LECTURE 5: INTERACTION DESIGN FOR VIRTUAL REALITY

COMP 4010 – Virtual Reality
Semester 5 – 2017

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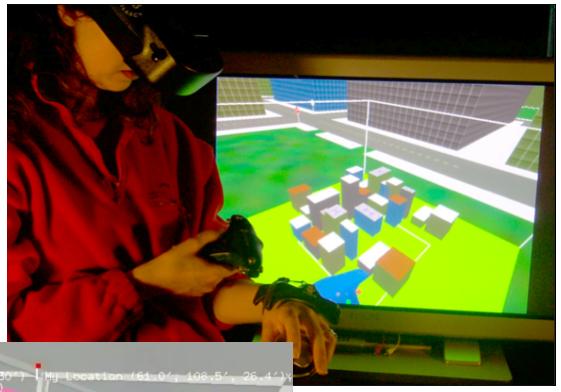
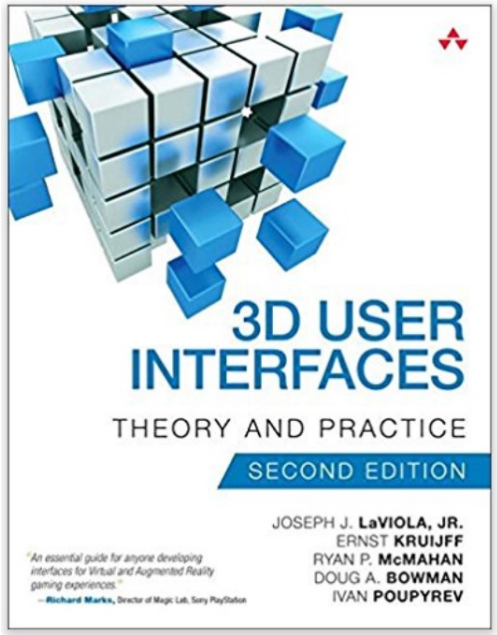
Lecture 4: Recap

- 3D User Interfaces
  - User interfaces for VR systems
  - Need good 3D UI guidelines
- But 3D interaction is difficult
  - Needs spatial input
  - Interface Layout more complex
  - Lack of constraints, precision
  - Lack of standards, tools
  - User Fatigue, perception needs





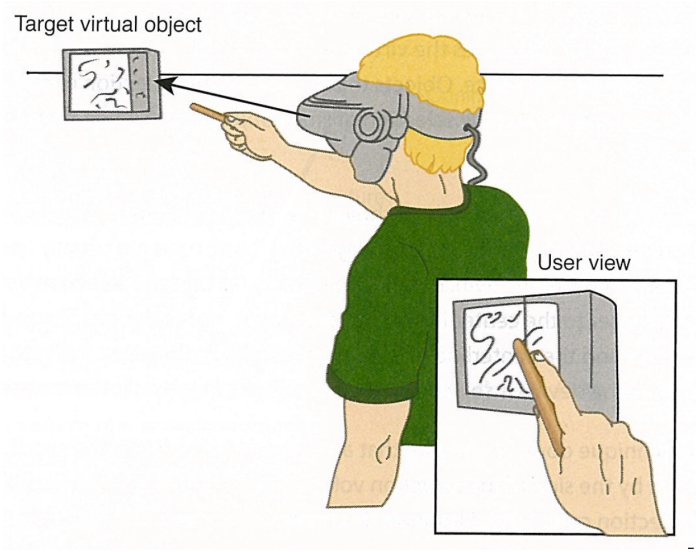
Universal 3D Interaction Tasks in VR

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

Object Interaction

- Selection:
  - specifying one or more objects from a set
- Manipulation:
  - modifying object properties
    - position, orientation, scale, shape, color, texture, behavior, etc.

