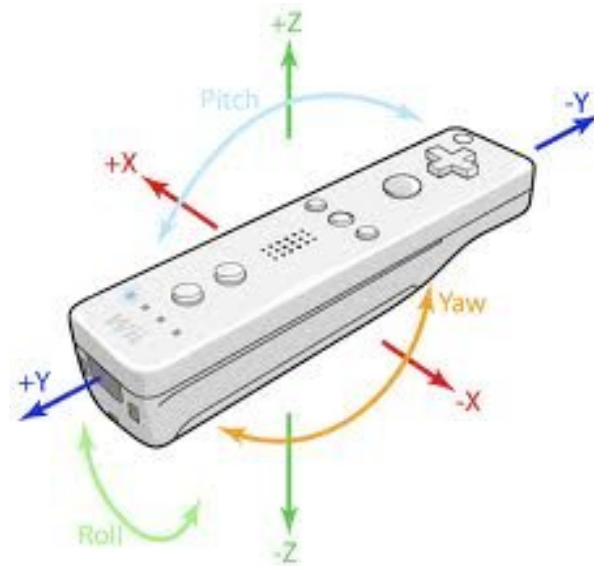
2D, 3D, and Interaction

- Interface based on 2D rectangular image
 - Rendering pipeline ends in 2D (raster) image
 - Most positional input devices (mouse, tablets, touch screens) designed for 2D
- Many interactions affect 3D world (scene graph)
 - Mapping of 2D-based interaction into 3D world
- Special interaction devices for 3D remain rarely used
 - Game controllers may change the situation



3D Mouse

“3Dconnexion SpaceNavigator”



Nintendo Wiimote

Logical Classification of Input Devices

- **Locator:**
 - Device for specifying one coordinate position
- **Stroke:**
 - Device for specifying a sequence of coordinate positions
- **String:**
 - Device for specifying text input
- **Valuator:**
 - Device for specifying a scalar input
- **Choice:**
 - Device for selecting a menu option
- **Pick:**
 - Device for selecting a component of a picture
 - Specific adaptations for 3D, see later

Accessing Physical Input Devices

- Standard input devices:
 - Mouse with several buttons and wheel
 - Keyboard
- Graphics API always provides access to standard devices
 - Java: Standard AWT/Swing API
 - JOGL/OpenGL: NEWT API for high performance multi-threaded programs
- Event listener approach:
 - Register/deregister method processing a specific type of event
- All of the high-level interaction methods described below have to be mapped to basic input device methods!

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Navigation in a 3D scene

- Two possible perspectives (and mental models):
- Move around or turn a 3D object
 - camera or object actively controlled
- Move within a 3D world
 - way of moving often borrowed from real world (walk, fly, drive, ...)
 - camera often associated with an “avatar”

Walk Mode

- Well known from many ego shooter games
- Use mouse or (cursor) keys to
 - move forward or backward
 - turn left or right
- Ground level needs to be defined
- Up always stays up
- „Gravity“ keeps avatar to the ground
- Additional actions may be defined (Jump, ...)
- User can get lost or trapped
- Often used in conjunction with navigation aids



<http://revistagames.files.wordpress.com/2009/12/doom11.jpg>

http://cache.kotaku.com/assets/resources/2007/05/tomb_raider_wii_500.jpg



Fly Mode

- Just like walk, but get rid of gravity
- Additional key or mouse mappings for up/down
- Can still be reasonably constrained
 - up stays up
 - gravity eventually pulls you down
- Can be fully unconstrained
 - additional mapping for roll left/right
 - scene can become all mixed up
- Provides better overview
 - just fly up high to see all terrain

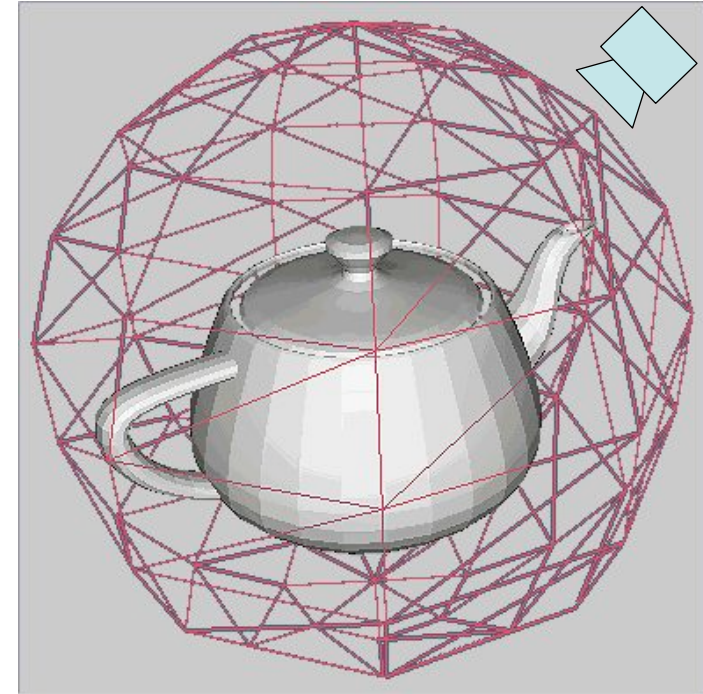


http://www.blogcdn.com/socialsoftware.weblogsinc.com/media/2006/01/second_life_web.jpg

