3D Interaction Techniques

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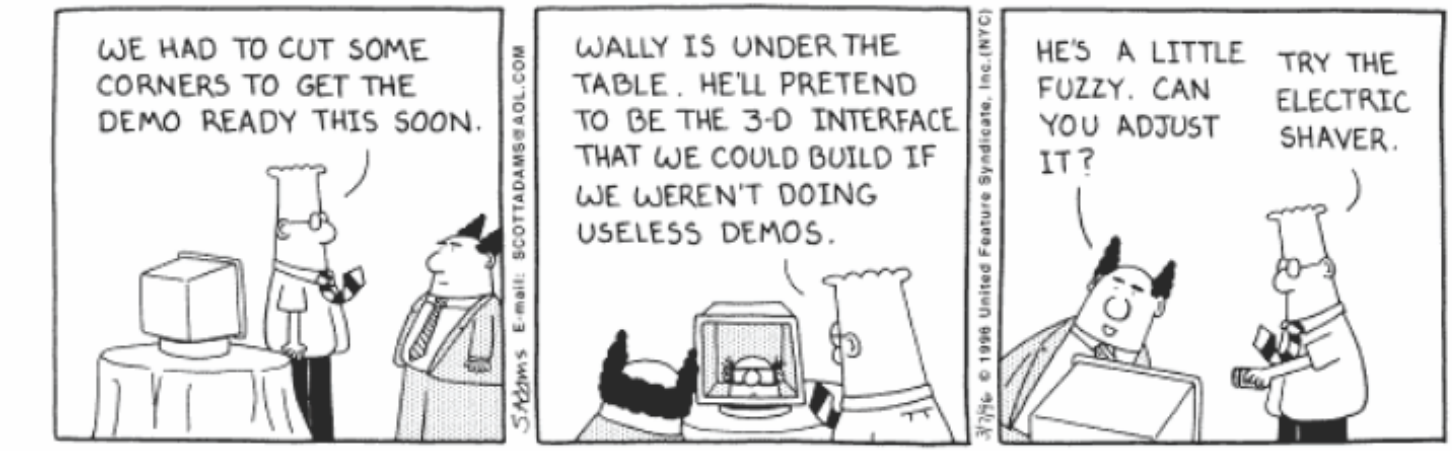
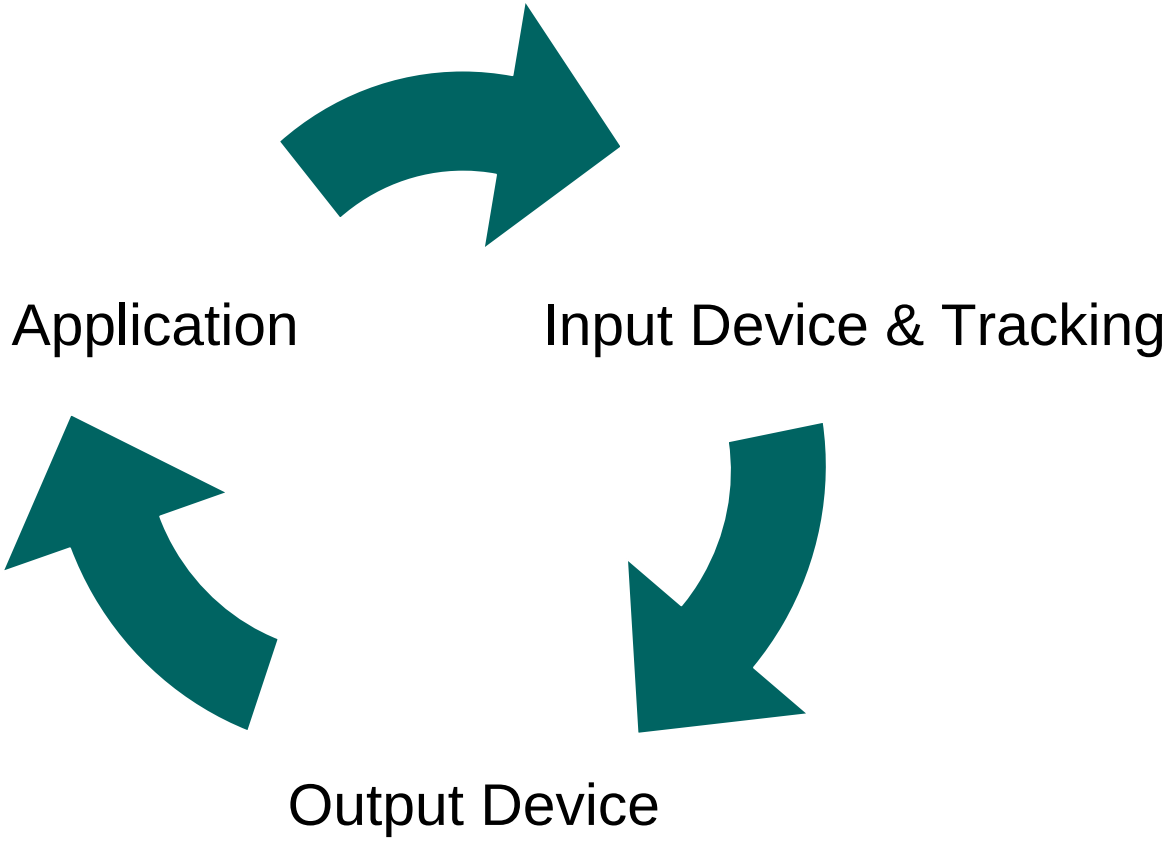
Based on material by Chris Shaw, derived from Doug Bowman‘s work

