Design Guidelines

Lecture 5

RVAU - Realidade Virtual e Aumentada - EIC0070

2019/2020 - 1S

Filipe A. Rodrigues

Jorge A. Silva

(adaptado de slides Rui Nóbrega, A. Augusto Sousa)

Interaction

INTERACTION IN VR?

- At first it seems obvious...
  - **Simply interact** with the **virtual** world **as we interact** with the **real** one!

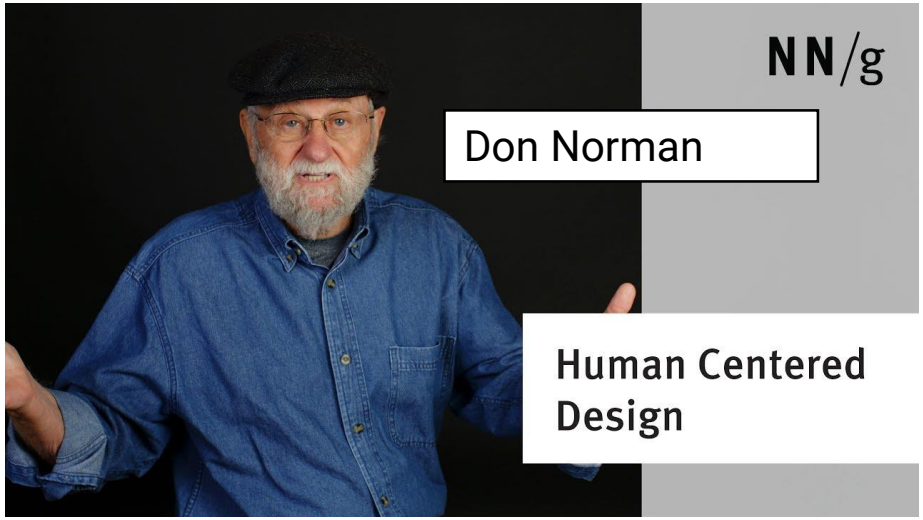
- **Unfortunately**, natural **real-world interfaces** (and Hollywood interfaces) **often** do **not work** well **within VR**
- **Not** only **because virtual** worlds **modelling** and/or **technology** is **not accurate…**

- But abstract interfaces can be better…

Human-Centered Design

INTERACTION IN VR?

- Perhaps the **most important part of VR** is the **person doing** the **interacting**!
- **Human-centered** interaction **design focuses** on the **human side** of **communication** between user and **machine**
  - The **interface** from the **user's point of view**



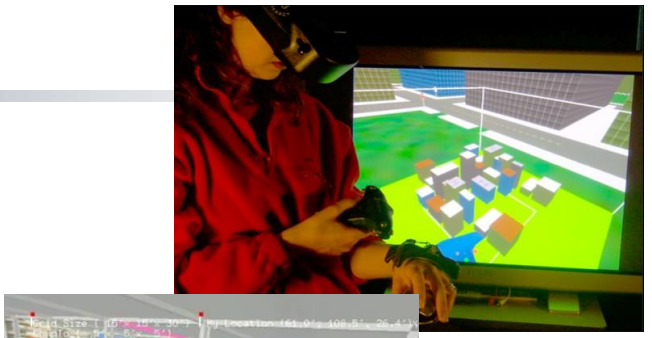
https://www.youtube.com/watch?v=rmM0kRf8Dbk

System Design Guidelines

- General Design
  - **Design** for **short user experiences**
  - **Minimize visual** stimuli **closer** to **eye** (vergence-accommodation conflict)
  - For **binocular** displays, do **not use 2D overlays**/HUDs
  - Design for **sitting**, **or** provide **physical barriers**
  - Show **virtual warning** when user **reaches end** of **tracking area**
- Motion Design
  - **Avoid moving** the virtual **viewpoint** in a way that **deviates** from **actual** head **motion** of the **user**
  - **With** high **latency**, **do not design tasks** requiring **fast head motion**
- Interaction Design
  - Design **interfaces** so user's can **work** with **hands** in a **comfortable position**
  - Design **interactions** to **be non-repetitive** to reduce strain injuries

Jason Jerald, *The VR Book*, 2016

Object Interaction



- 3D design/interaction is difficult
  - Needs **spatial input**
  - **Interface Layout** is **complex**
  - **Lack** of **constraints**
  - **Lack** of **standards**
  - **User Fatigue**

- We have thousands of years of standards and guidelines for “screen” design
  - Humans are used to design/dispose data in canvas/screen 2d formats (e.g., paintings, photography, cinema…)

Object Interaction Vision Vs Reality…

- Natural interface
- Gesture, speech
- Wide field of view
- Full body input

- Limited input
- Wireless, limited range tracking
- (Reduced field of view)
- 2D GUI in VR

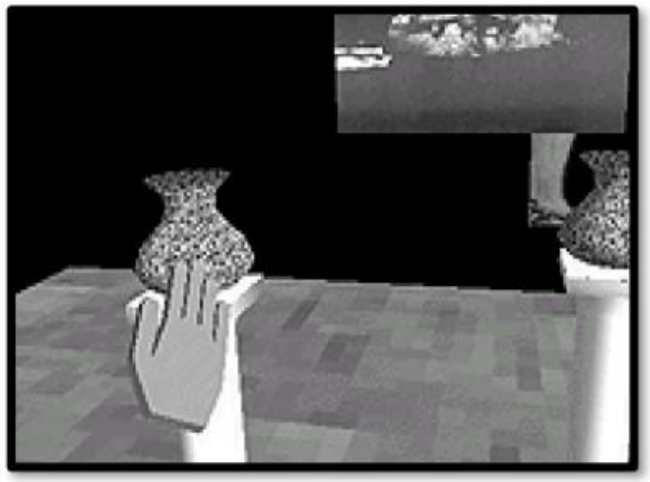
Current Interactions
Universal Tasks in VR

- Object Interaction
  - ***Selection***: Picking object(s) from a set
  - ***Manipulation***: Modifying object properties (scale, position/orientation, shape, color,…)
- Navigation
  - ***Travel***: motor component of viewpoint motion
  - ***Wayfinding***: cognitive component; decision-making
- System control
  - Issuing a command to change system state or mode

Interaction
Selection

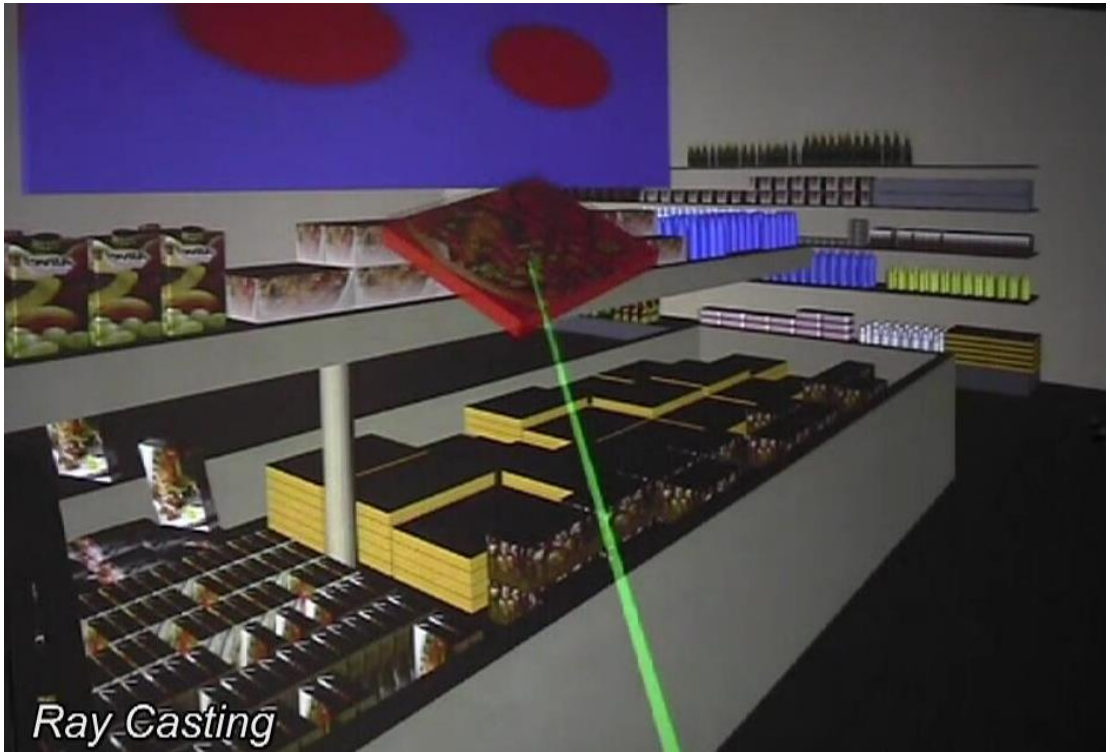
- Goals of Selection:
  - Indicate action on an object
  - Make object active
  - Travel to object location
  - Set up manipulation

Interaction - Selection
Simple Virtual Hand Technique



- Process:
  - One-to-one mapping between physical and virtual hands
  - Objects selected by “touching”
  - “Natural” mapping
- Limitation:
  - Only select objects in hand reach