Examine Mode

- Object to be examined is at the center of an invisible bounding sphere
- Mouse click touches the sphere and
- Mouse move drags its surface around

- No constraints, up doesn't stay up
- Can easily get lost and turn world upside down
- Motion can be constrained to one axis
 - less danger to get disoriented
 - danger of a „gimbal lock“ state



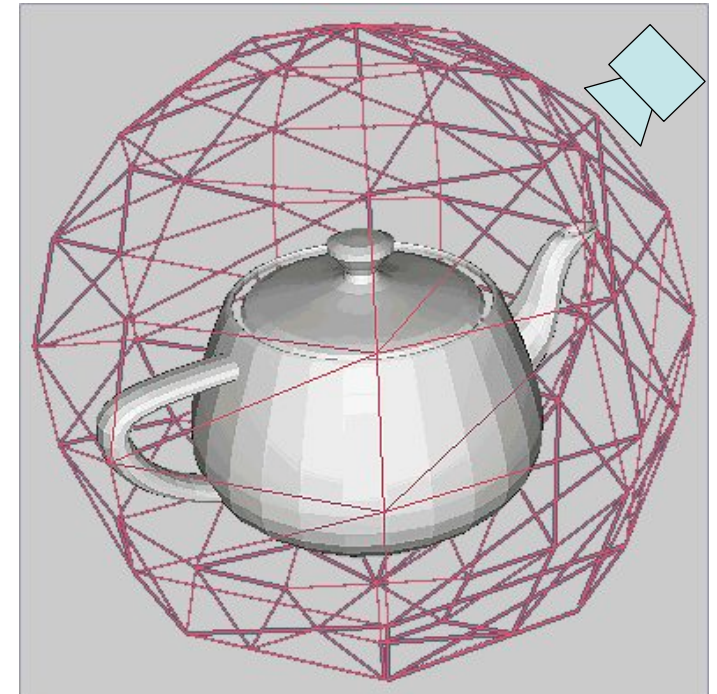
[http://docs.autodesk.com/3DSMAX/13/ENU/Autodesk 3ds Max 2011 Help/images/MED/Zelda-Ref/III/III_boundingSphere.png](http://docs.autodesk.com/3DSMAX/13/ENU/Autodesk%203ds%20Max%202011%20Help/images/MED/Zelda-Ref/III/III_boundingSphere.png)

Quiz:

There is one place on earth, from which you can go 10 Km south, 10 Km east and 10 Km north and you arrive at the same point. Where is this?

Scene in Hand - Camera in Hand

- In Examine mode there are two interface metaphors
 - they result in exactly opposite motions
- Scene in hand
 - moving the mouse left turns the scene left
- Camera in hand
 - moving the mouse left moves the camera left
 - this causes the scene to turn right
- Read up:
 - [Ware & Osborne 1995: Exploration and Virtual Camera Control in Virtual Three Dimensional Environments]



Navigation Aids

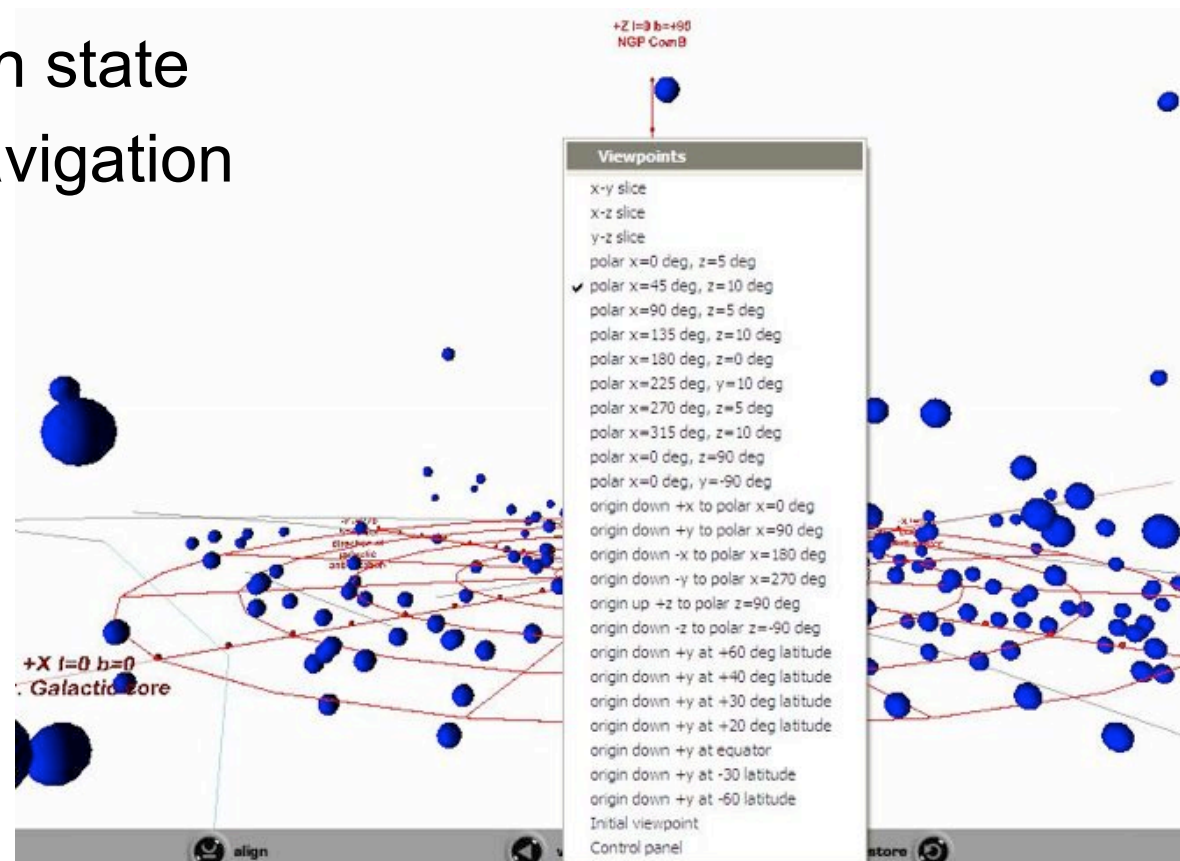
- Maps
 - provide overview and orientation
 - can provide additional info (objects, enemies)
- Compass
 - shows heading info
 - helps keeping track of orientation in a maze