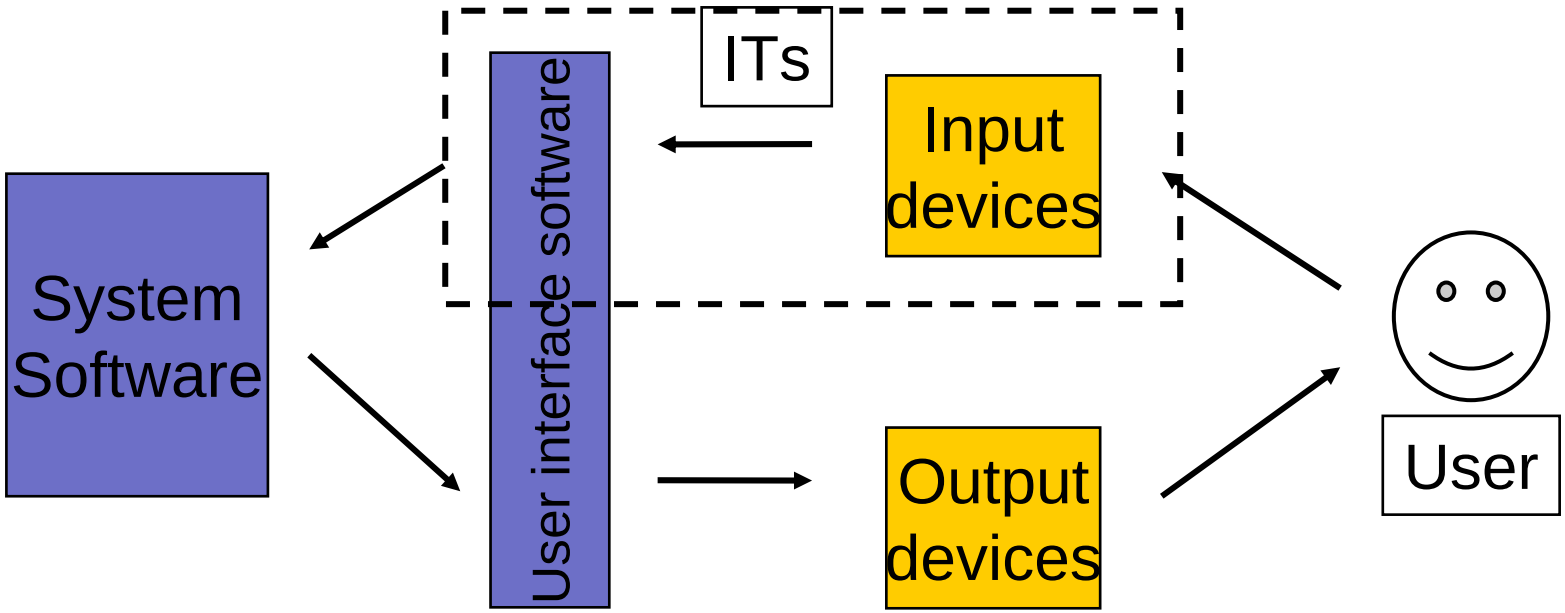


Why 3D Interaction?



3D Interaction Techniques

- Methods used to accomplish a given task via the interface
  - Hardware components: Input & Output devices
  - Software components = *control-display mappings*: translating information from input devices to system actions -> display to user



The Interface Challenge – The best of both Worlds

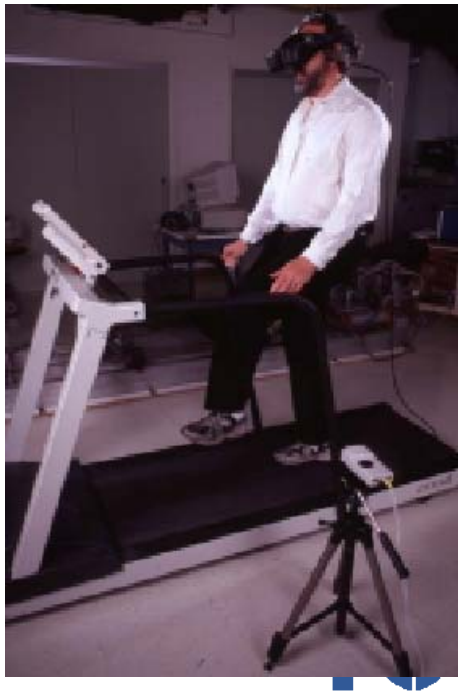
Naturalism: make VE & interaction work exactly like real world.

Magic: give user new abilities

- Perceptual
- Physical
- Cognitive

The Interface Challenge

- Will the cognitive overhead required to use the interface distract users from the intended tasks and goals?



Goals of Interaction Design

- Performance
  - efficiency
  - accuracy
  - productivity
- Usability
  - ease of use
  - ease of learning
  - user comfort
- Usefulness
  - users focus on tasks
  - interaction helps users meet system goals

- But, most current VE apps either
  - are not complex interactively, or
  - have serious usability problems

What makes 3D Interaction difficult?

- Spatial input
- Lack of constraints
- Lack of standards
- Lack of tools
- Lack of precision
- Fatigue
- Layout more complex

Philosophies of Interaction Design

- Artistic approach
  - Intuition about users, tasks
  - Heuristics, metaphors
  - Aesthetics
  - Adaptation
- Scientific approach
  - Formal analysis
  - Formal evaluation
  - Performance requirements

Own Experience:

Combination of both gives best results!

Universal Interaction Tasks

- Selection: picking object(s) from a set
- Manipulation: modifying object properties (esp. position/orientation, shape, color,…)
- Navigation
  - Travel – motor component
  - Wayfinding – cognitive component; decision making
- System control: changing system state or mode
- Symbolic input (covered in Input Devices Part 1)
- Modeling & Other tasks (create and modify 3d Obj.)

Selection & Manipulation

Goals of Selection:

- Indicate action on object
- Make object active
- Travel to object location
- Set up manipulation

Isomorphic vs. Nonisomorphic

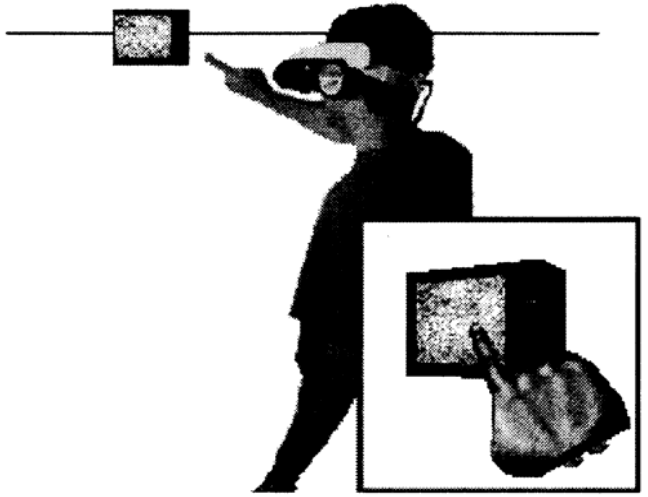
- Isomorphic:
  - strict, geometrical 1:1 correspondence between physical <-> virtual world
  - Most natural
  - Imitates physical reality and its limitations
- Nonisomorphic:
  - Magic virtual tools that extend working volume or arm length
  - Depends on application
  - Majority of manipulation techn. nonisomorphic