Selection and Manipulation Techniques



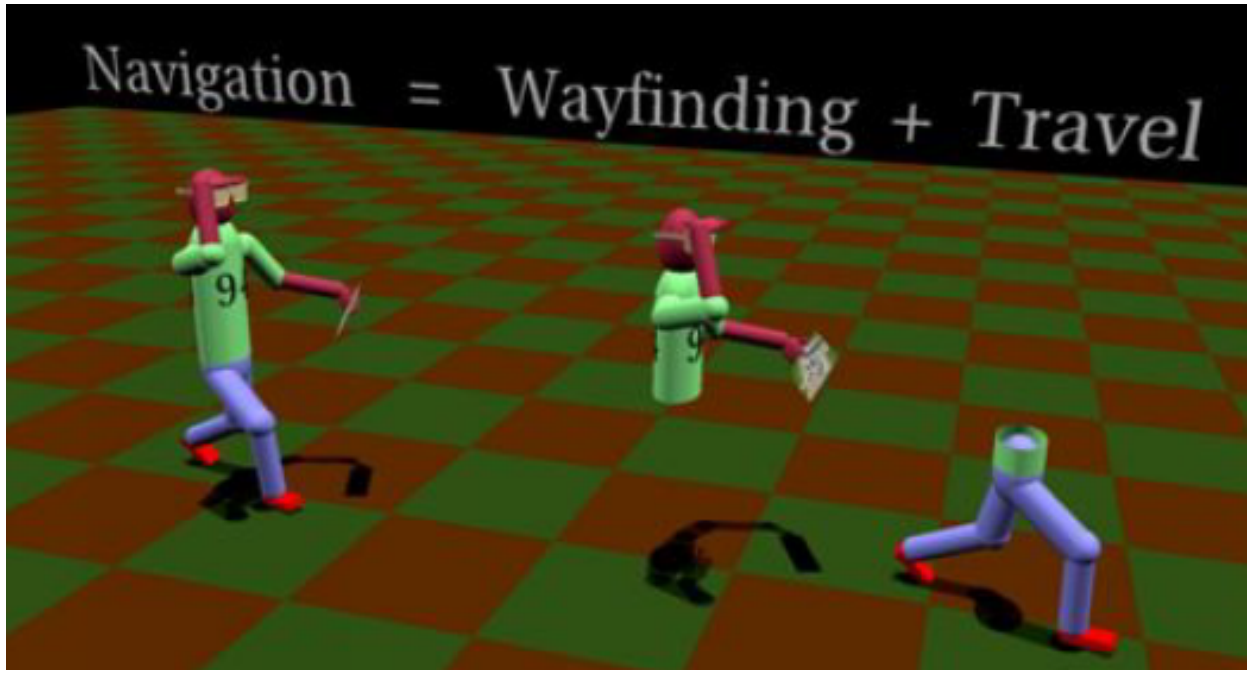
Manipulation

- 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

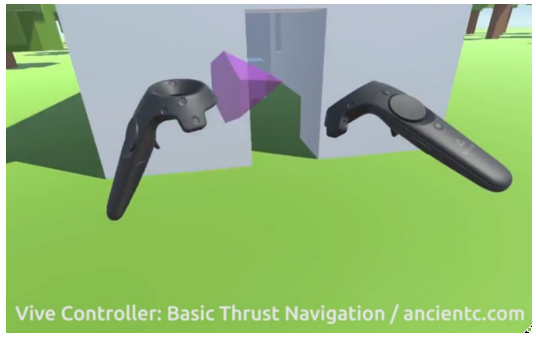
Navigation

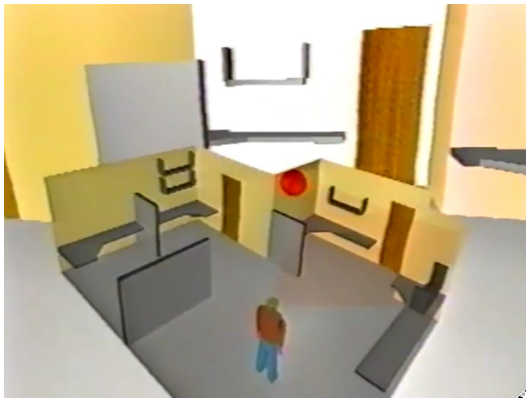


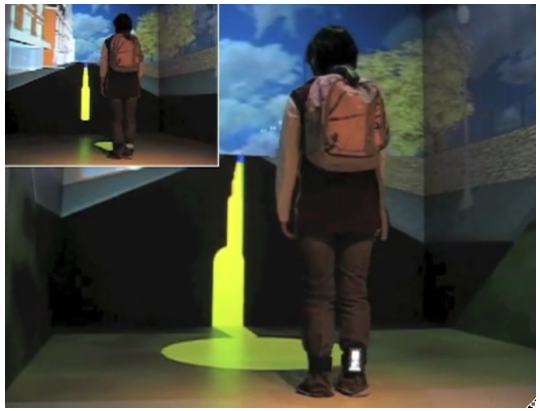
- How we move from place to place within an environment
- The combination of travel with wayfinding
  - *Wayfinding*: cognitive component of navigation
  - *Travel:* motor component of navigation
- Travel without wayfinding: "exploring", "wandering"

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

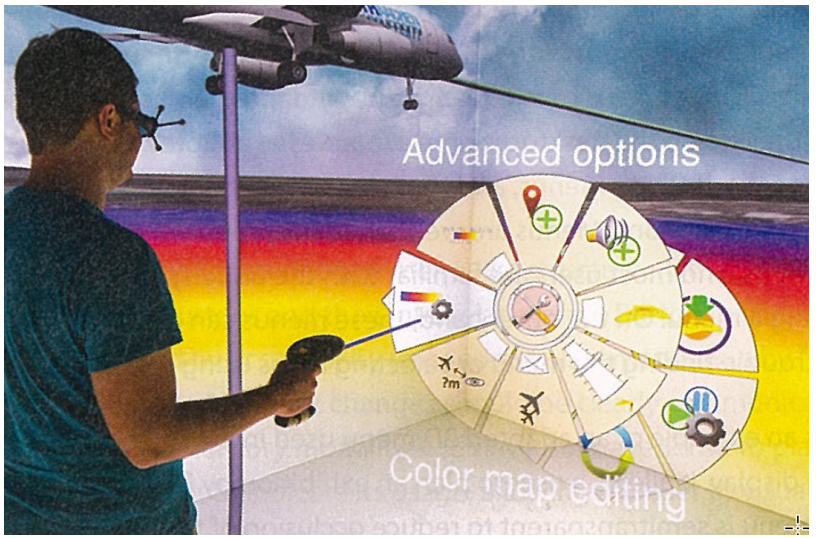




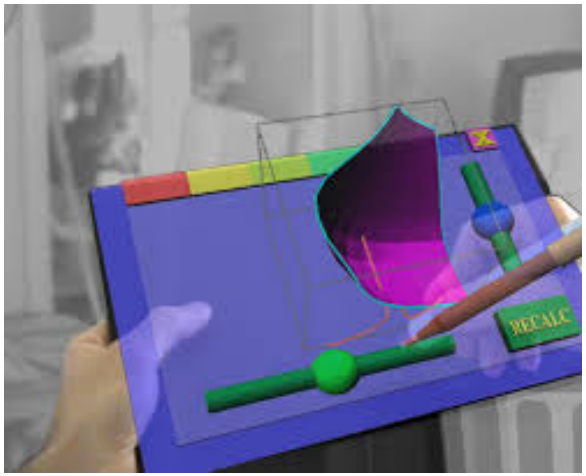


System Control

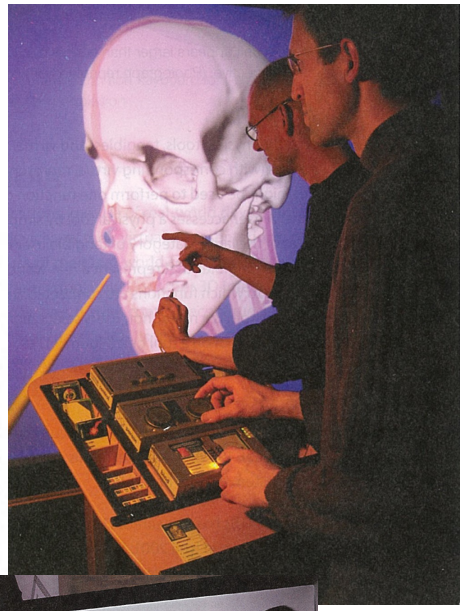
- Issuing a command to change system state or mode
- Examples
  - Launching application
  - Changing system settings
  - Opening a file
  - Etc.

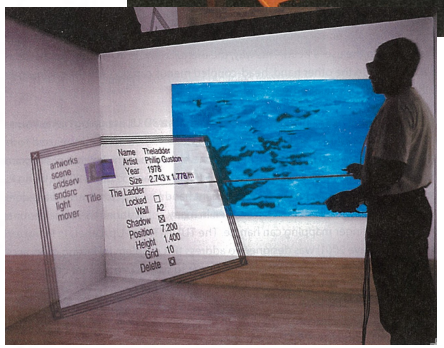


- Key points
  - Make commands visible to user
  - Support easy selection



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

INTERACTION DESIGN FOR VIRTUAL REALITY

How Can we Design Useful VR?