http://www.wizards.com/dnd/images/rhod_maps/95695.jpg

Fixed Viewpoint Transitions

- Define multiple viewpoints (cameras) in scene
- Move from one viewpoint to another
 - animate camera movement
 - camera „cut“
- Always land in a safe and known state
- Use in conjunction with other navigation
 - provides a „safe anchor“



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Picking

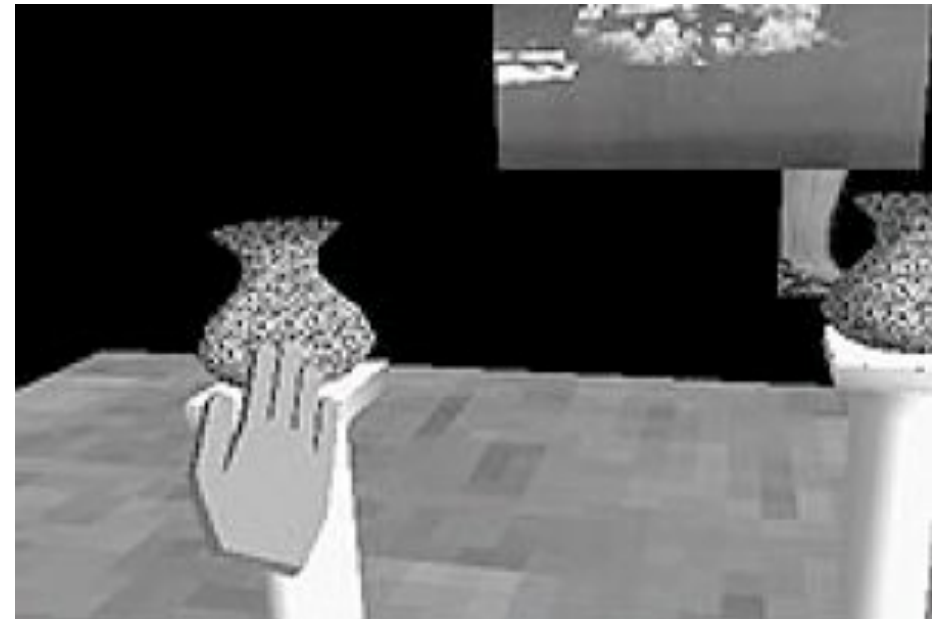
- Given a mouse position, which object in the 3D scene is hit by it?
 - potentially several
 - We may want all to select from them, or just the first
- Expensive: Intersect ray with all objects (as in raytracing)
- Cheaper: OpenGL picking by modified rendering
 - see next slide
- Very cheap: color coding
 - Define unique color for each object (independent of actually rendered color)
 - Render with these special colors on back buffer (invisible to user)
 - Derive object identity from color of pixel
 - Assumes double buffering. Do not swap front and back buffer here!
- <http://www.lighthouse3d.com/opengl/picking/>

OpenGL Picking

- Uses a special rendering mode (*GL_SELECT*)
 - Rendering only internally for picking, not actually shown on display!
- Can deliver all objects at a certain (2D specified) position
 - Using a *pick buffer* to store found objects
 - Objects can be assigned unique IDs (numbers) for this
 - Otherwise just minimum and maximum depth are recorded
- Uses a *pick window*
 - Small viewing volume around the mouse
- Basic sequence:
 - Prepare pick buffer and object IDs
 - Get window coordinates of mouse
 - Enter selection mode
 - Define pick window and render all objects/Polygons in that smaller volume
 - Exit selection mode and identify objects rendered in pick window