Selection performance

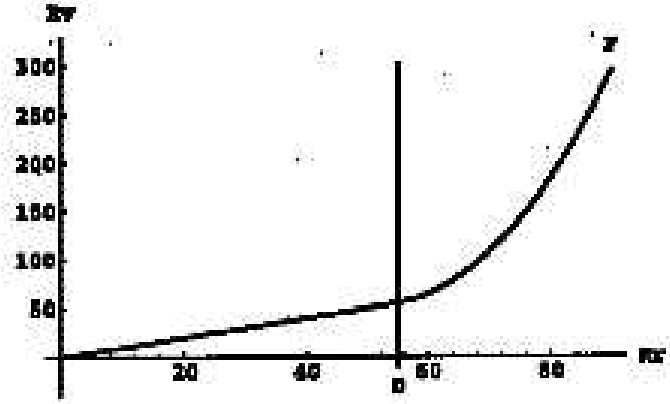
- Variables affecting user performance
  - Object distance from user
  - Object size
  - Density of objects in area

Common Selection Techniques

- Pointing
  - Touching with virtual hand/pointer
  - Ray casting
  - Cone casting (Flashlight)
  - Aperture
  - Two-handed pointing
  - Image plane
- Naming (speech rec.)

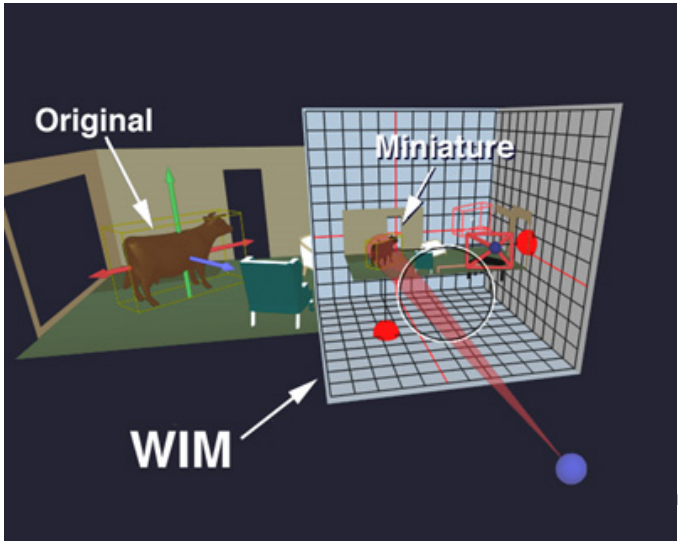


Enhancements to Basic Techniques

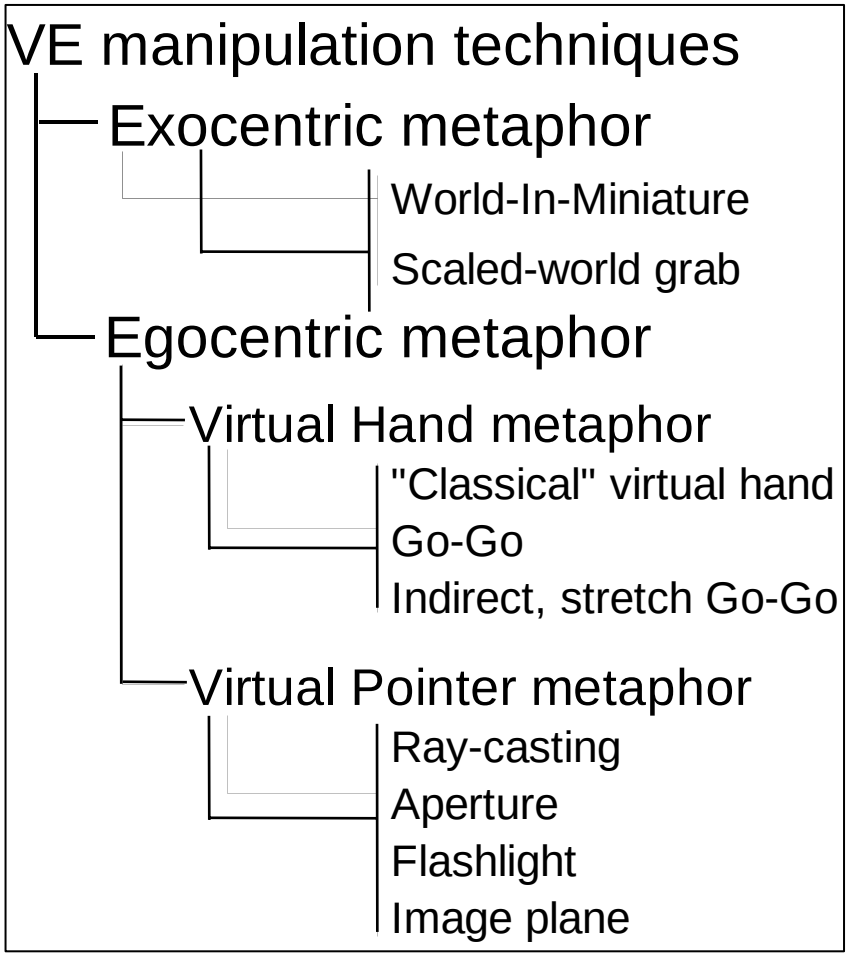


- Arm-extension
  - Go-Go Technique
    (non-linear mapping)
  - Fishing-Reel Technique (additional device: distance)