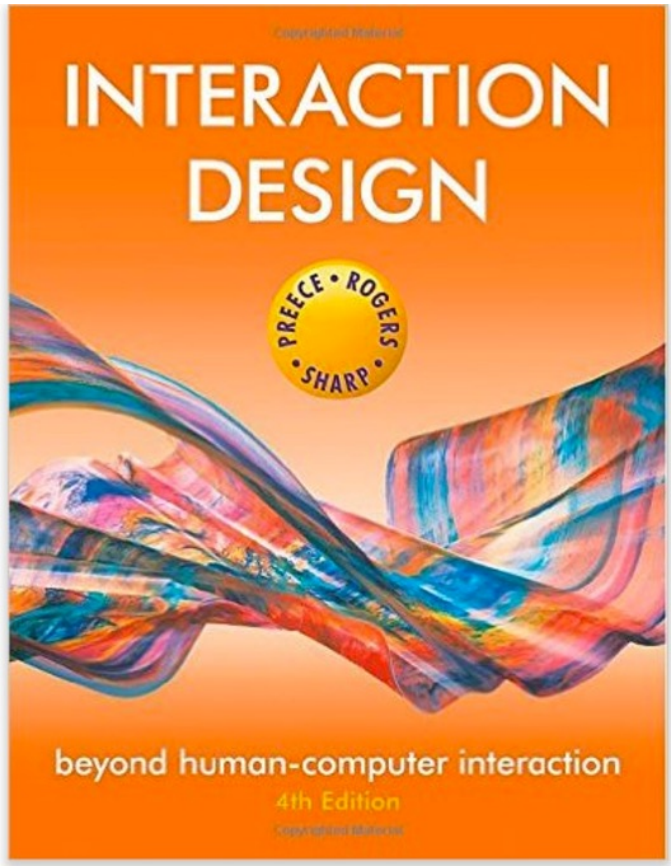
- Designing VR experiences that meet real needs

What is Interaction Design ?

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

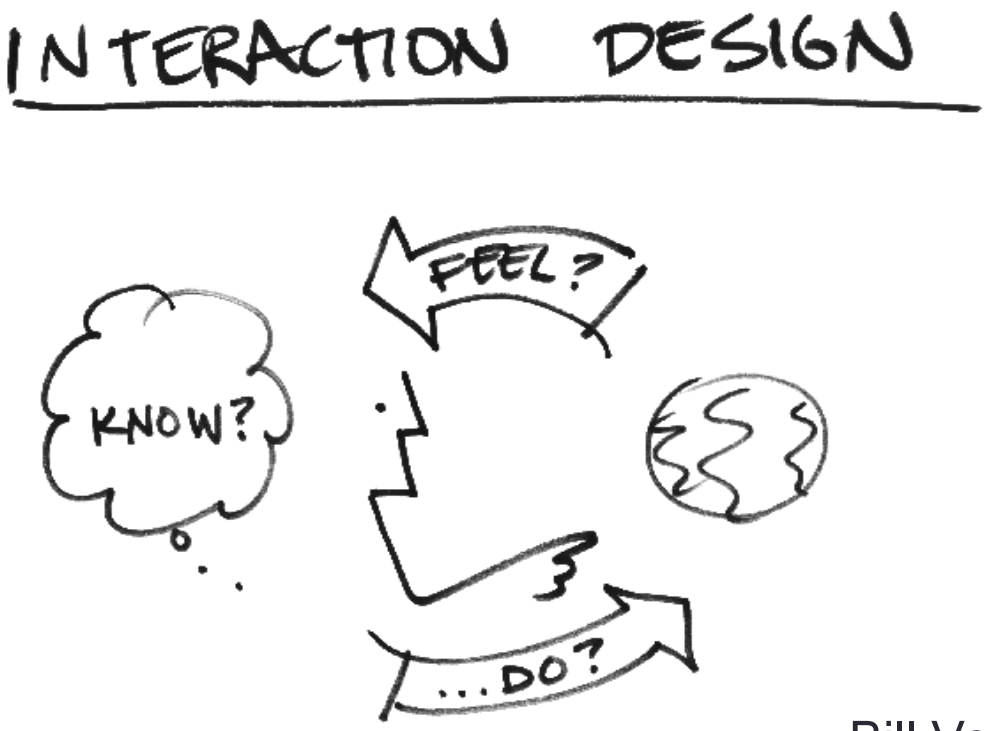
Preece, J., (2002). Interaction Design

- Interaction Design is the design of user experience with technology



Bill Verplank on Interaction Design

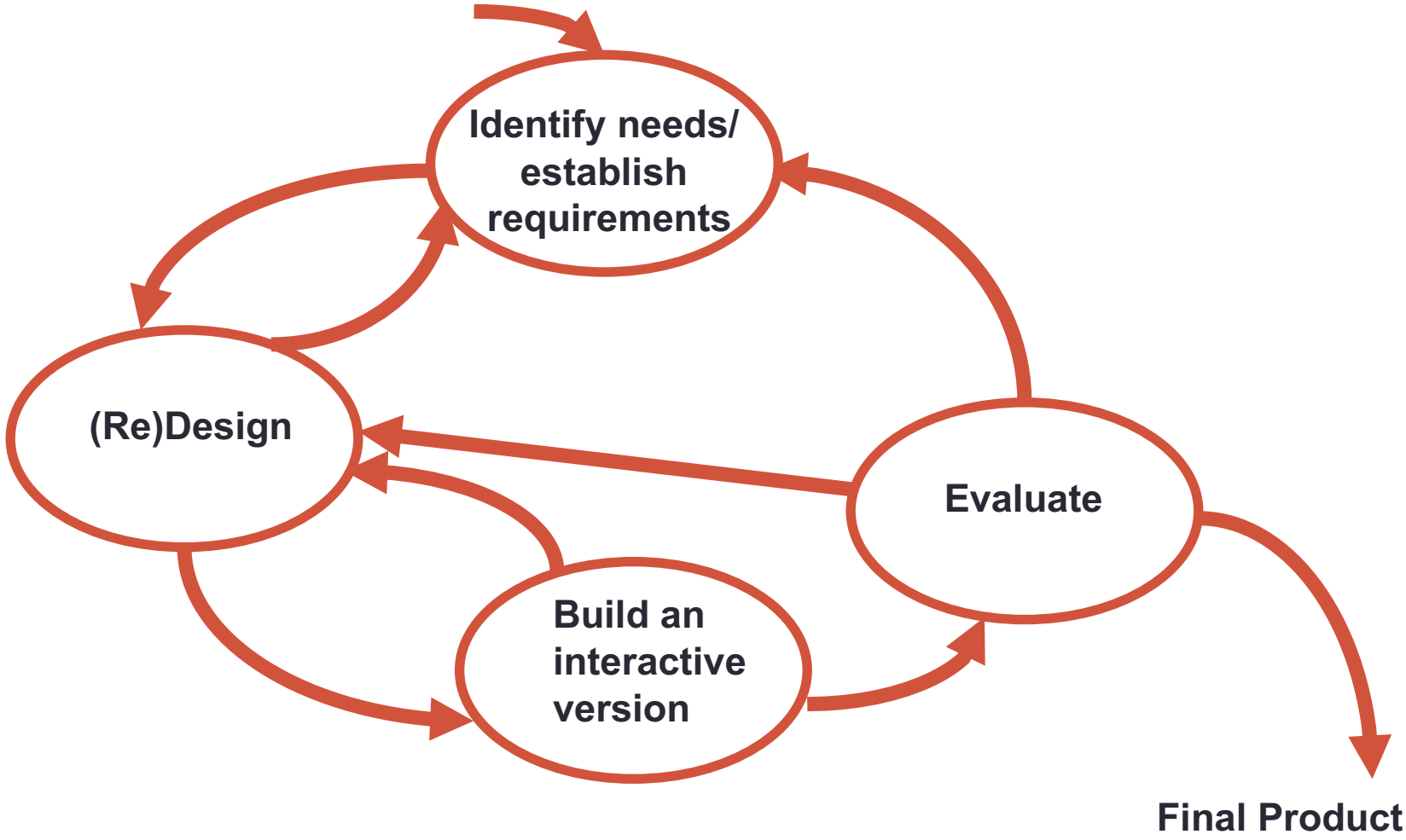
- https://www.youtube.com/watch?v=Gk6XAmALOWI