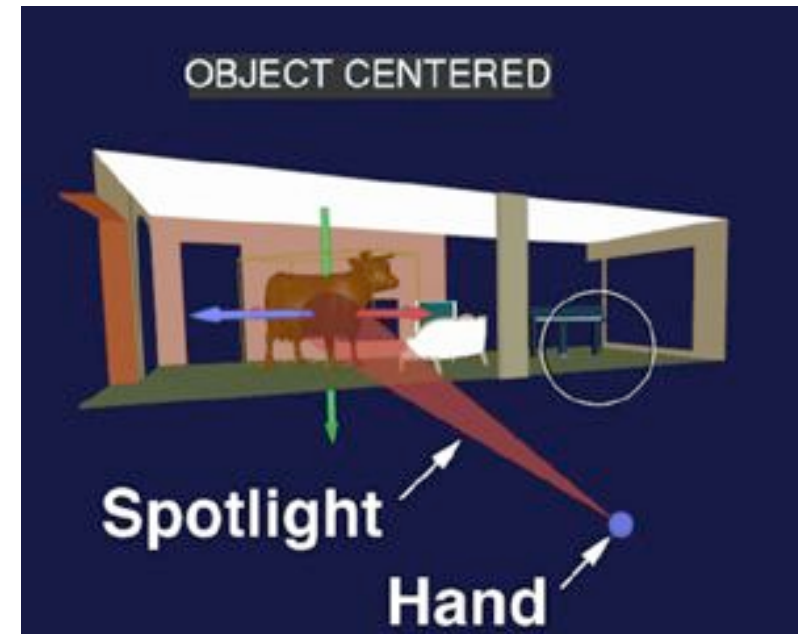
Direct Hand Manipulation (3D Cursor)

- Move a cursor (or hand) in 3D space with input device
 - 3DOF space mouse directly
 - regular mouse with modes
- Select object by moving the 3D cursor directly to its position
- Efficient object retrieval via octrees
- Problem: object may be out of reach



Ray and Beam casting

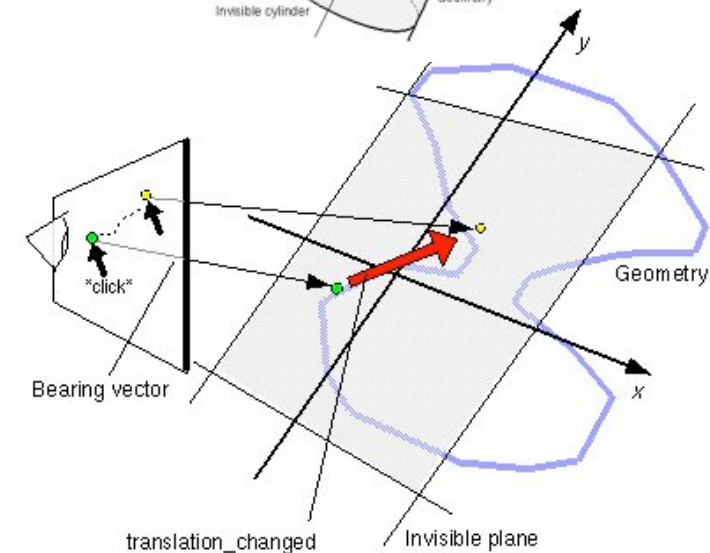
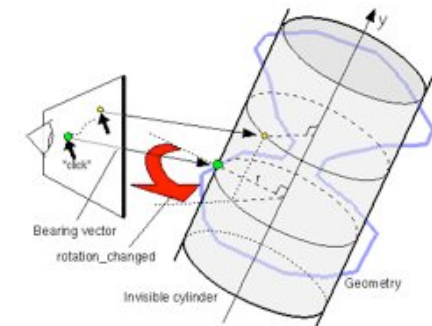
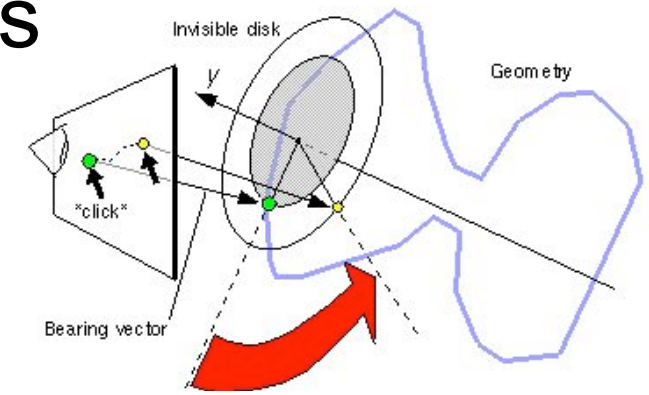
- Technique for selecting objects out of reach
- Given an immersive 3D world (HMD, data glove, ...)
 - compute a ray or beam from the hand into the scene
 - find the first intersecting object
 - susceptible to Jitter (think of a laser pointer)
- read up:
 - [Mark R. Mine, '95: Virtual Environment Interaction Techniques]
 - <ftp://ftp.cs.unc.edu/pub/technical-reports/95-018.ps.Z>



http://w3-mmt.inf.tu-dresden.de/english/projekte/CONTIGRA/Realisierung/Widget_Classification/images/spotlight.jpg

Manipulation with Constrained Motions

- Select an object in the scene using the techniques above
- Unconstrained motion would need 3 DOF input
- Constrain motion to 1 or 2 dimensions
- Example in VRML:
 - Cylinder sensor: object rotates about 1 axis (1 DOF)
 - PlaneSensor: object moves in a plane (2 DOF)