Interaction - Selection Raycasting

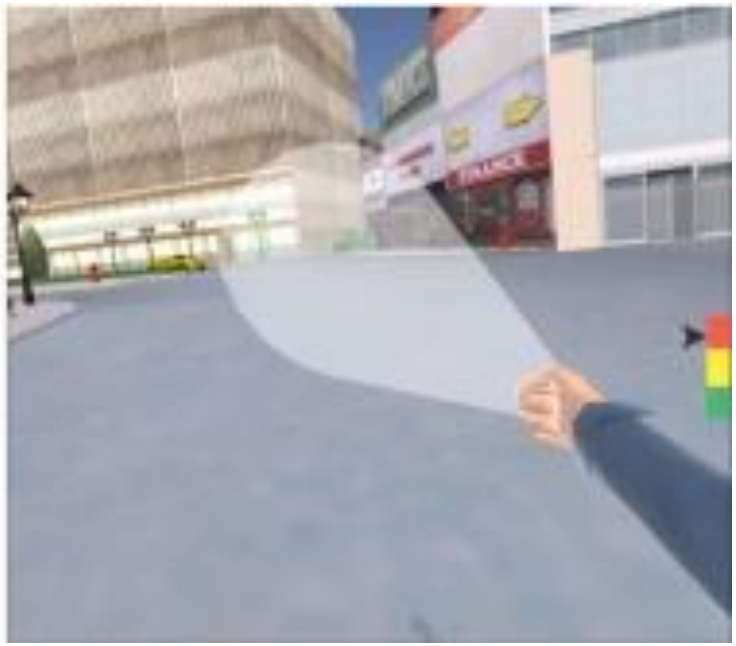


- Example:
  - https://www.youtube.com/watch?v=W1ZUBTPCL3E

Interaction - Selection Flashlight

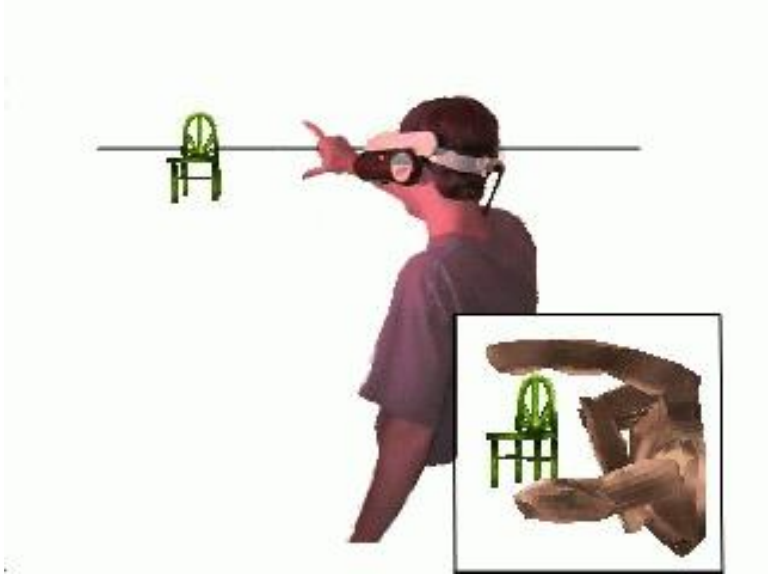
- Selection cone
  - The user selects objects inside the cone

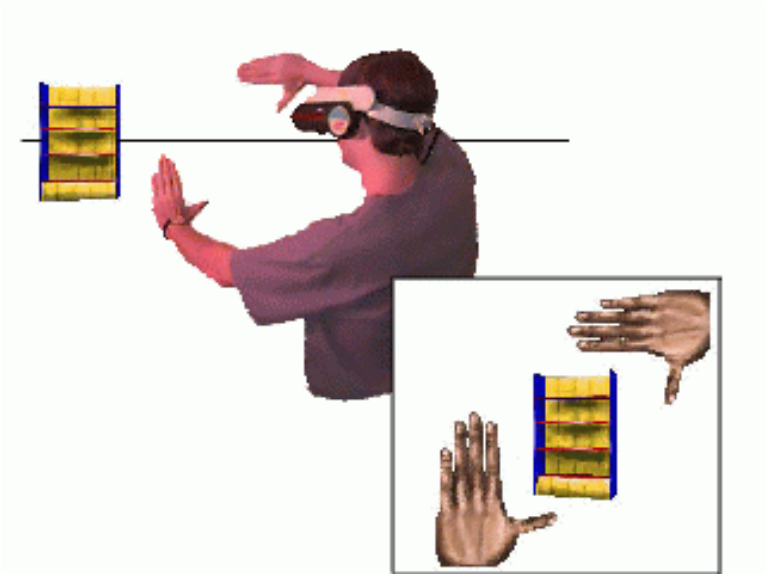
Interaction - Selection Aperture-Based



- Selection cone with an aperture angle
  - The user is able to control the angle

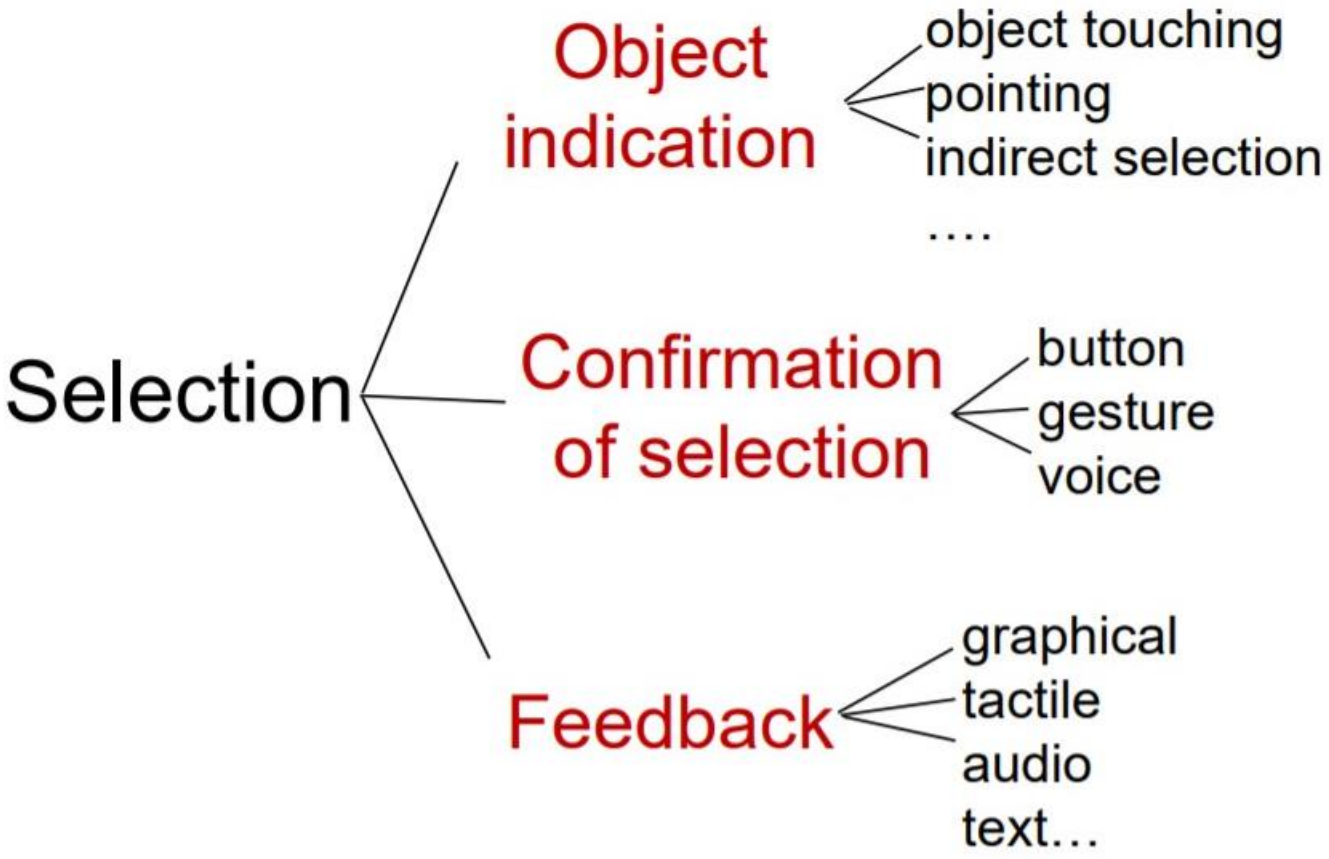
Interaction - Selection Image-Plane





- Selection of 3D objects by creating a 2D “frame”

Interaction - Selection Task Decomposition



Interaction Manipulation

- Goals of Manipulation:
  - Object placement (Design, Layout, and Grouping)
  - Tool usage
  - User Travel
- Manipulation Techniques:
  - **Egocentric**: viewing and manipulating a virtual model of the environment from outside of it
  - **Exocentric**: first-person view of the world and interacts from within the environment

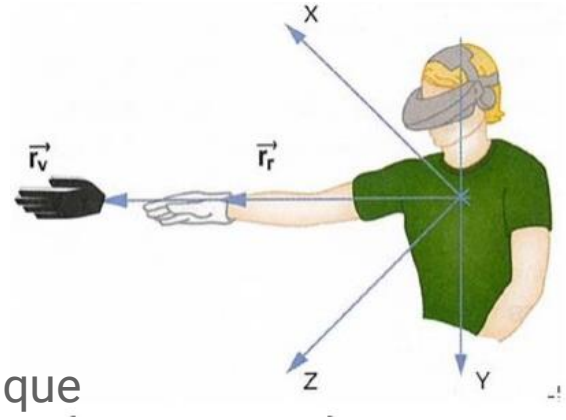
Interaction - Manipulation Techniques

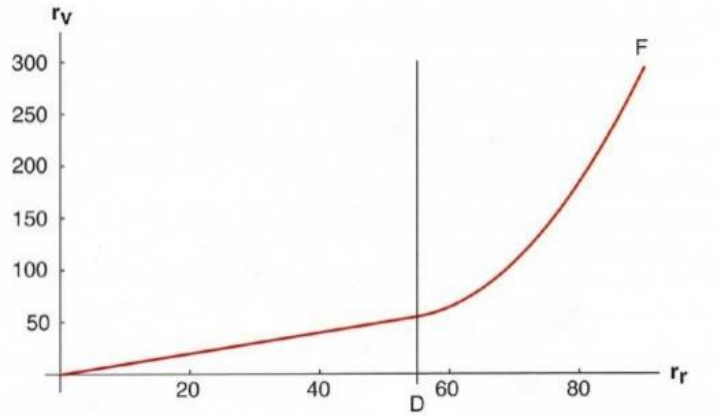
- We can mix Egocentric and Exocentric Techniques!