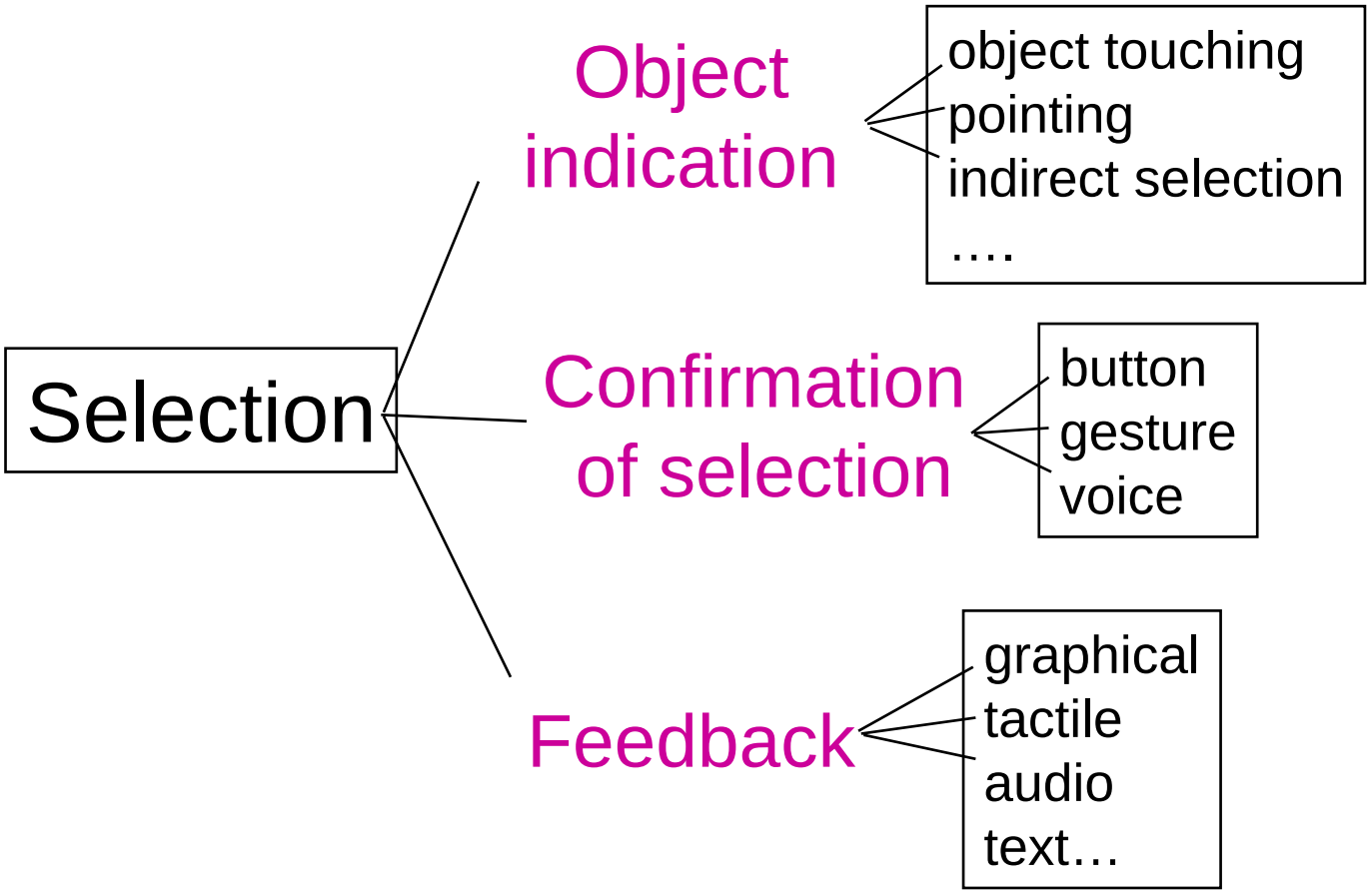
- World in Miniature (WIM)
  - Select icon-like objects



Technique Classification by Metaphor



Selection: Task Decomposition



Evaluation: Selection Task

- Ray-casting and image-plane generally more effective than Go-Go
  - Exception: selection of very small objects can be more difficult with pointing
- Ray-casting and image-plane techniques result in the same performance (2DOF)
- Image-plane technique less comfortable

Goals of Manipulation

- Object placement
  - Design
  - Layout
  - Grouping
- Tool usage
- Travel

Variables affecting user performance
  - Required translation distance
  - Amount of rotation (avoid clutching)
  - Required precision of placement

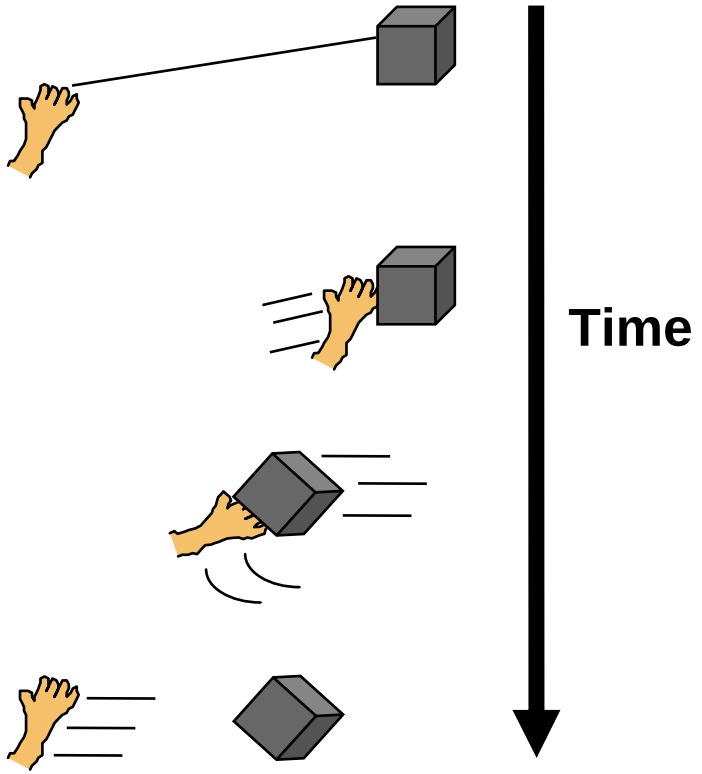
Manipulation Metaphors 1

- Simple virtual hand
  - Natural, easy placement
  - Limited reach, fatiguing, overshoot
  - 1:1 position mapping
- Ray casting
  - little effort required
  - Exact positioning and orienting very difficult (lever arm effect)
- Indirect depth mapping
  - Infinite reach, not tiring
  - Not natural, separates DOFs