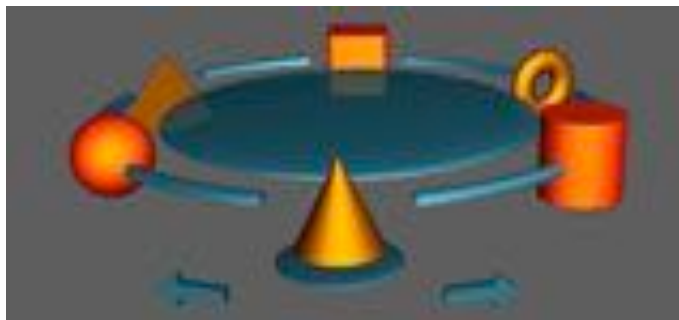


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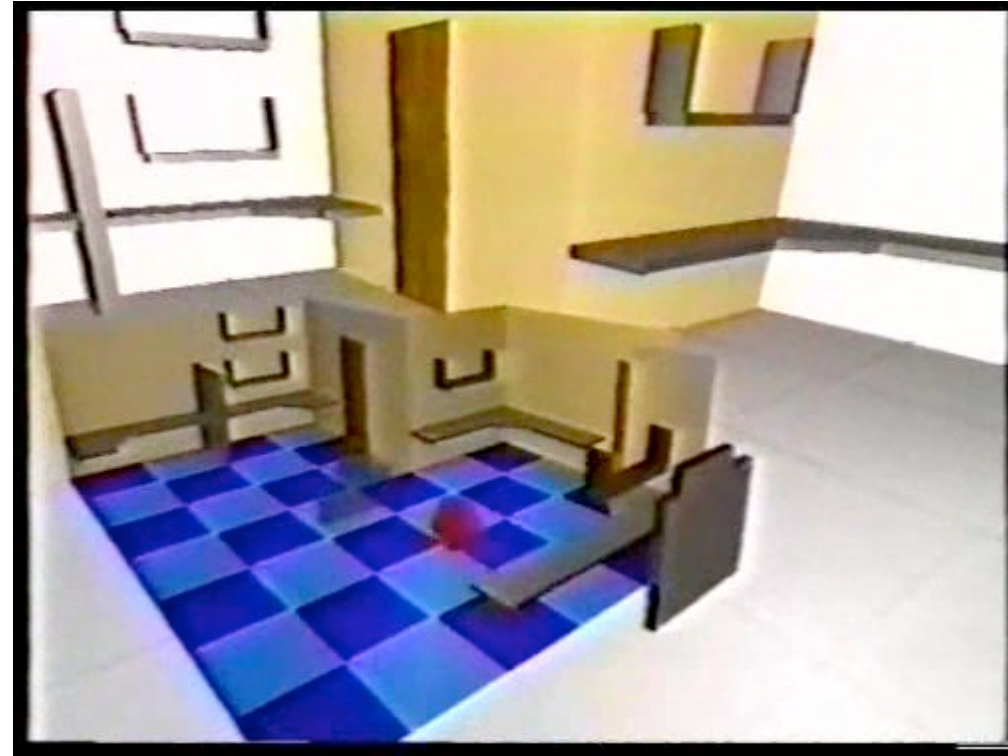
3D Widgets

- Tools which are mostly part of the 3D scene themselves
- Used for object selection, manipulation and navigation/inspection
- Many examples at Raimund Dachsel's collection
– <http://www.3d-components.org/>



World in Miniature - WIM

- Miniature copy of the entire 3D world
 - can be manipulated in the hand
 - acts as a representation of the big world
 - feels like a 3D map
- Interaction techniques using a WIM:
 - Quickly changing the point of view
 - Object selection over a distance
 - Object manipulation
- read up:
 - [Stoakley et al. 1995: Virtual reality on a WIM: interactive worlds in miniature]
 - <http://www.cs.cmu.edu/~stage3/publications/95/conferences/chi/paper.html>



Silk Cursor

- Use a semi-transparent volume as a 3D cursor
- Controlled in 3 degrees of freedom
 - translation along 3 axes
- Judge depth ordering by the partial occlusion effect
- Used to select objects out of reach
- read up:
 - Shumin Zhai, William Buxton, Paul Milgram 1996: The Partial-Occlusion Effect: Utilizing Semitransparency in 3D Human-Computer Interaction
 - http://etclab.mie.utoronto.ca/people/shumin_dir/SILK/silk.html