Figure 26.1 An exocentric map view from an egocentric perspective. (Courtesy of Digital ArtForms)

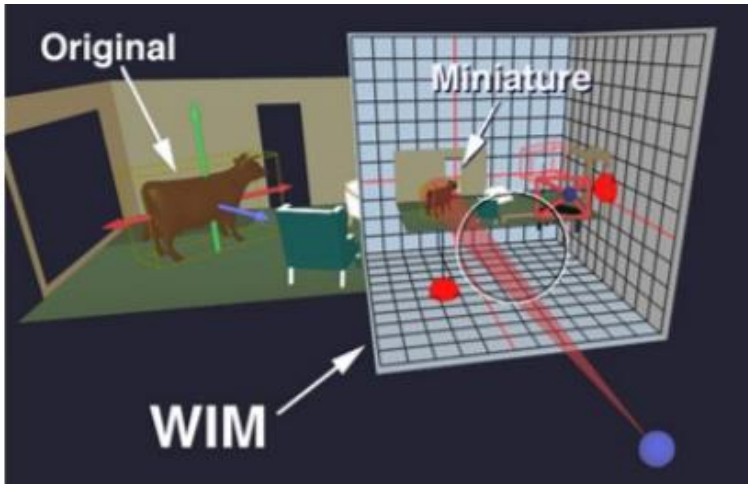
Jason Jerald, *The VR Book*, 2016

Interaction - Manipulation Enhancements to Basic Techniques

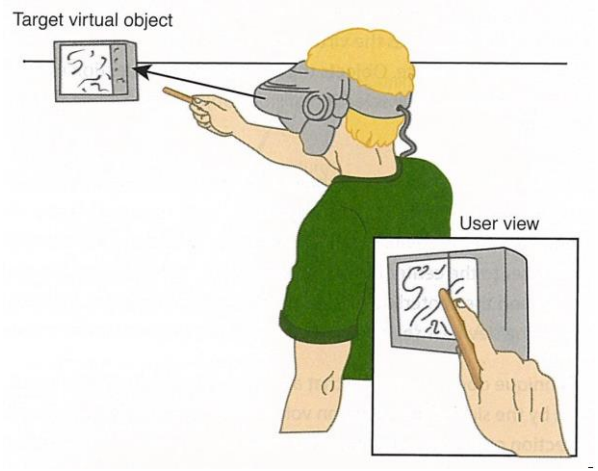




- Arm-extension
  - Go-Go Technique
    - Non-linear mapping between physical and virtual hand position
  - Indirect Go-Go
    - Control proximity with buttons
- World in Miniature (WIM)
  - "**Dollhouse**" **world** held in user's **hand**
  - **Miniature objects** can be **manipulated directly**
  - **Moving miniature** objects
  - **Affects full-scale objects**
  - **Can** also be **used** for **navigation**



Selection and Manipulation Classification



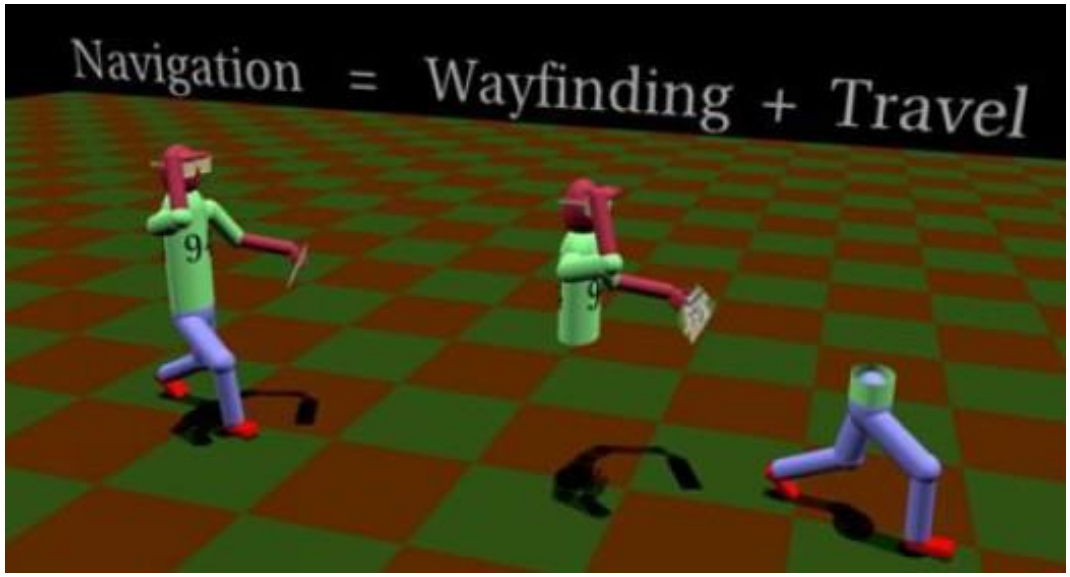
Manipulation

- VE manipulation techniques
  - Exocentric metaphors
    - World-in-miniature
    - Automatic scaling
  - Egocentric metaphors
    - Virtual hand metaphors
      - "Classical" virtual hand
      - Go-Go
      - Indirect Go-Go
    - Virtual pointer metaphors
      - Ray-casting
      - Aperture
      - Flashlight
      - Image plane

Selection

- **Selection Technique**
  - Indication of object
    - occlusion
    - object touching — list, voice sel., automatic, iconic objects
    - pointing — 2D, 3D gaze, 3D hand
    - indirect selection — 1 to 1, pos → pos, vel → pos, pos → vel
  - Confirmation of selection — event, gesture, voice command, no explicit command
  - Feedback — text/symbolic, aural, visual, force/tactile

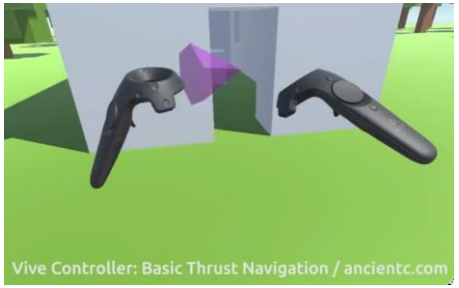
Navigation

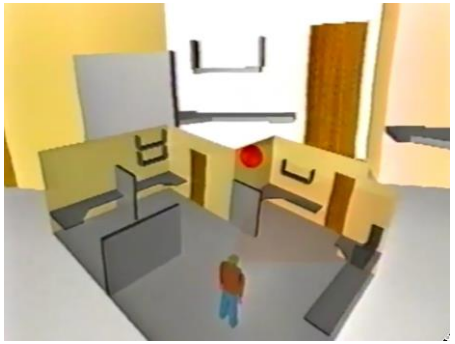


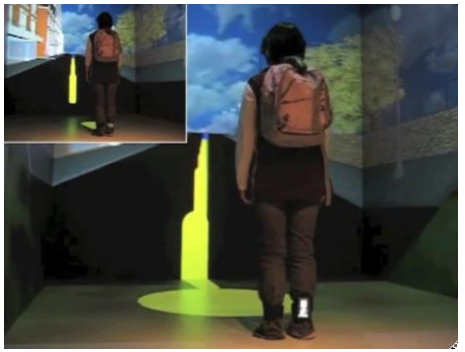
- How we move from place to place within an environment
- The **combination** of **travel** with **wayfinding**
  - ***Wayfinding***: cognitive component of navigation
  - ***Travel***: motor component of navigation
- Travel without wayfinding: "exploring", "wandering"

Taxonomy of Travel Techniques

- **Direction/Target Selection**
  - Gaze-directed steering
  - Pointing/gesture steering (including props)
  - Discrete selection
    - Lists (e.g., menus)
    - Environmental/direct targets (objects in the virtual world)
  - 2D pointing
- **Velocity/Acceleration Selection**
  - Constant velocity/acceleration
  - Gesture-based (including props)
  - Explicit selection
    - Discrete (1 of N)
    - Continuous range
  - User/environment scaling
  - Automatic/adaptive
- **Input Conditions**
  - Constant travel/no input
  - Continuous input
  - Start and stop inputs
  - Automatic start or stop





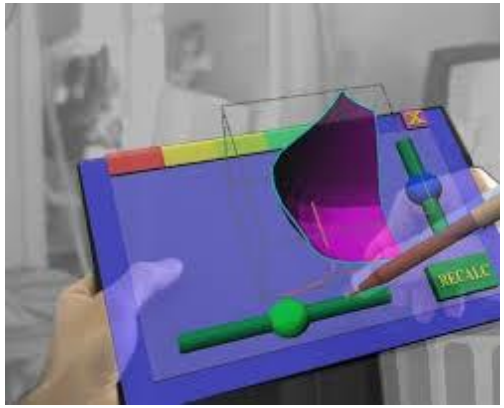


System Control

Issuing a command to change system state or mode

- Examples
  - Launching application
  - Changing system settings
  - Opening a file
  - Etc…