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?

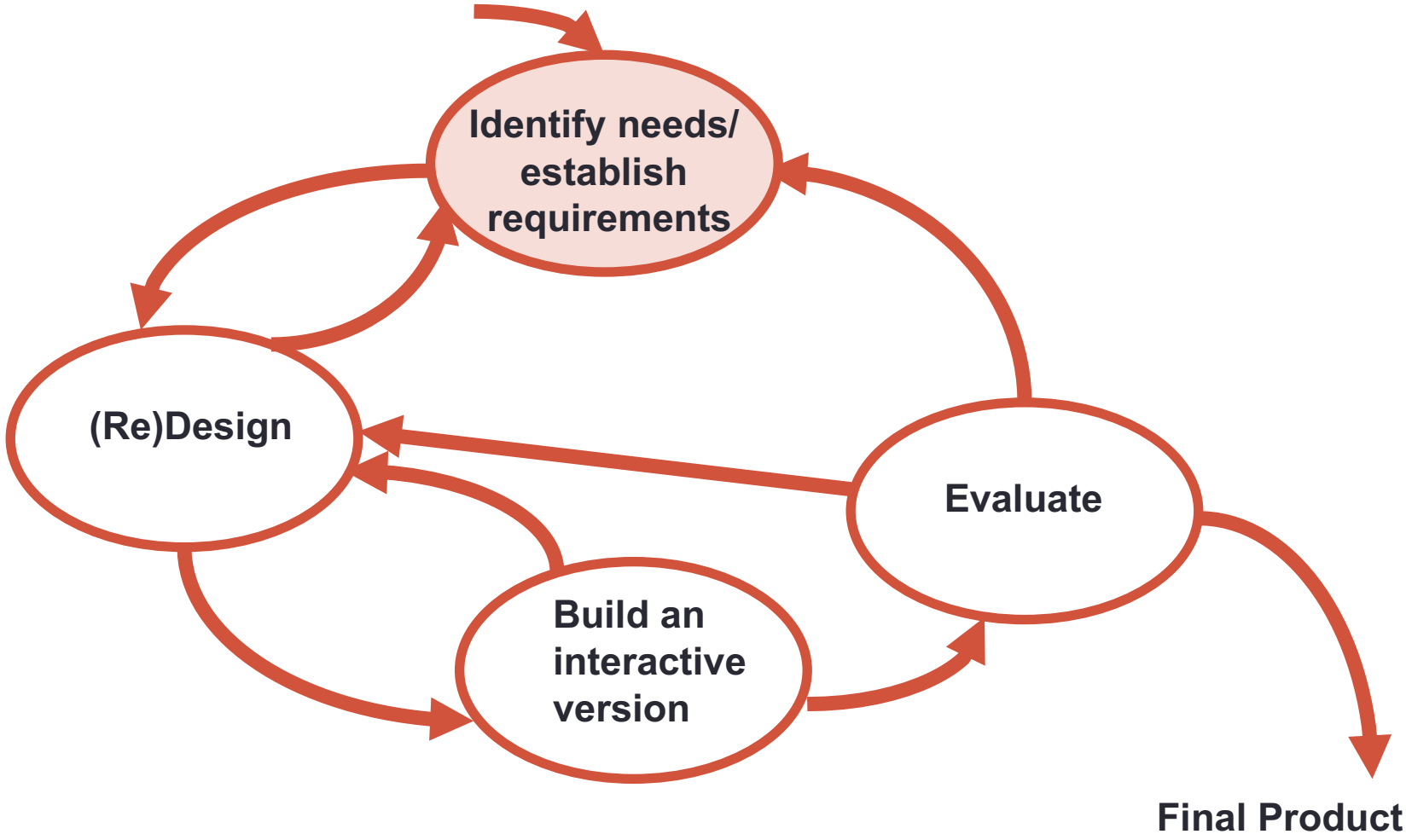
The Interaction Design Process



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

NEEDS ANALYSIS

Interaction Design Process



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

Needs Analysis Goals

1. *Create a deep understanding of the user and problem space*
2. *Understand how VR can help address the user needs*

Key Questions

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

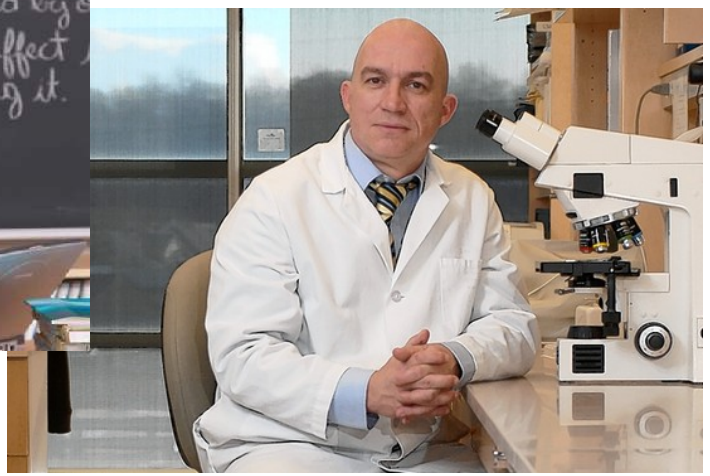
Learn from analogous settings

Immersive yourself in context

1. Learn from People

- Learn from target users by:
  - Questionnaires and interviewing
  - Running focus groups
  - Observing people performing target tasks

2. Learn from Experts



- Experts have in-depth knowledge about topic
  - Can give large amount of information in short time
  - Look for existing process/problem documentation
- Choose participants with domain expertise
  - Expertise, radical opinion, etc.