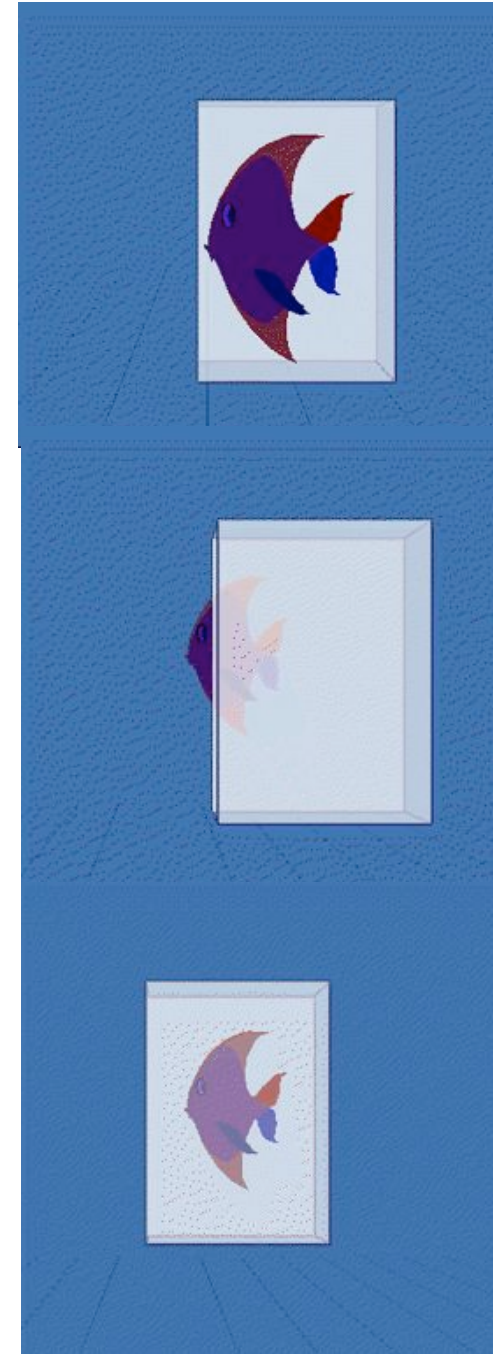
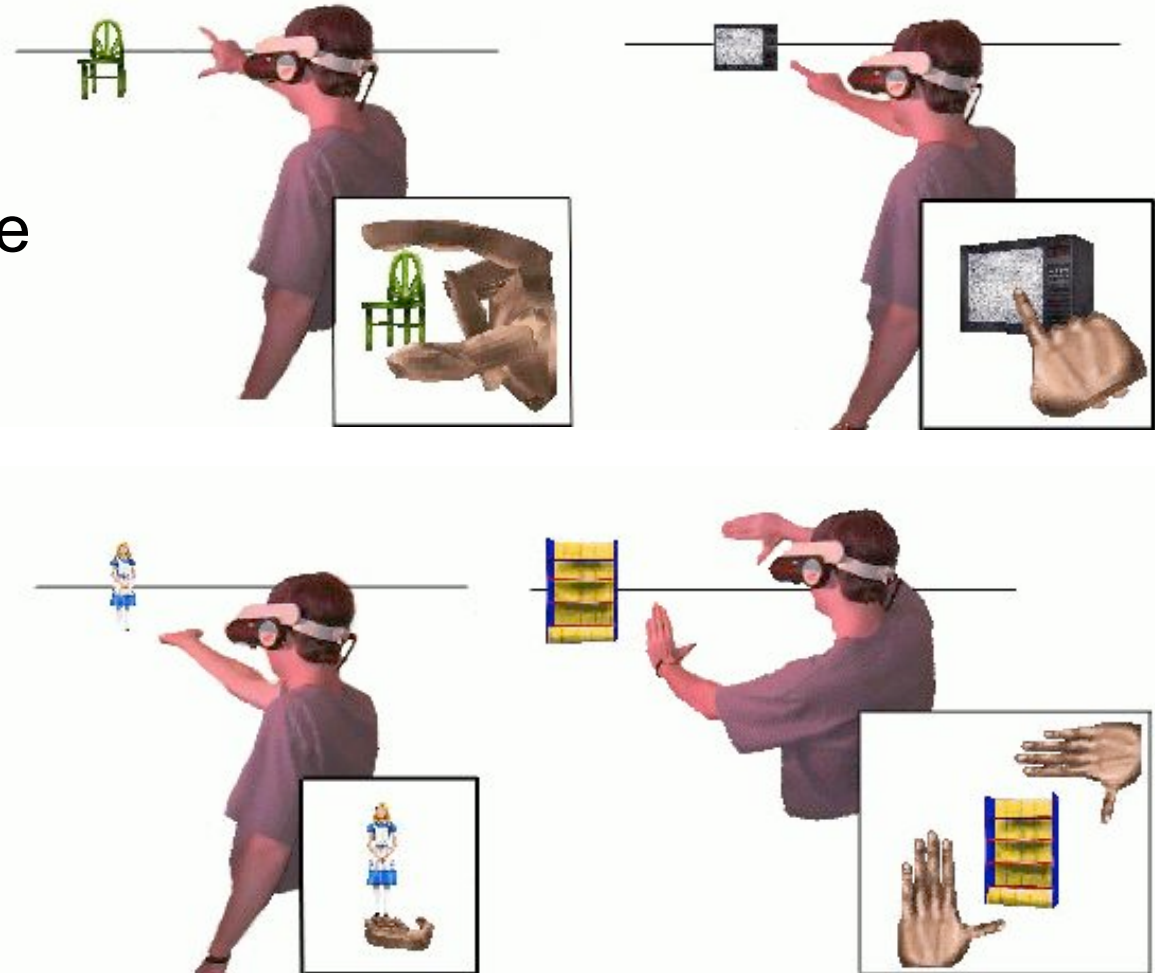


Image Plane Interaction

- Used with HMDs
- Find finger positions in the image
- Cast a ray into the scene, and intersect it with objects
- Several techniques proposed:
 - head crusher
 - sticky finger
 - lifting palm
 - framing hands
- Read up:
 - [Pierce et al. 1997: Image Plane Interaction Techniques In 3D Immersive Environments]



– <http://www.cs.cmu.edu/~stage3/publications/97/conferences/3DSymposium/HeadCrusher/>

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PerspectiveTable

- Gemeinsames Projekt RWTH Aachen & LMU München
 - Aktuelle Forschungsarbeit
- Basiert auf zwei Arbeitsplatz-Prototypen, die große horizontale und vertikale Touch Displays kombinieren