- Key points
  - Make commands are visible to user
  - Support easy selection

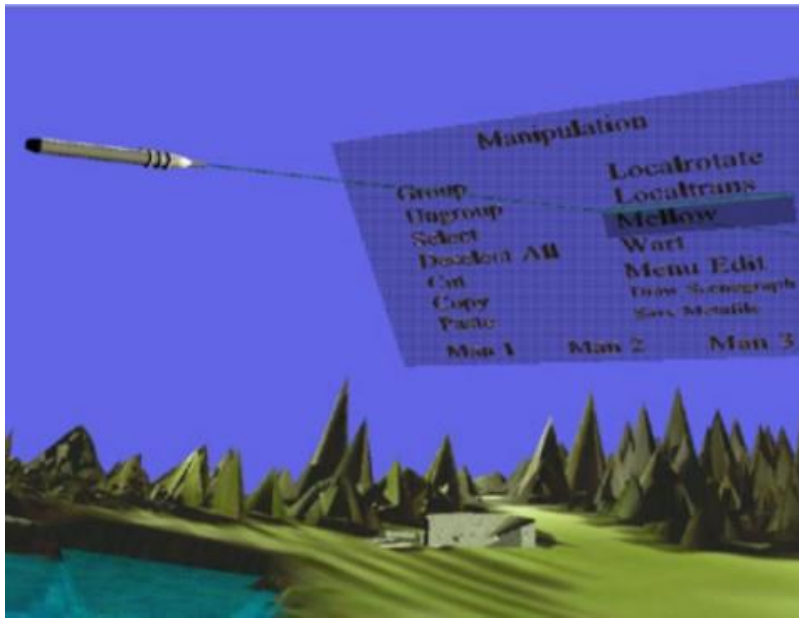


System Control
Common types of control

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

System Control
Floating Menus in 3D

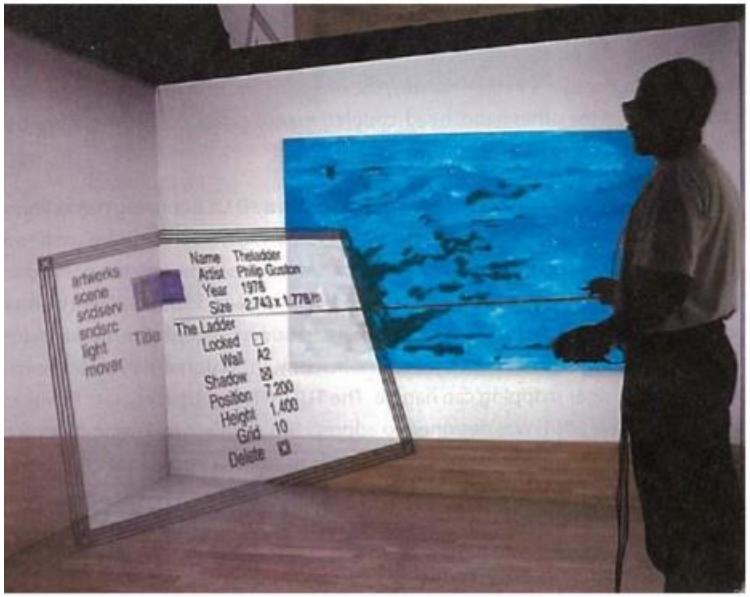
- Can **occlude** environment
- Using 3D selection for a 1D task
- Can be difficult to find
- **Better than Heads-up Display** (HUD) but **still bad design**
- Better if menu follows user



System Control
Example: Gear VR

- 2D Interface in 3D Environment
- In this case: Dedicated menu environment
- **Head pointing** and **click** to **select**

System Control
2D Menus in VR



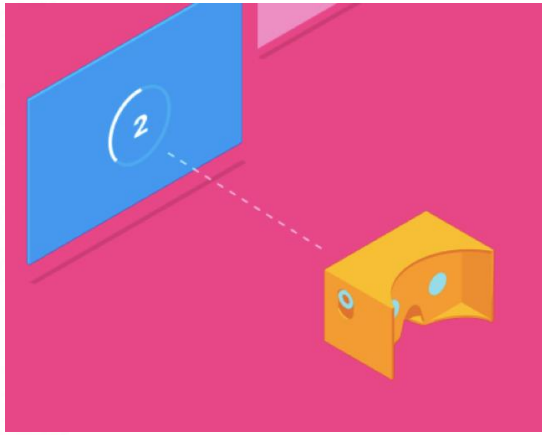
2D Menu in VR CAVE

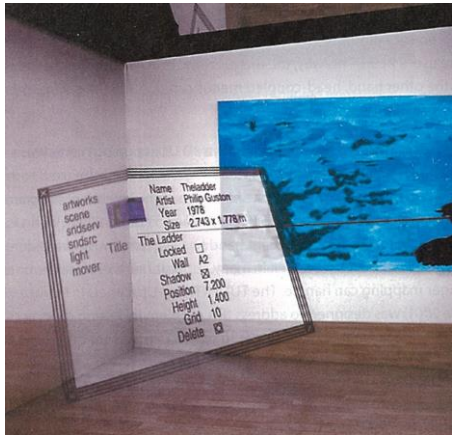
Nested Pie Menu

- Many examples of 2D GUI and floating menus in VR

System Control Options

- System control
  - Physical controllers
    - Buttons
    - Switches
  - Graphical menus
    - Adapted 2D menus
    - 1 DOF menus
    - 3D widgets
  - Voice commands
  - Gestural commands
    - Mimic gestures
    - Symbolic gestures
    - Sweeping
    - Sign language
    - Speech connected hand gestures
    - Whole-body interaction
  - Tools
    - Physical tools
    - Virtual tools
    - Tangibles
  - Multimodal techniques





How Can we Design UsefulVR?

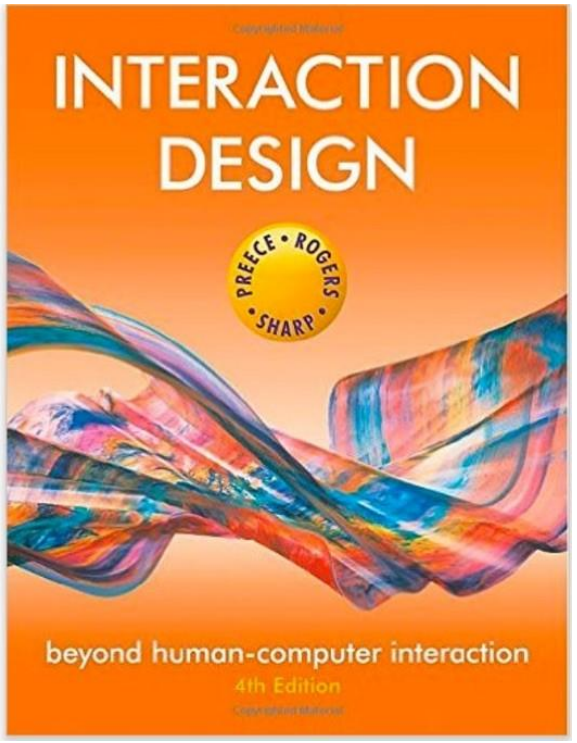
- Designing VR experiences that meet real needs
- **Interaction Design**

What is Interaction Design?

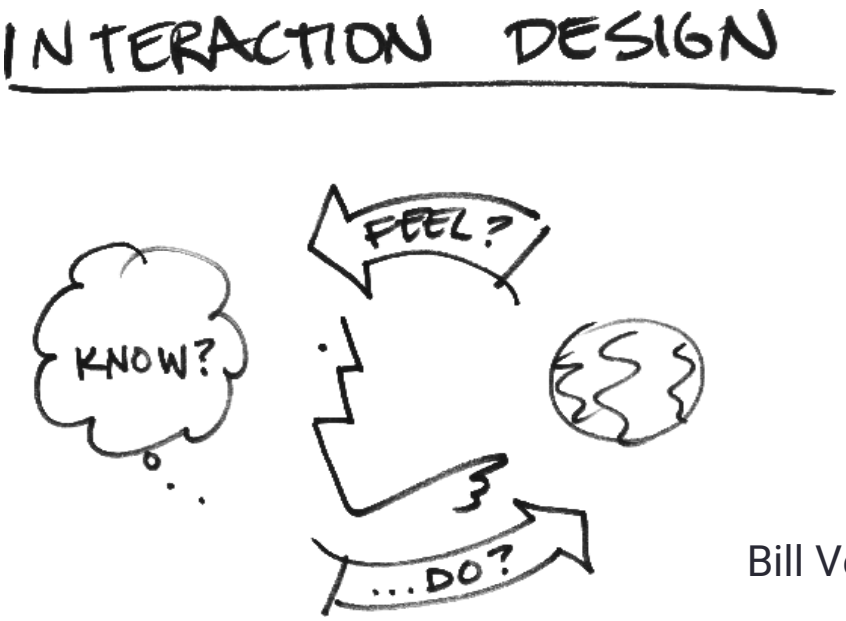
"Designing interactive products to support people in their everyday and working lives"