HOMER technique

Hand-Centered
Object **M**anipulation
Extending **R**ay-Casting

- Select: ray-casting
- Virtual hand moves to object
- Manipulate: hand

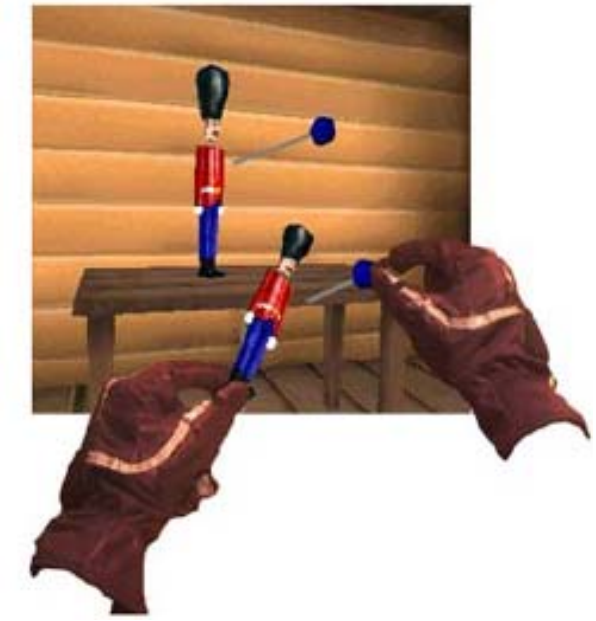


Manipulation Metaphors 2

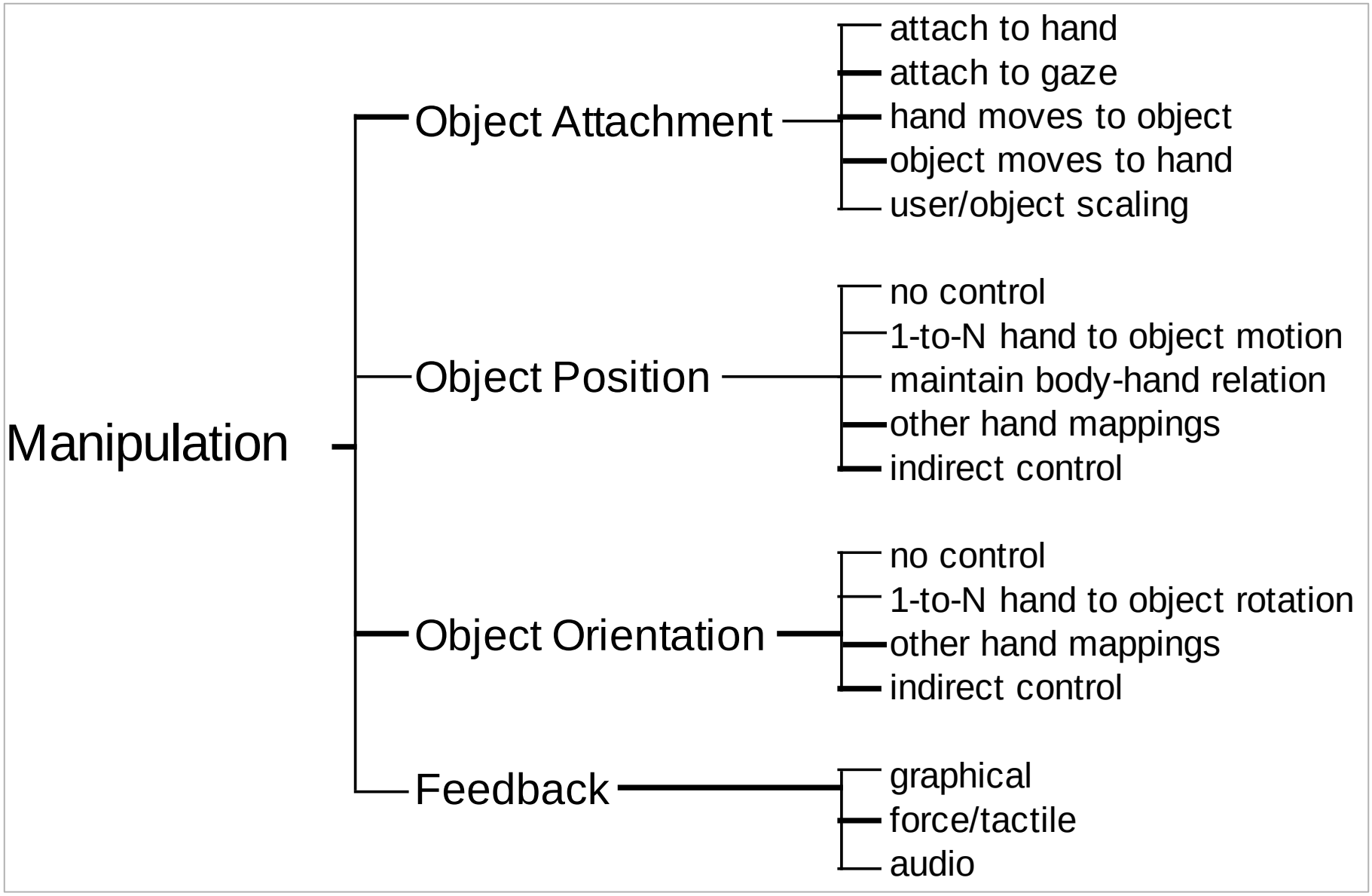
- HOMER (ray-casting + arm-extension)
  - Easy selection & manipulation
  - Expressive over range of distances
  - Hard to move objects away from you
- Scaled-world grab
  - Selection by image plane
  - World scaled down around virtual hand
  - Easy, natural manipulation
  - Hard to move objects away

Manipulation Metaphors 3

- World-in-miniature
  - All manipulation in reach
  - Doesn’t scale well for large environments
  - Indirect
- Voodoo Dolls
  - Two-handed (2 pinch gloves)
  - Create “dolls” by image-plane technique
  - Indirect manipulation



Classification by Components



Evaluation: Positioning Task

- Ray casting effective if the object is repositioned at constant distance
- Scaling techniques (HOMER, scaled world grab) difficult in outward positioning of objects: e.g. pick an object located within reach and move it far away
- If outward positioning is not needed then scaling techniques might be effective

Evaluation: Orientation Task

- Setting precise orientation can be very difficult
- Shape of objects is important
- Orienting at-a-distance harder than positioning at-a-distance
- Techniques should be hand-centered

Manipulation notes

- No universally best technique
- Constraints and reduced DOFs
- Naturalism not always desirable
- If VE is not based in the real, design your environment for optimal manipulation