3. Immersive yourself in Context

A day in the Life of.. **Cultural Probes..** **Role Playing..**

- Put yourself in the position of the user
  - Role playing, a day in the life of a user, cultural probes
  - Observing the problem space around you – how do you feel?
- Take notes and capture your observations

4. Seek Inspiration in Analogous Setting

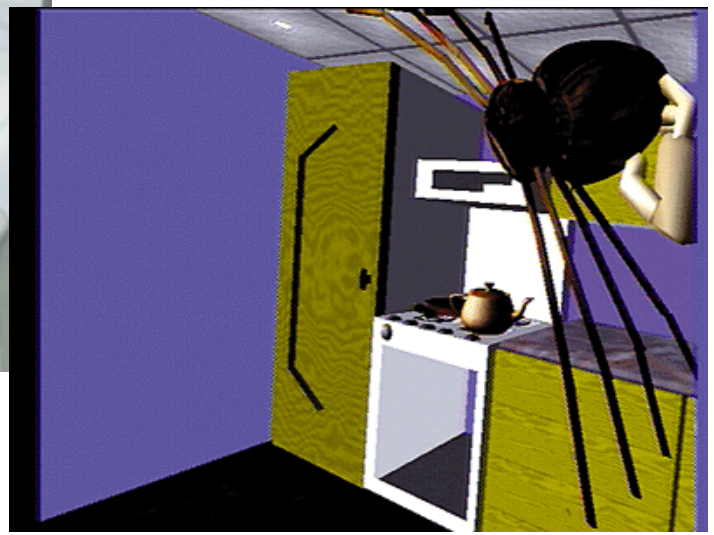
What can public libraries learn from Apple stores?

- Inspiration in different context than problem space
  - E.g. redesign library by going to Apple store
- Think of Analogies that connect with challenge
  - Similar scenarios in different places

Identifying User Needs

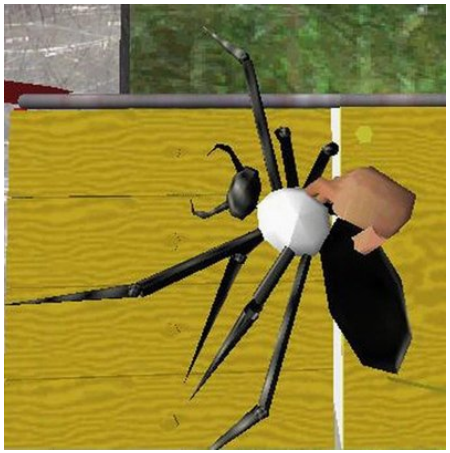
- From understanding the user, look for needs
  - Human emotional or physical necessities.
  - Needs help define your design
- Needs are Verbs not Nouns
  - Verbs - (activities and desires)
  - Nouns (solutions)
- Identify needs from the user traits you noted, or from contradictions between information
  - disconnect between what user says and what user does..

Example: VR for Arachnophobia



- True story:
  - Mark's father, Alan, didn't seem afraid of anything
  - He went to the HIT Lab to try VR for the first time
  - In a virtual kitchen he saw a VR spider and screamed
- Contradiction:
  - Afraid of nothing, but screams at virtual spider

Example: VR for Arachnophobia



State the Problem

User Need

- [User] needs [verb phrase] in a way that [way]
- How might we [verb phrase] ?

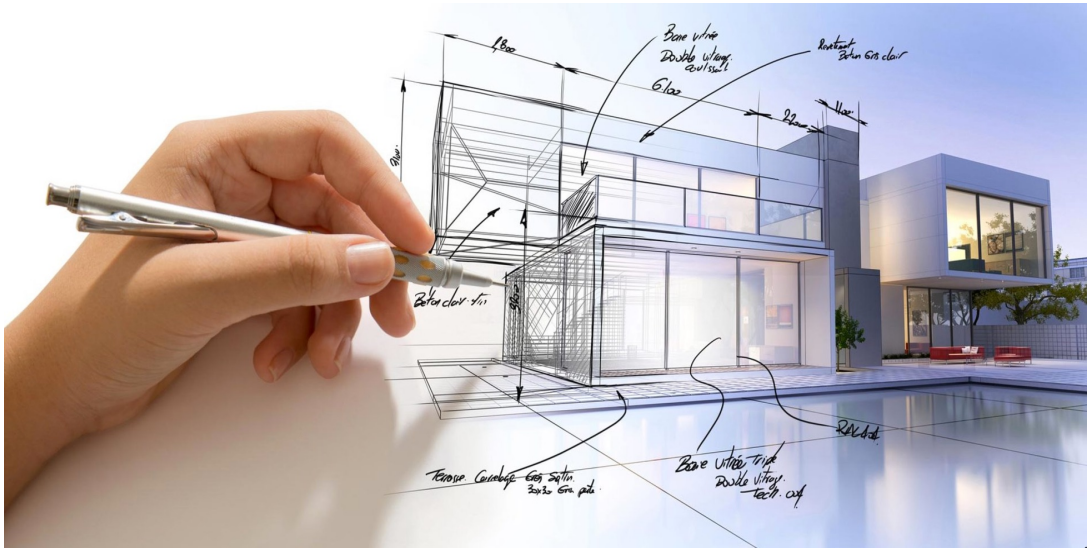
Example

- Alan needs to overcome his fear of spiders in a way that that is easy and painless
- How might we help him overcome his fear of spiders ?

Is VR the Best Solution?