Preece, J., (2002). Interaction Design

- Interaction Design is the design of user experience with technology



Interaction Design

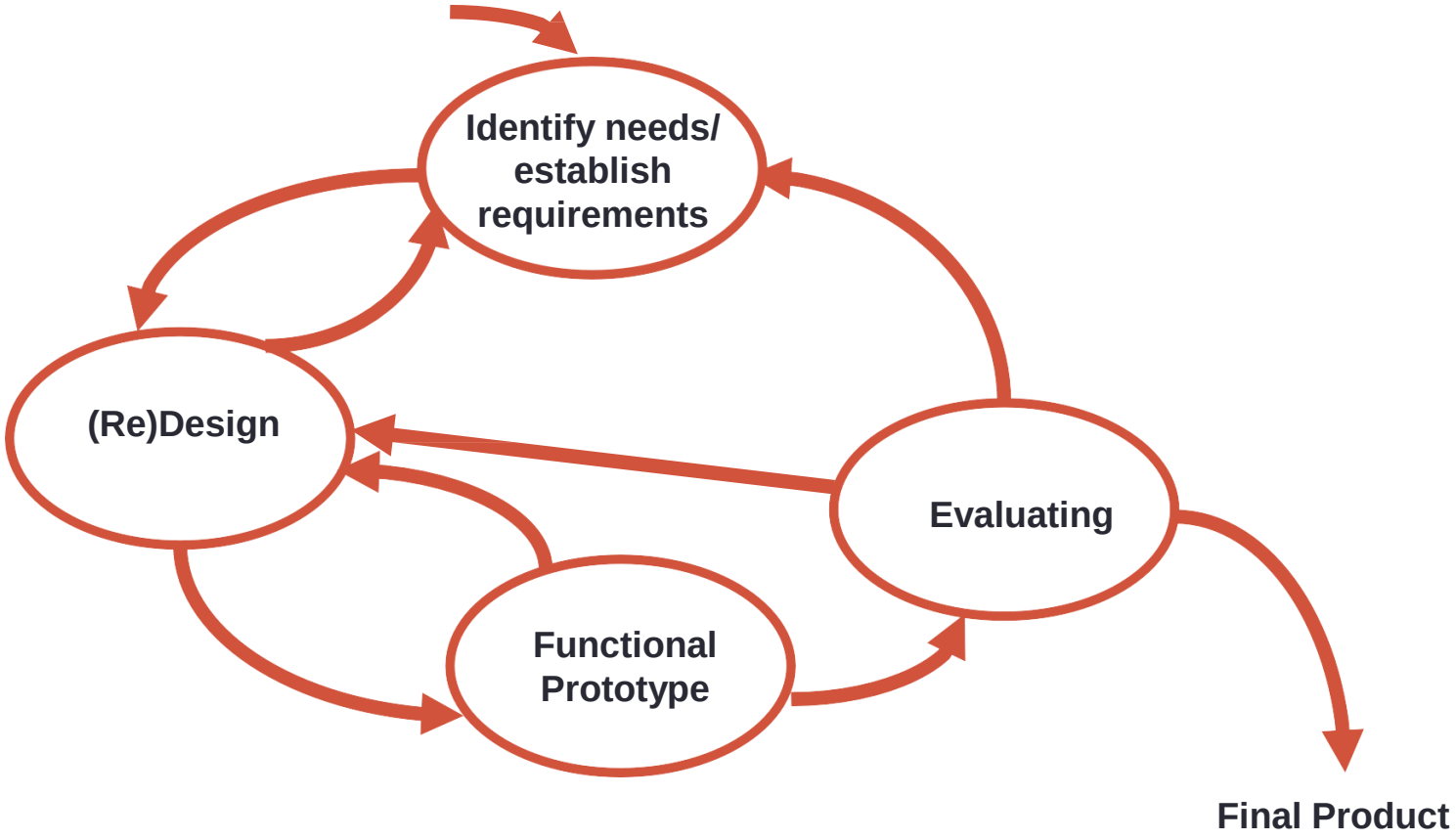


Bill Verplank

Interaction Design involves answering three questions:

- **What do you do**? - How do you affect the world?
- **What do you feel**? – What do you sense of the world?
- **What do you know**? – What do you learn?

The Interaction Design Process

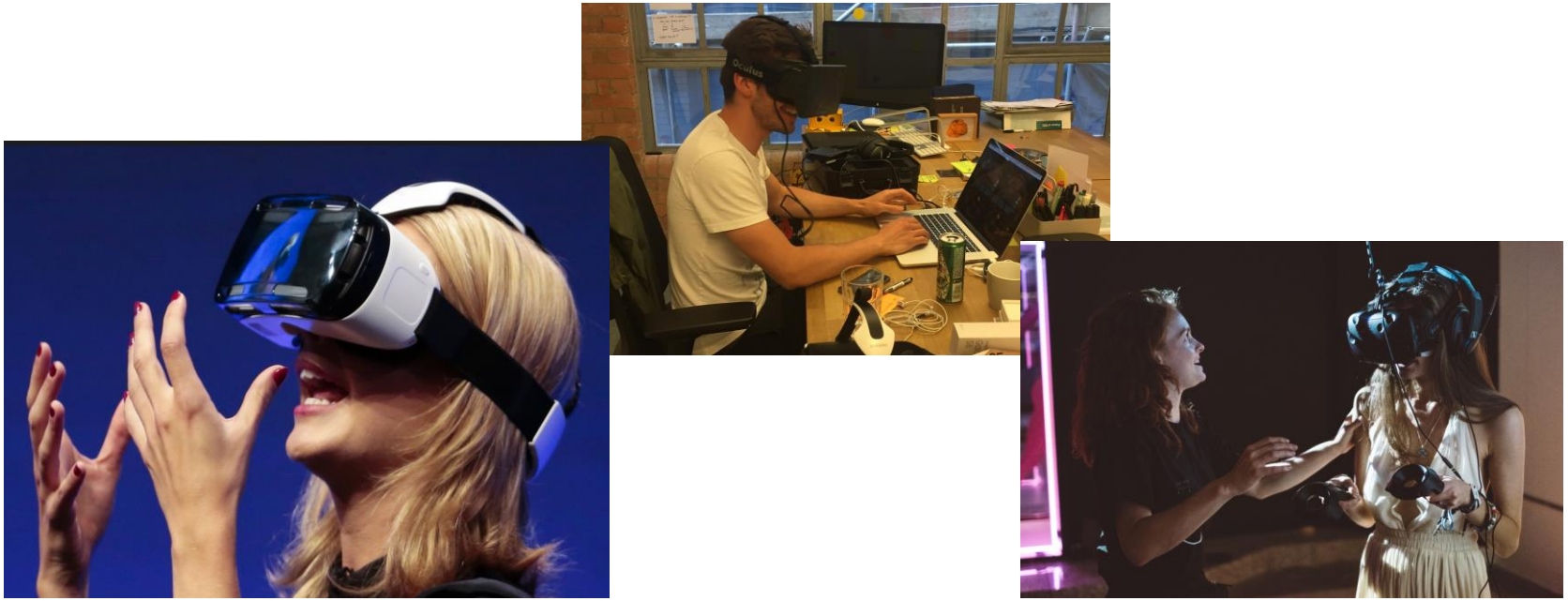


Develop alternative prototypes/concepts and compare them. And iterate, iterate, iterate....

Important Questions in VR

1. Who is the user?
   - Different types of users
2. What are the user needs?
   - Understand the user, look for insights
3. Can VR address those needs?
   - VR cannot solve all problems

Who are the Users?



- Different types of users, must consider them all
  - *Primary:* people regularly using the VR system
  - *Secondary:* people providing tech support/developing system
  - *Tertiary:* people providing funding/space for VR system

Methods for Identifying User Needs

Learn from people

Learn from Experts

Learn from analogous settings

Immersive yourself in context

Design Thinking
Identifying User Needs

- To **understand** the **user**, we need to **look** for **needs**
  - When **trying** to **understand** user **needs** it pays to **dig deeper than** the **obvious** solutions
    - This means: **framing and reframing the problem** we are trying to solve
- **Needs are Verbs not Nouns**
  - A **verb** will **allow** your **imagination** to **fly**
  - While **thinking** of your **users need** as a **noun means** you have **already defined** the **solution**
    - Nouns constrain our thinking to variations on a theme
  - Verbs allow us to stray away from the obvious and come up with blue sky ideas

- Verbs => activities and desires
- Nouns => solutions

Example: The Bridge (1/2)

- Why build a bridge? What *needs* are we trying to solve?
  - If we were to **simply say:** there is a ***need* for** a ***bridge*** then the **solution** is already **defined**
    - We get an engineer and build it…
  - But if we were to say: **the *need*** was **to *transport* vehicles across** a body of **water:**
    - **Other** possible **solutions**: a **ferry** or **underwater tunnel**

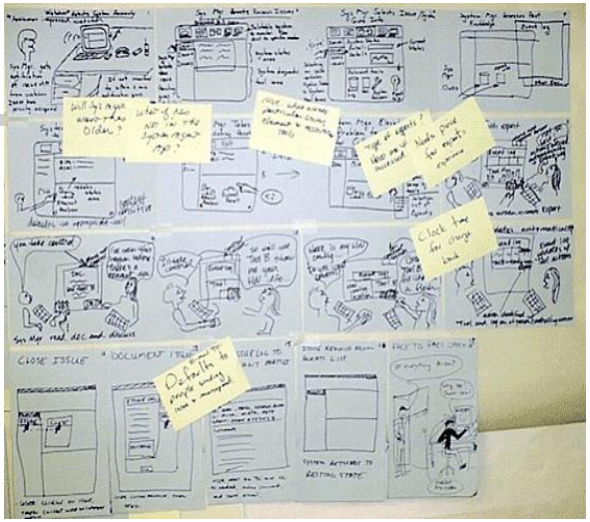
Example: The Bridge (2/2)

- Why build a bridge? What need are we trying to solve?
  - Well... And if we were to say: **The *need* was to *transport* people accross?**
    - Train? Swimming?
    - Zip-line?
    - Human catapult?!
  - If we push to come up with some wild ideas.. we may even start designing the future!

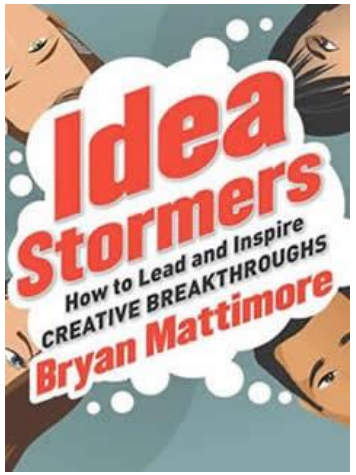
Is VR the Best Solution?