BendDesk

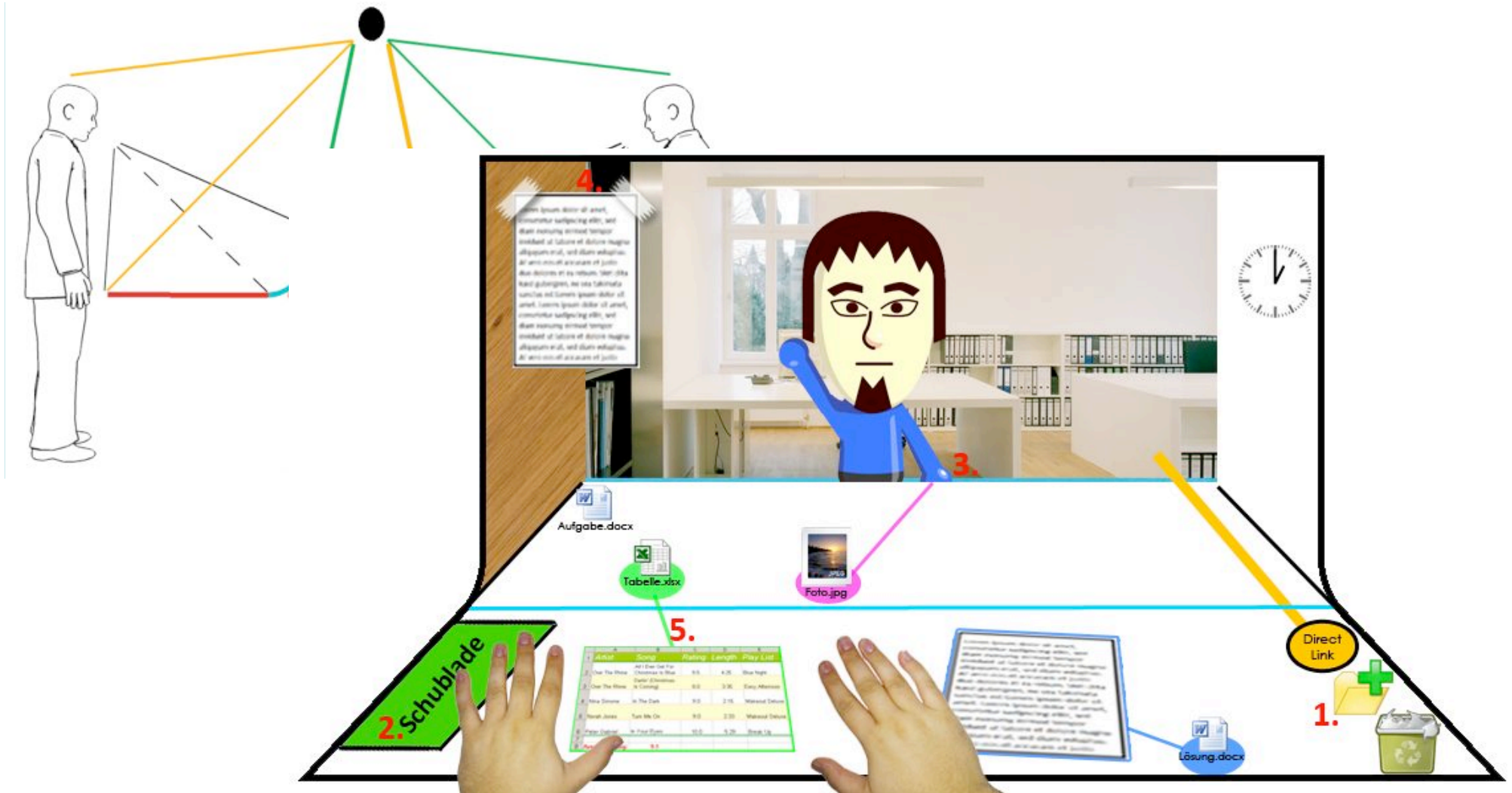
RWTH Aachen



Curve

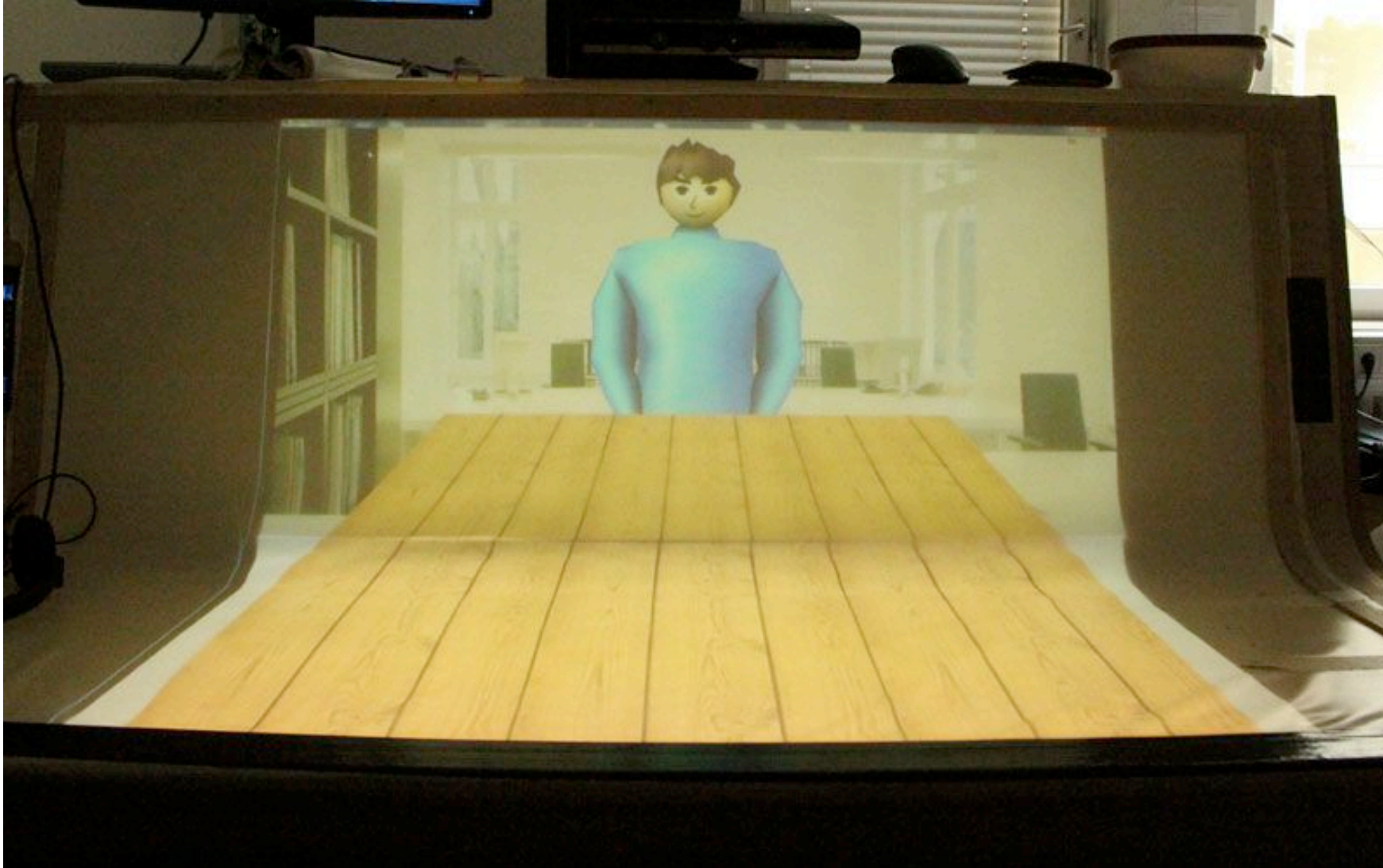
LMU München

Telekooperation über zwei Tischpulte