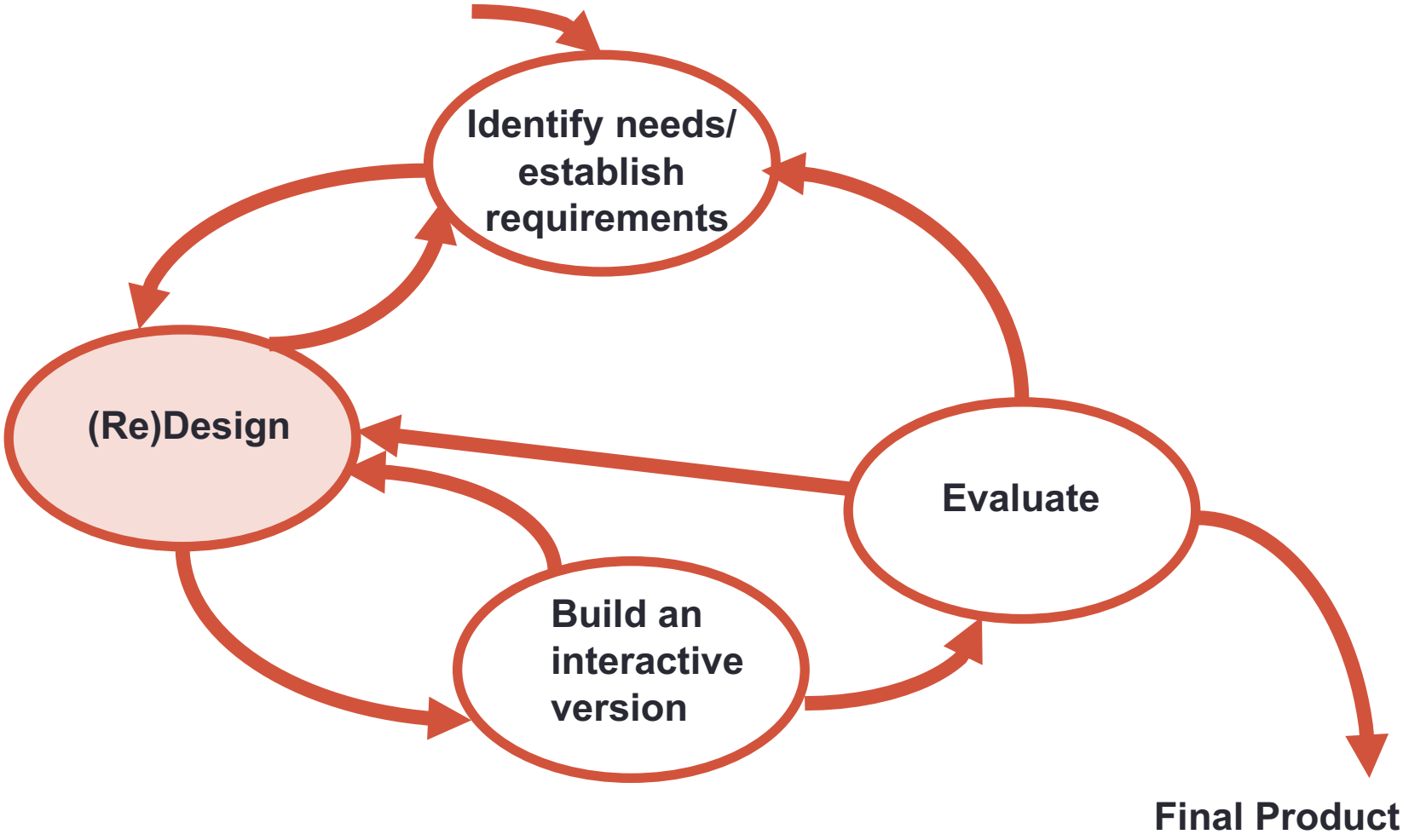
- Not every problem can be solved by VR..
- Problems Ideal for Virtual Reality, have:
  - visual elements
  - 3D spatial interaction
  - physical manipulation
  - procedural learning
- Problems Not ideal for Virtual Reality, have:
  - heavy reading, text editing
  - many non visual elements
  - need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

Suitable for VR or not?