- Not every problem can be solved by VR..
- Problems Ideal for Virtual Reality, have:
  - visual elements
  - 3D spatial interaction
  - physical manipulation
  - procedural learning
- Problems Not ideal for Virtual Reality, have:
  - heavy reading, text editing
  - many non-visual elements
  - need for connection with real world
  - need for tactile, haptic, olfaction feedback

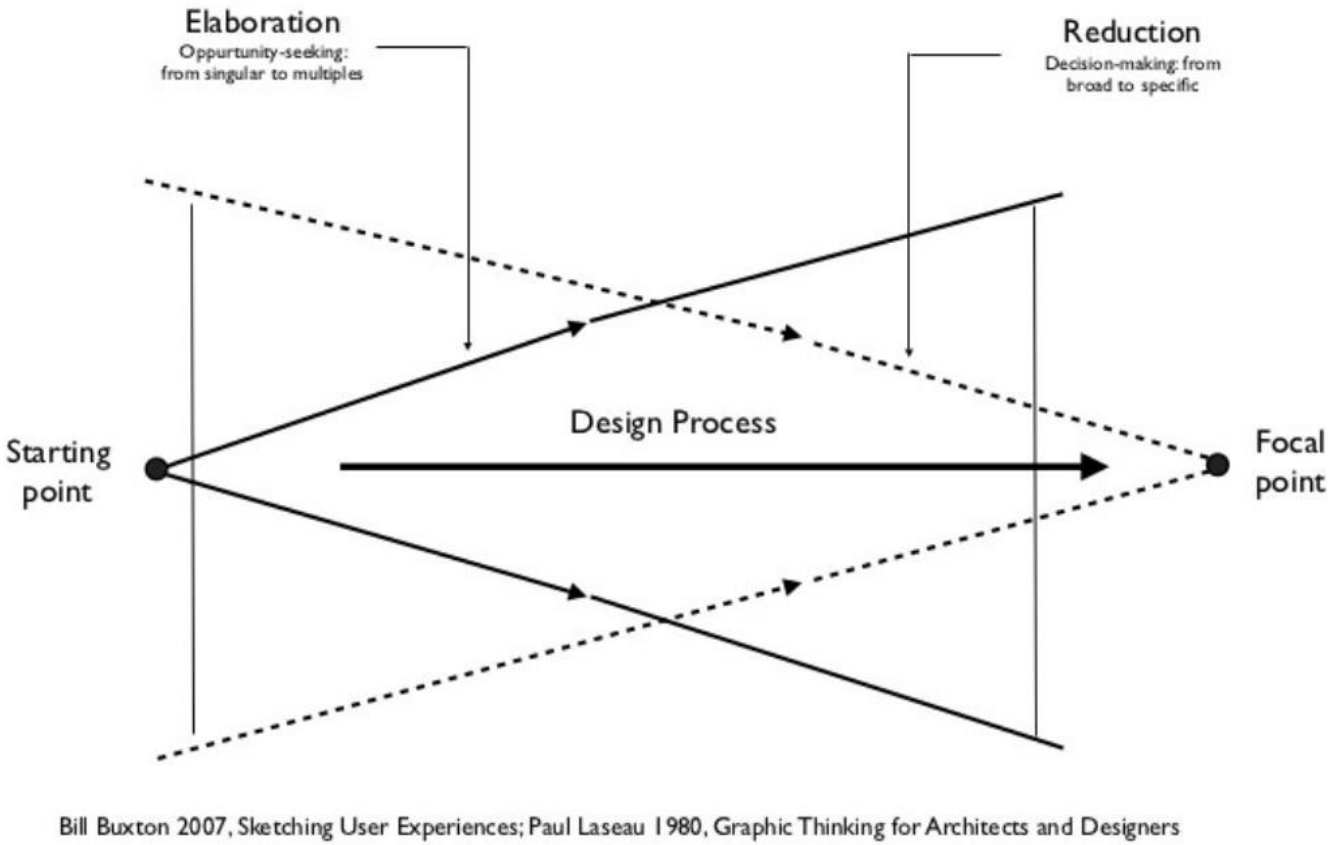
Idea Generation



- **Once** user **need** is **found**, solutions can be proposed
- Idea generation through:
  - Brainstorming
  - Lateral thinking
  - Formal problem solving
  - Etc…



Design Process
Elaboration and Reduction

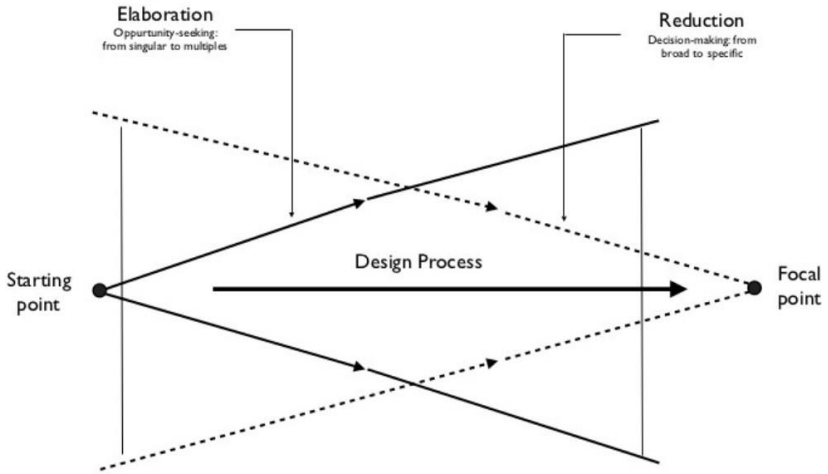


Bill Buxton 2007, Sketching User Experiences; Paul Laseau 1980, Graphic Thinking for Architects and Designers

Elaborate on Ideas and Reduce to Final Design Direction

- ***Elaborate*** generate solutions. These are the opportunities
- ***Reduction*** – decision making. Evaluate your ideas and reduce them

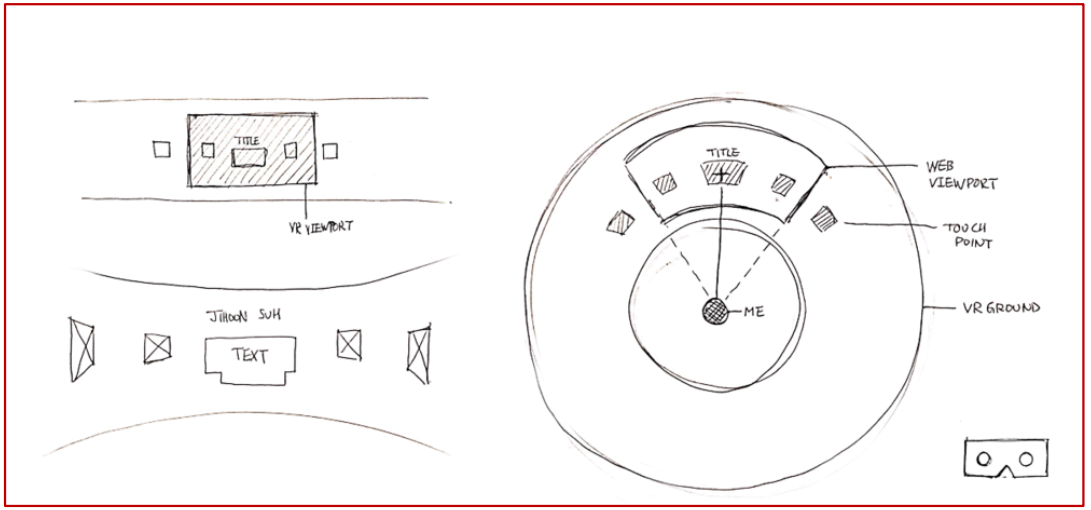
Design Process
Elaboration and Reduction



The **best way** to **Elaborate and Reduce** towards a **solution** is by **getting constant feedback**.

Don't move through a stage **without sharing**!

VR Interface Design Sketches

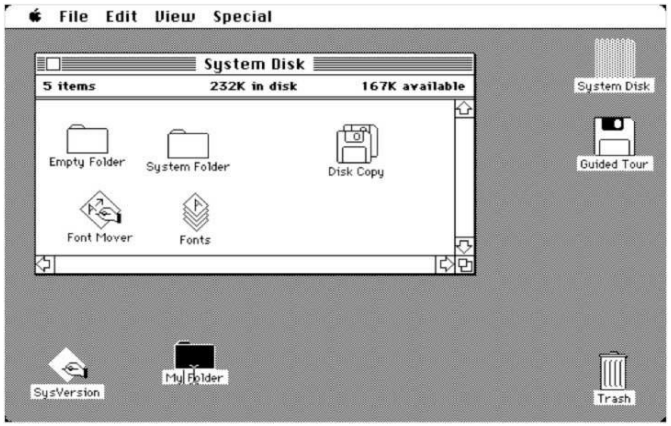


- Sketch out Design concept(s)

VR Design Considerations

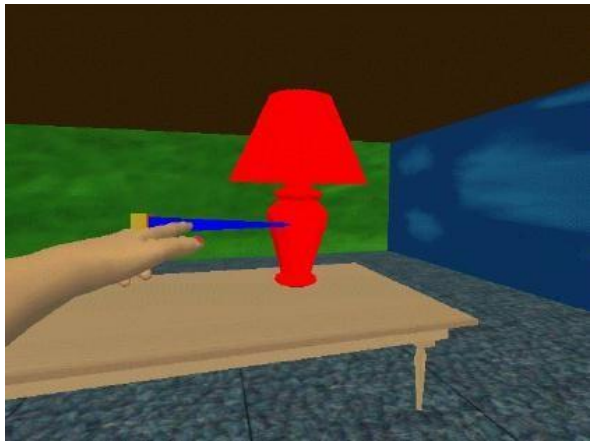
- Use UI Best Practices
  - Adapt know UI guidelines to VR
- Use of Interface Metaphors/Affordances
  - Decide best metaphor for VR applications
- Design for Humans
  - Use Human Information Processing model
- Design for Different User Groups
  - Different users may have unique needs
- Design for the Whole User base
  - Social, cultural, emotional, physical cognitive