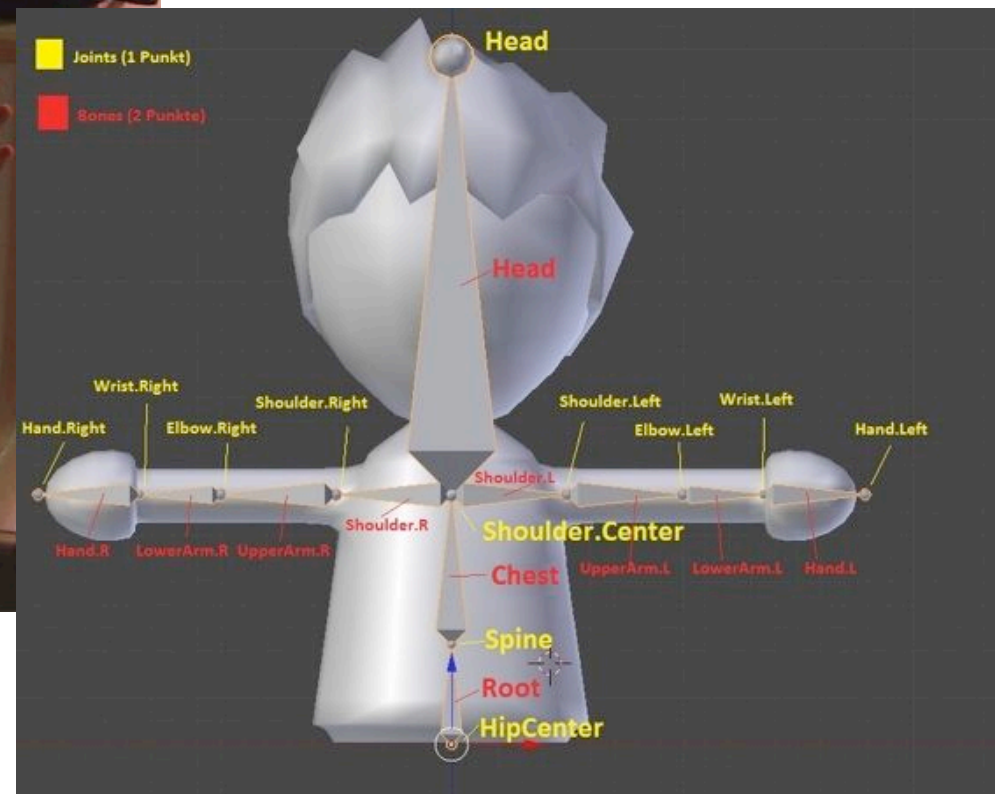


Genüber als Avatar repräsentiert

- Fertiges System:



Skelettanimation gesteuert durch Tiefenkamera



Arbeitsbereiche und Metaphern