Travel

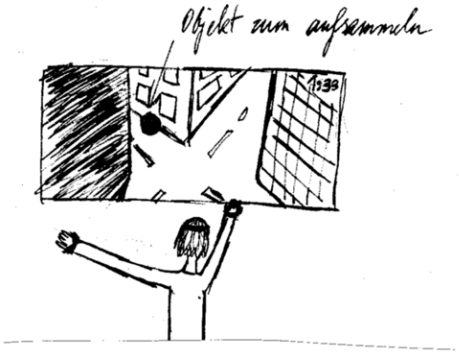
- Motor component of navigation
- Movement between 2 locations
- Setting the position (and orientation) of the user's viewpoint
- Most basic and common VE interaction technique
  - used in almost any large-scale VE

Travel Tasks

- Exploration
  - travel which has no specific target
  - build knowledge of environment
- Search
  - naive: travel to find a target whose position is not known
  - primed: travel to a target whose position is known
  - build layout knowledge
  - move to task location
- Maneuvering
  - travel to position the viewpoint for a task
  - short, precise movements

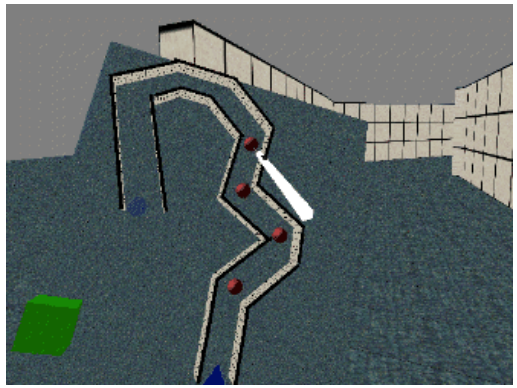
Traveling metaphors 1/2

- Steering metaphor: continuous specification of direction of motion
  - gaze-directed
  - Pointing (the “fly” gesture)
  - physical device (steering wheel, joystick)
  - Examples: Beckhaus – chair (video)



- Target-based metaphor: discrete specification of the goal location
  - point at object
  - choose from list
  - enter coordinates
  - Example: Reitmayr - Outdoor

Traveling metaphors 1/2



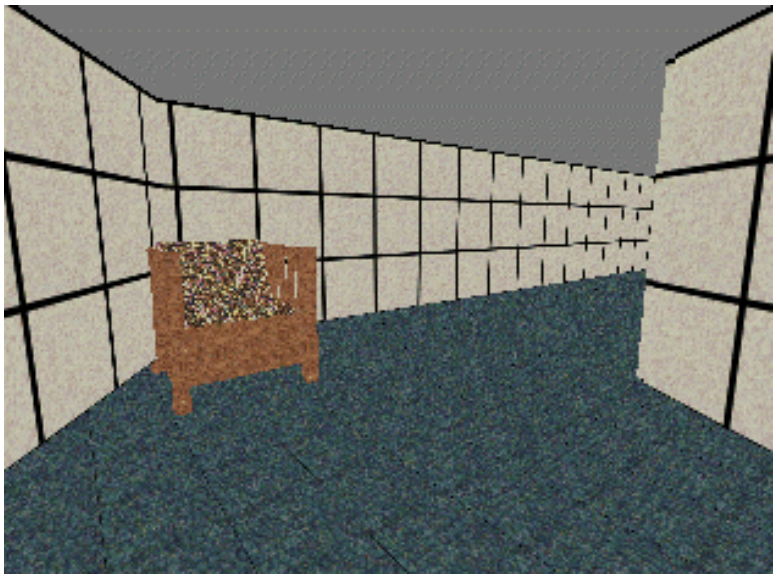
- Route-planning metaphor: one-time specification of path
  - place markers in world
  - move icon on map
- Manipulation metaphor: manual manipulation of viewpoint
  - “camera in hand”
  - fixed object manip.
    - Example: film camera movement
  - Grabbing in the air technique (2 gloves)

“Natural” travel metaphors

- Walking techniques
- Treadmills
- Bicycles
- Other physical motion
  - VMC / Magic carpet
  - Disney’s river raft ride
  - Simulation of flying

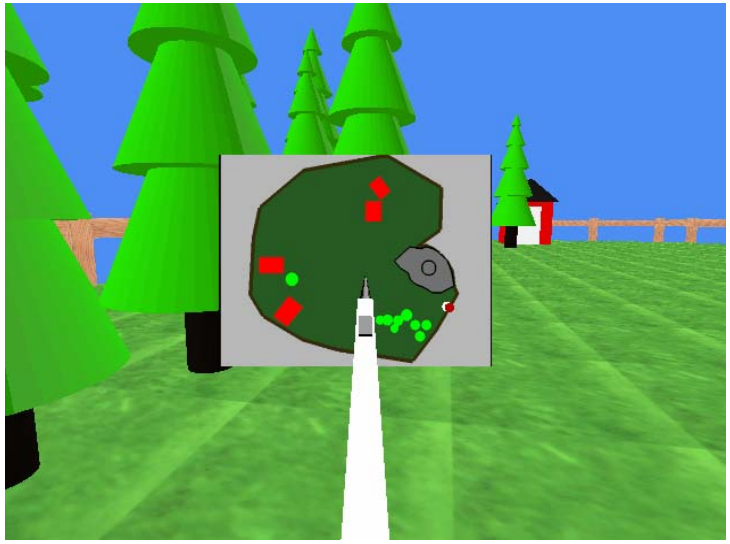
Evaluation results (by Bowman)

- “Teleportation” can lead to significant disorientation
- Env. complexity affects information gathering
- Travel IT and user’s strategies affect spatial orientation



Evaluation results – 2

- Steering techniques best for naive and primed search
- Map-based techniques not effective in unfamiliar environments, or when any precision is required



Myths

- *There is one optimal travel technique for VEs.*
- *A “natural” technique will always be better than another technique.*
- *Desktop 3D, workbench, and CAVE applications should use the same travel ITs as HMD-based VEs.*

Design guidelines

- Make simple travel tasks simple (target-based techniques for motion to an object, steering techniques for search).
- Provide multiple travel techniques to support different travel tasks in the same application.
- Use transitional motions (not teleportation!) if overall environment context is important.