Use Interface Metaphors



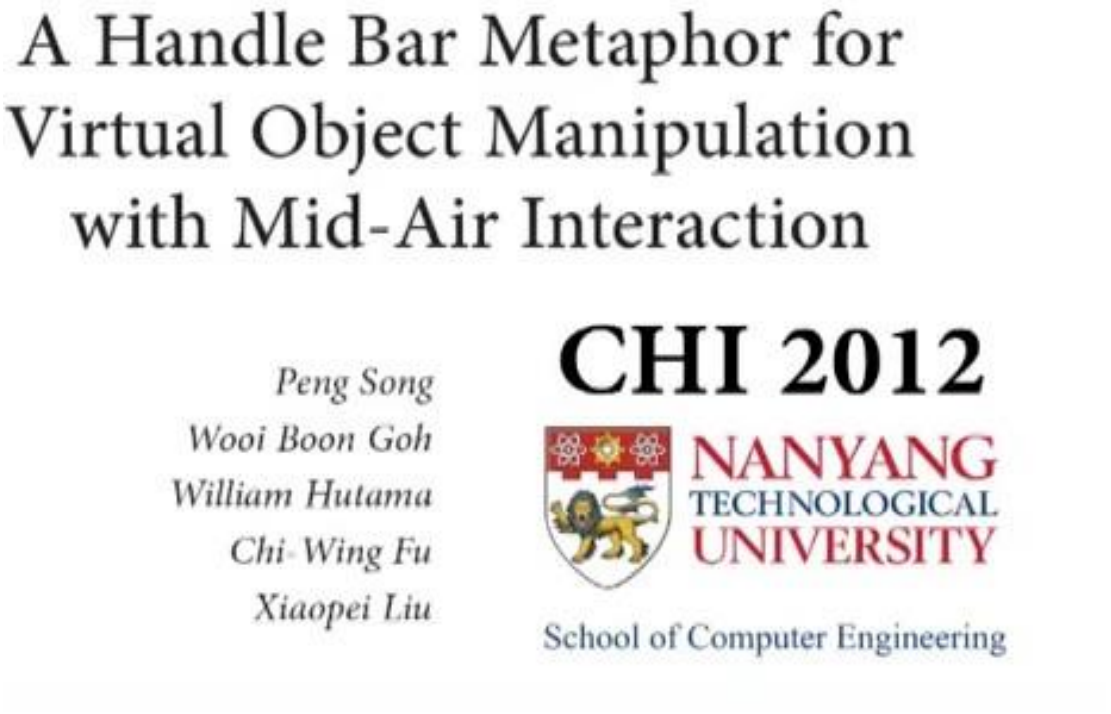
- Design interface object to be similar to familiar physical object that the user knows how to use
  - E.g. Desktop metaphor, spreadsheet, calculator
- Benefits
  - Makes learning interface easier and more accessible
  - Users understand underlying conceptual model

Typical VR Interface Metaphors



- Direct Manipulation
  - Reach out and directly grab objects
- Vehicle Movement
  - Move through VR environment through vehicle movement

Example: Handle Bar Metaphor



- https://www.youtube.com/watch?v=VBCP63jD3OI

Affordances

”… the **perceived** and **actual properties** of the thing, primarily those fundamental properties that determine just how the thing could possibly be used. [...]

Affordances provide strong clues to the operations of things.”

(Norman, The Psychology of Everyday Things 1988, p.9)

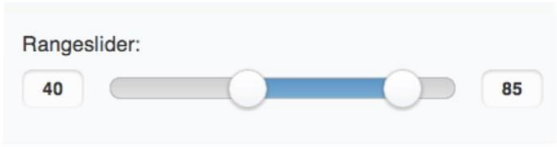
Affordances

Affordances by Dan Norman

https://www.youtube.com/watch?v=NK1Zb_5VxuM

Physical vs. Virtual Affordances

- Physical Affordance
  - Look and feel of real objects
  - Shape, texture, colour, weight, etc.
  - Industrial Design
- Virtual Affordance
  - Look of virtual objects
    - Copy real objects
  - Interface Design



Affordances in VR

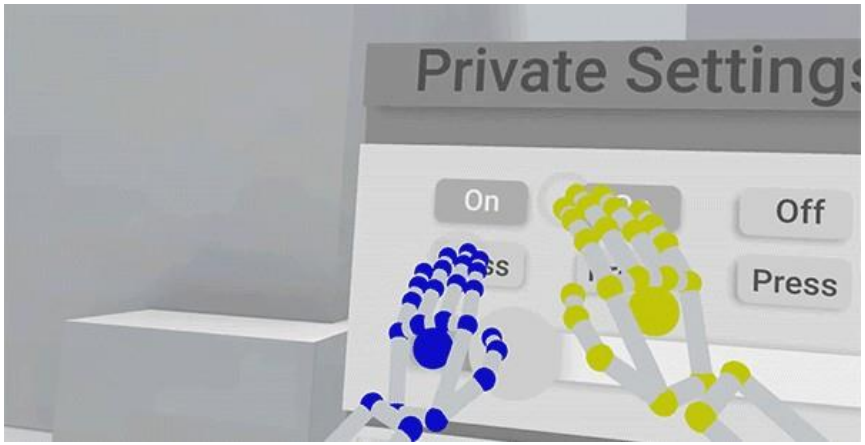
Familiar objects in Job Simulator

Object shape shows how to pick up

Keep in mind when designing interface objects:

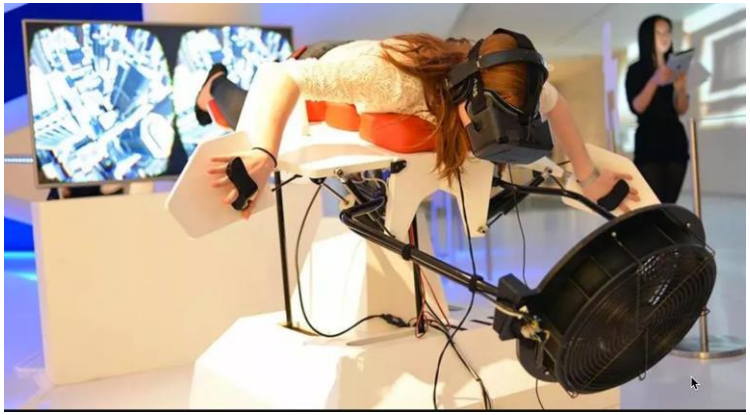
- Use **visual cues** to **show** possible **affordances**
- **Perceived affordances** should match **actual affordances**
- **Good cognitive model** - map object behavior has expected

Examples of Affordances in VR



Virtual buttons can be pushed

Virtual doors can be walked through



Flying like a bird in Birdly

Virtual objects can be picked up

Design for Perception

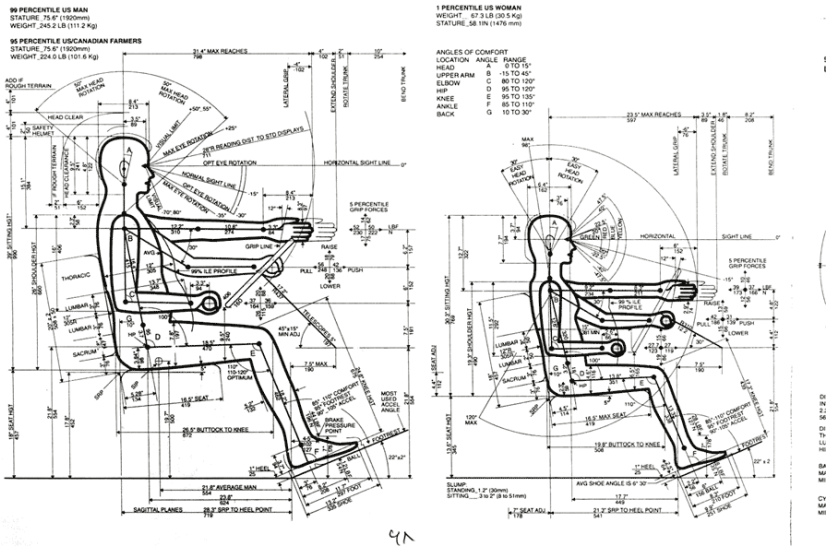
Need to understand perception to design VR

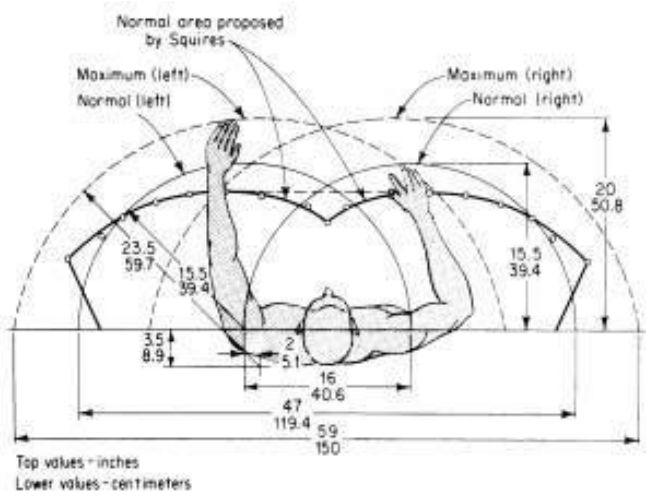
- Visual perception
  - Many types of visual cues (stereo, oculomotor, etc.)
- Auditory system
  - Binaural cues, vestibular cues
- Somatosensory system
  - Haptic, tactile, kinesthetic, proprioceptive cues
- Chemical Sensing System
  - Taste and smell