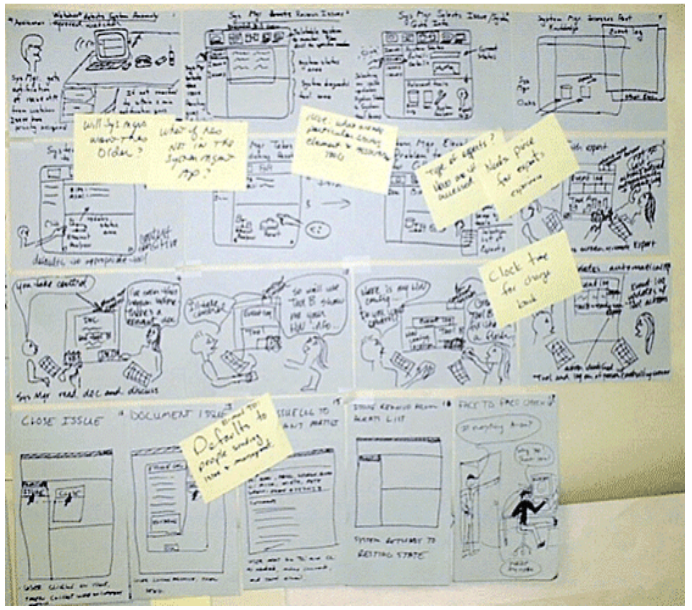


DESIGN

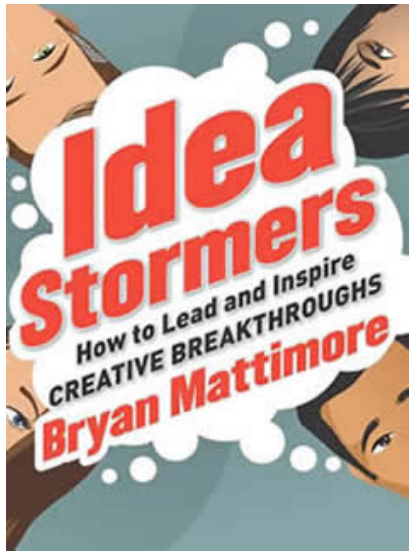
The Interaction Design Process



Idea Generation



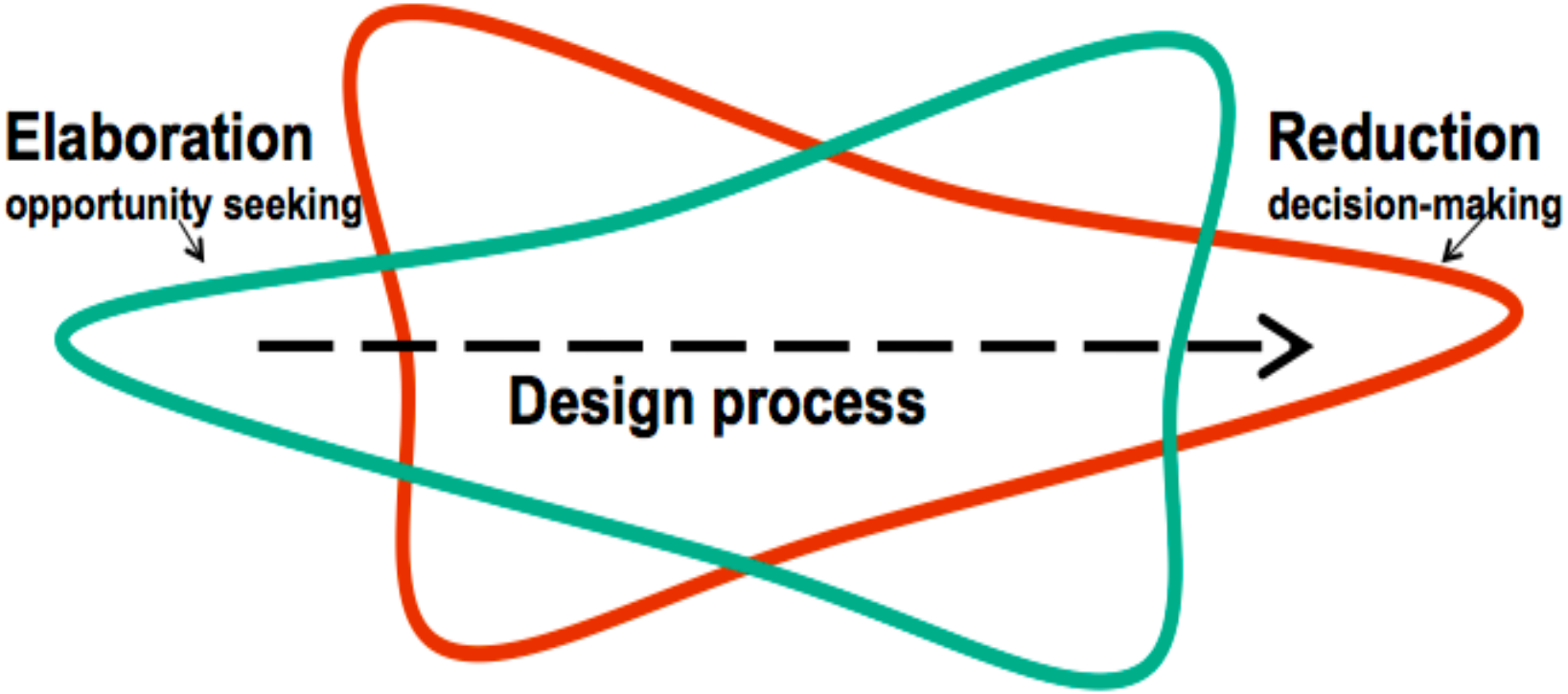
- Once user need is found, solutions can be proposed
- Idea generation through:
  - Brainstorming
  - Lateral thinking
  - Ideal storming
  - Formal problem solving
  - Etc..



Example:

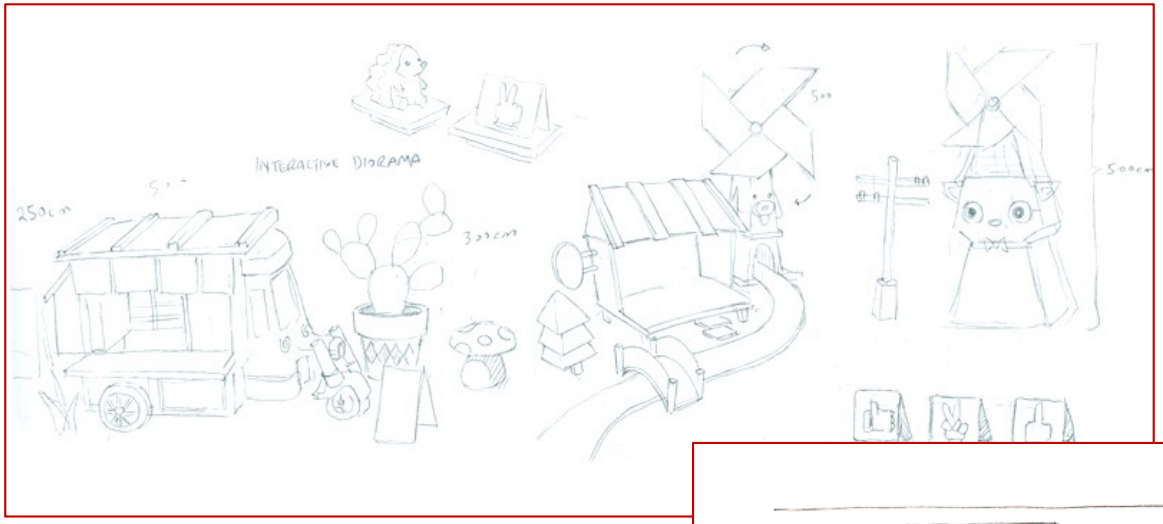
- Ideas for overcoming fear of spiders
  - Watching spider videos
  - Exposure to real spiders
  - Using toy spiders
  - Virtual Reality therapy
  - Augmented Reality spider viewing

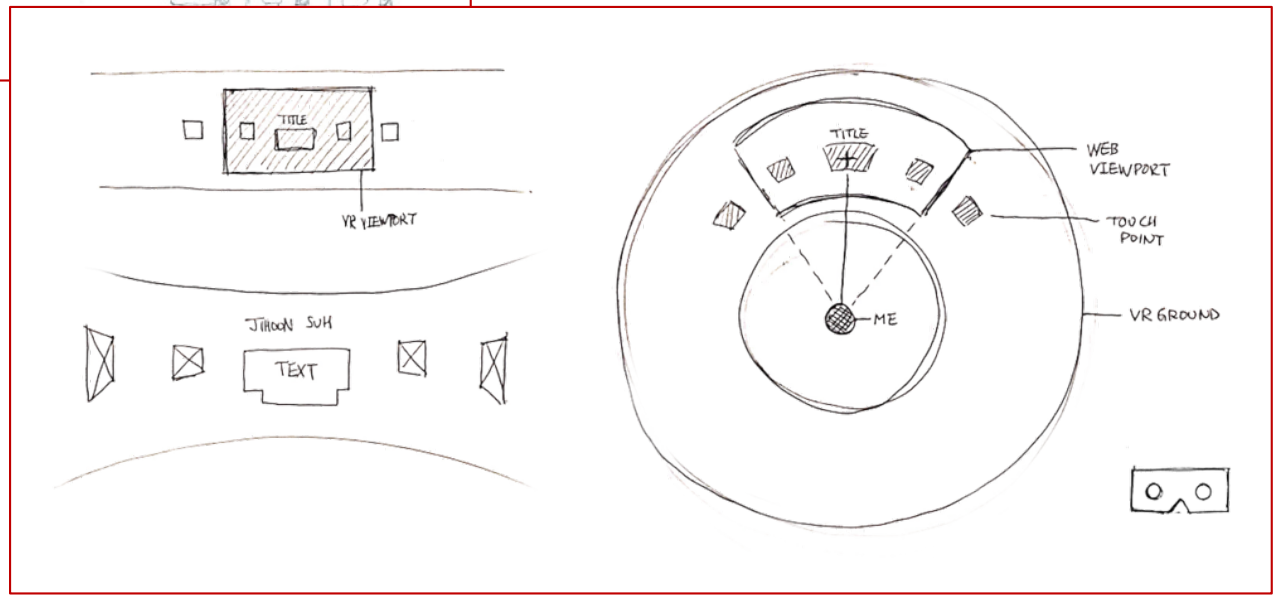
Elaboration and Reduction



- Elaborate on Ideas and Reduce to Final Design Direction
  - *Elaborate* - generate solutions. These are the opportunities
  - *Reduce* - decide on the ones worth pursuing
  - *Repeat* - elaborate and reduce again on those solutions