System control

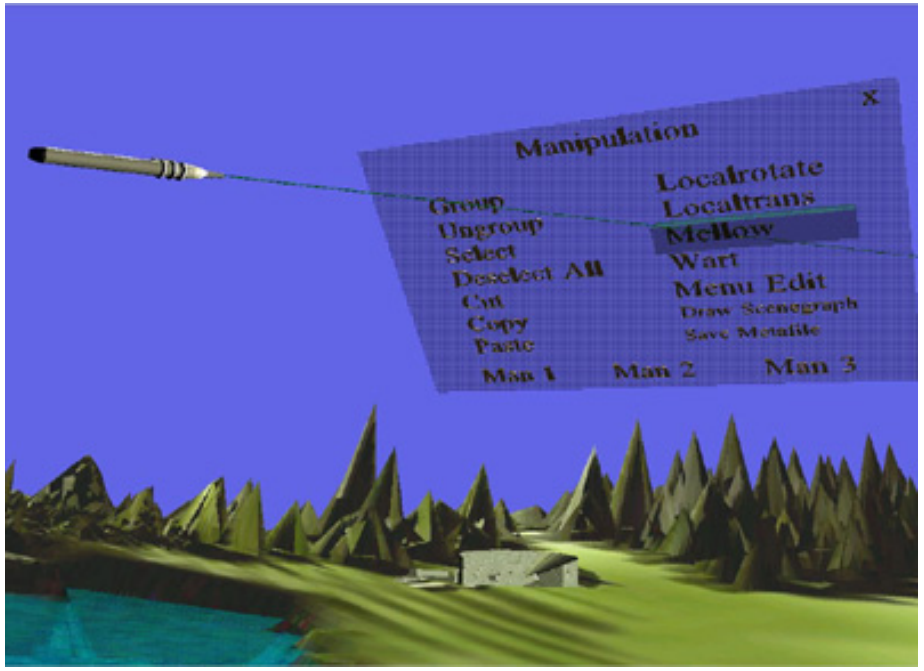
- Catch-all for other types of VE interaction
  - Issuing command
  - Changing mode
  - Choosing tool
- Often composed of other tasks

Common types of system control techniques

- Menu systems
- Voice commands
- Gestures/postures
- Implicit control (e.g. pick up new tool to switch modes)

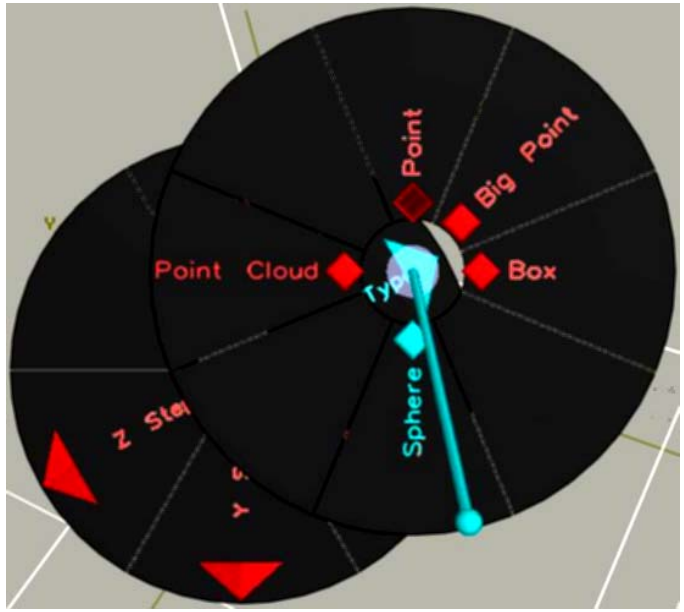
Floating menus

- Requires user knowledge
- Can occlude environment
- Using 3D selection for a 1D task
- Can be difficult to find
- Very bad design - AVOID



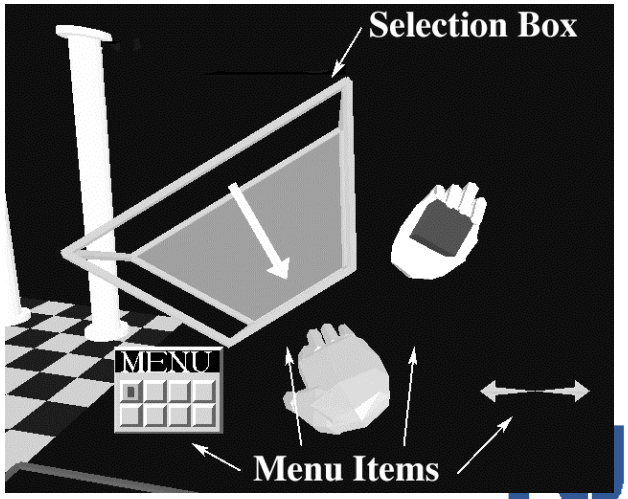
Pop-Up Menus - Radial

- Sundial
  - Pie menu with 3D selector
  - User rotates “Shadow stick” to occlude desired segment
- Example: iOrb