Design for Cognition

- Design for Working and Long term memory
  - Working memory
    - Short term storage, **Limited** storage (**~5-9 items**)
  - Long term memory
    - Memory recall **trigger by associative cues**
- Improve Situational Awareness
  - Provide cognitive cues to help with situational awareness
    - Landmarks, procedural cues, map knowledge
    - Support both egocentric and exocentric views

Design for Physical Ergonomics





- Design for the human motion range
  - Consider human comfort and natural posture
- Design for hand input
  - Coarse and fine scale motions, gripping and grasping
  - Avoid “Gorilla arm syndrome” from holding arm pose

Designing for Different User Groups

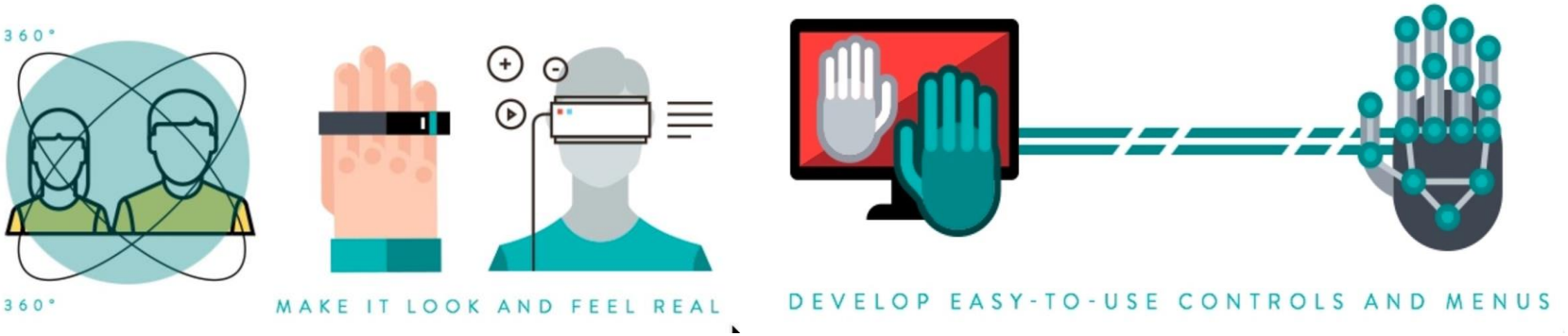
- Design for Different Ages
  - Children require different interface design
  - Older uses have different needs than younger
- Consider the User Experience with VR systems
  - Familiar with HMDs, VR input devices
- People with Different Physical Characteristics
  - Height and arm reach, handedness
- Perceptual, Cognitive and Motor Abilities
  - Colour perception varies between people
  - Spatial ability, cognitive or motor disabilities

UX Guidelines for VR

- The Four Cores of UX Design for VR
  - Make **interface Interactive** and **Reactive**
  - **Design** for **Comfort** and **Ease**
  - Use **Text** and **Image Scale**
  - Include **positional audio** and **3D sound**

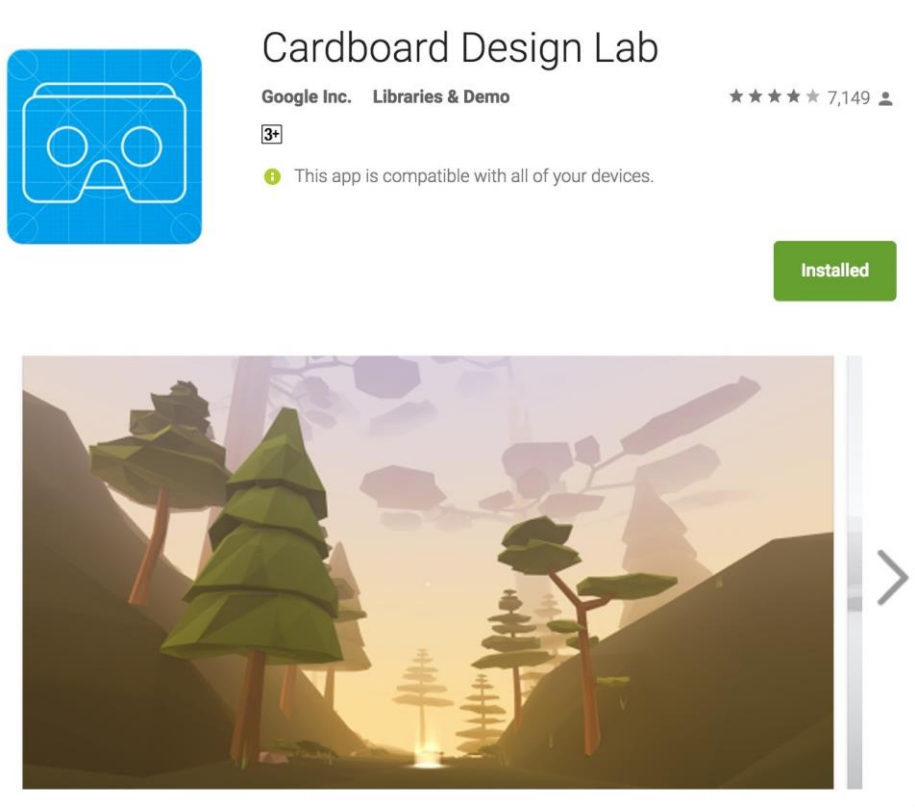
https://www.dtelepathy.com/blog/philosophy/ux-guide-designing-virtual-reality-experiences

UX Challenges



- Problems to be aware:
  - **Keep** the **user safe**
  - Make it **look** and **feel real**
  - Make sure **users don't** get **simulation sickness**
  - Develop **easy-to-use controls** and **menus**

Good Practices for VR
Cardboard Design Lab

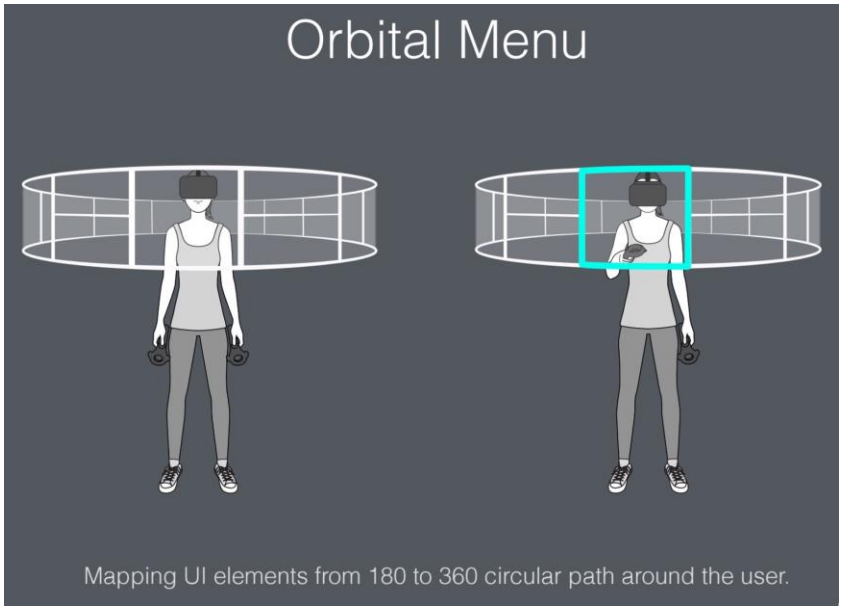


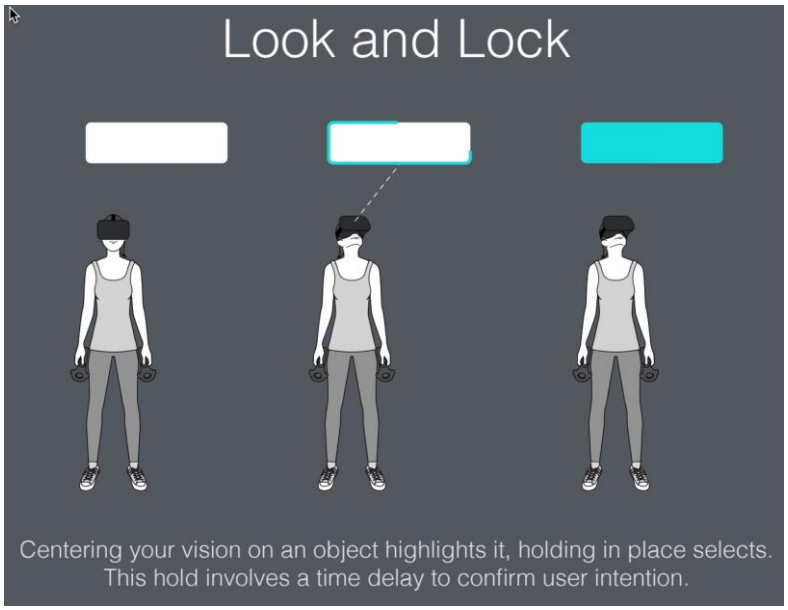
- Mobile VR App providing examples of best practices for VR designs and user interaction (iOS, Play app stores)

Demo: Cardboard Design Lab

- https://www.youtube.com/watch?v=2Uf-ru2Ndvc

VR Human Interface Guidelines





- Interface design website - http://vrhig.com/
- Set of VR interface design best practices

More VR Design Guidelines

- Use real-world cues when appropriate
- If there is a horizon line, keep it steady
- Be careful about mixing 2D GUI and 3D
- Avoid rapid movement, it makes people sick
- Avoid rapid or abrupt transitions to the world space
- Keep the density of information and objects on screen low
- Do not require the user to move their head or body too much

From https://www.wired.com/2015/04/how-to-design-for-virtual-reality/