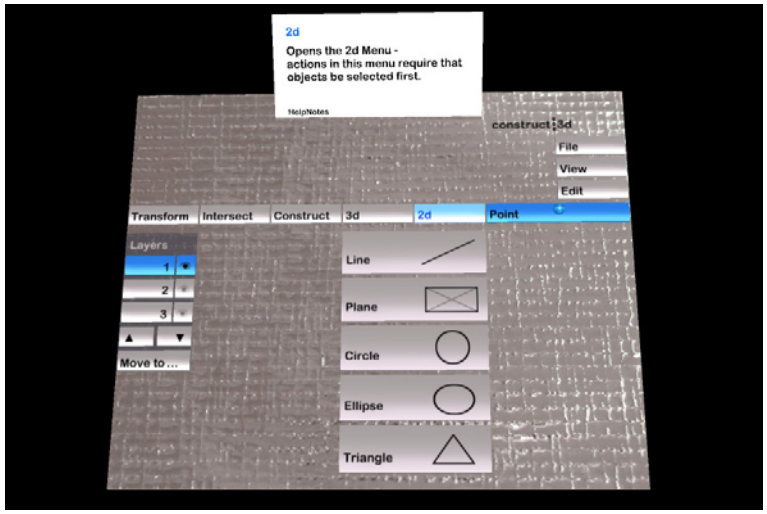


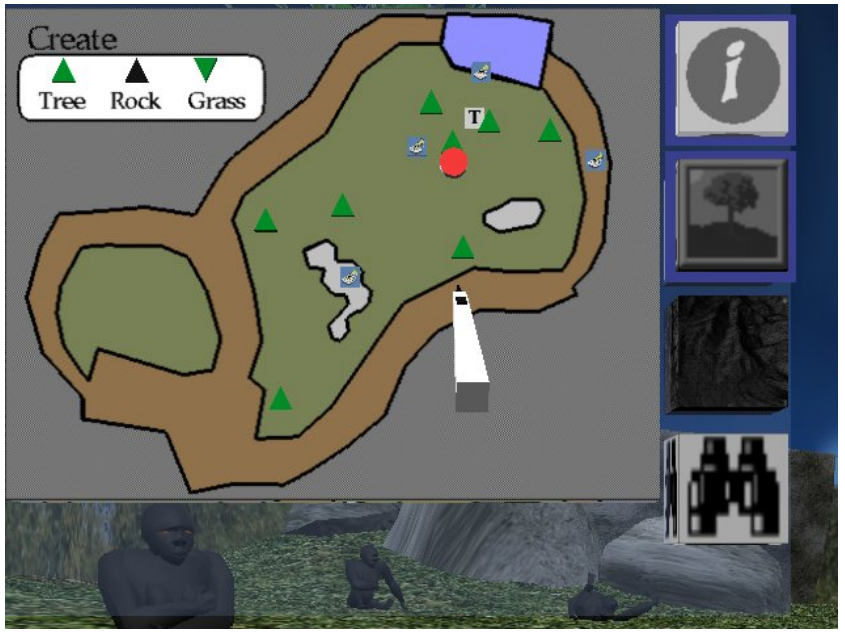
1 DOF menu

- Correct number of DOFs for the task
- Can be put away
- Only one menu level at a time



Pen & Tablet Interaction





Pen & Tablet Interaction

Tablet = real object:

- Can put away
- Handwriting input possible
- Can be used as a clipboard
- Constrained surface for input
- Usability: People are used to 2D input
- Combine 2D/3D interaction
- Use any type of 2D interface, not just menus

Pen:

- Direct manipulation
- Magic Lens Metaphor

2D interaction in a 3D world

- Quite useful for appropriate tasks
- Can integrate seamlessly with 3D
- If presence is important, the 2D interface should be *embedded*, not *overlaid*

Applications - Examples

- Real applications always **combine** interaction techniques

Examples:

- Projection Screen Interaction e.g. ArsBox
- Volumetric Displays e.g. Perspecta3D
- ARToolkit Interaction: Mozart MagicBook
- New Device: Handheld HMD

Literature

- 3D User Interfaces – Theory and Practice Doug Bowman, Ernst Kruijff, J. LaViola, Ivan Poupyrev; Addison Wesley, 2005.

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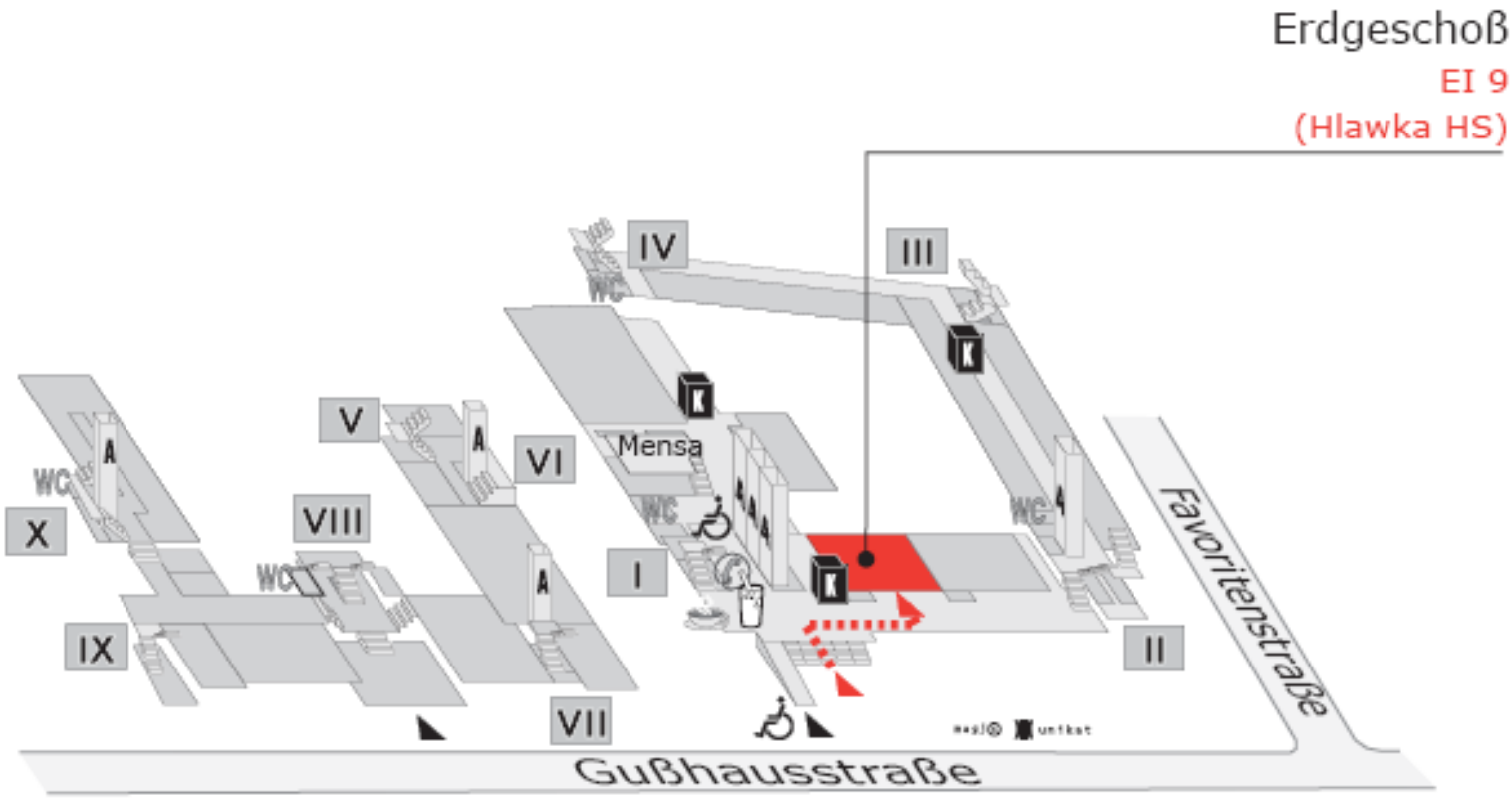

Vielen Dank
für die Aufmerksamkeit!

Fragen, Wünsche, Anregungen?