VR Interface Design Sketches

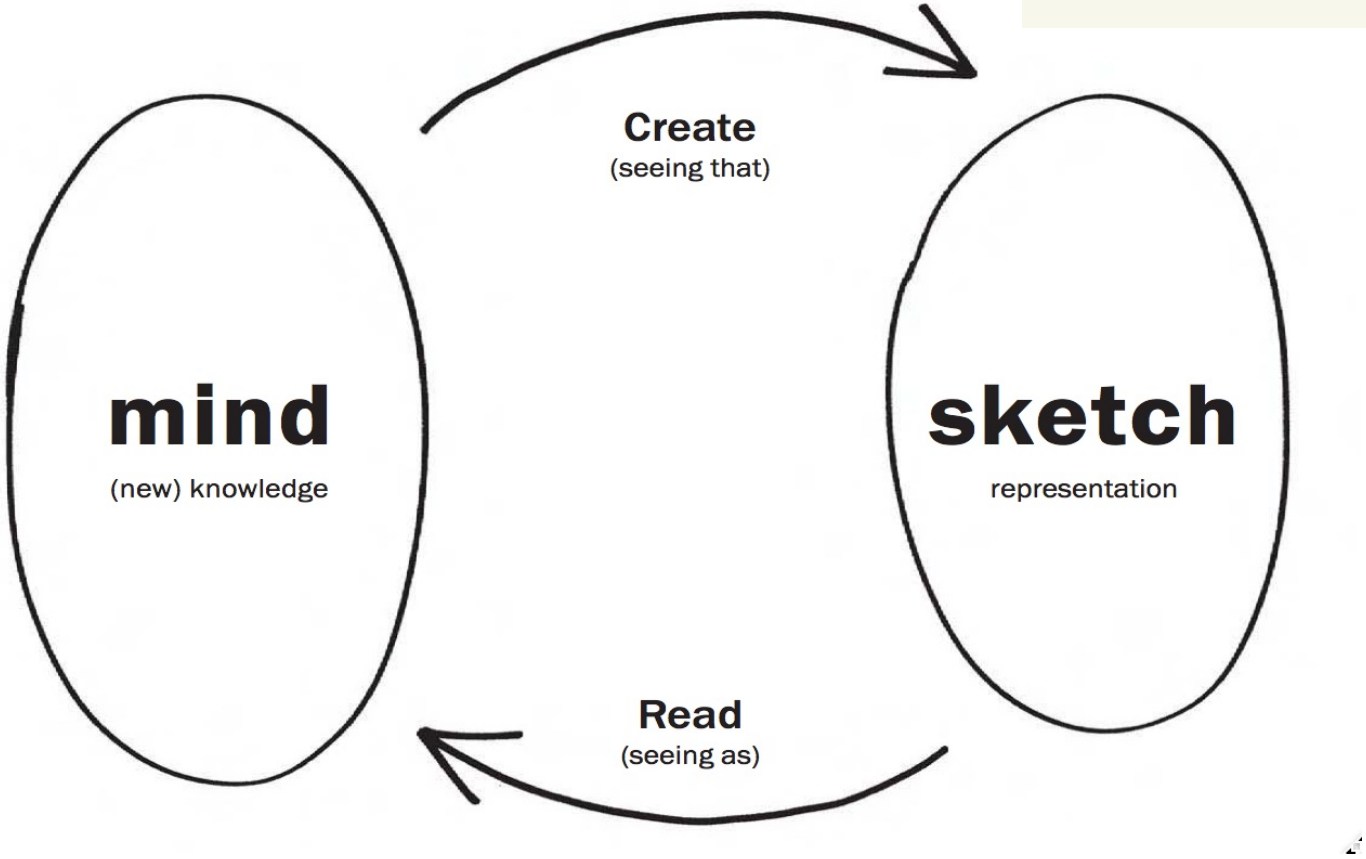




- Sketch out Design concept(s)

Role of Sketching

"Sketching is about the activity not the result"
– Bill Buxton



- Use sketching as way to communicate and create new ideas

Why is Sketching Useful?

- Early ideation
- Think through ideas
- Force you to visualize how things come together
- Communicate ideas to inspire new designs
- Ideal for active brainstorming
- Beginning of prototyping process

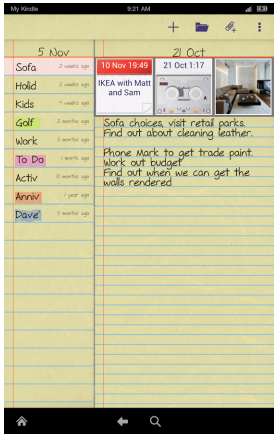
VR Design Considerations

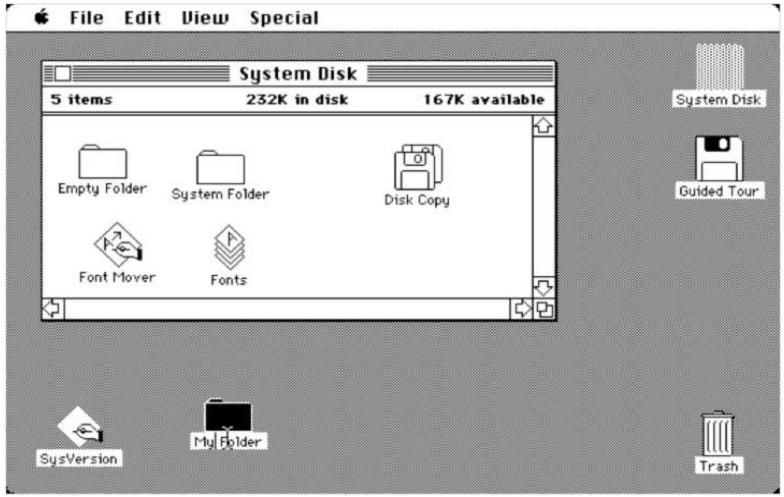
- Use UI Best Practices
  - Adapt know UI guidelines to VR
- Use of Interface Metaphors/Affordances
  - Decide best metaphor for VR application
- Design for Humans
  - Use Human Information Processing model
- Design for Different User Groups
  - Different users may have unique needs
- Design for the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

Use UI Best Practices

- General UI design principles can be applied to VR
  - E.g. Shneiderman's UI guidelines from 1998
- Providing interface feedback
  - Mixture of reactive, instrumental and operational feedback
  - Maintain spatial and temporal correspondence
- Use constraints
  - Specify relations between variables that must be satisfied
    - E.g. physical constraints reduce freedom of movement
- Support Two-Handed control
  - Use Guiard's framework of bimanual manipulation
    - Dominant vs. non-dominant hands

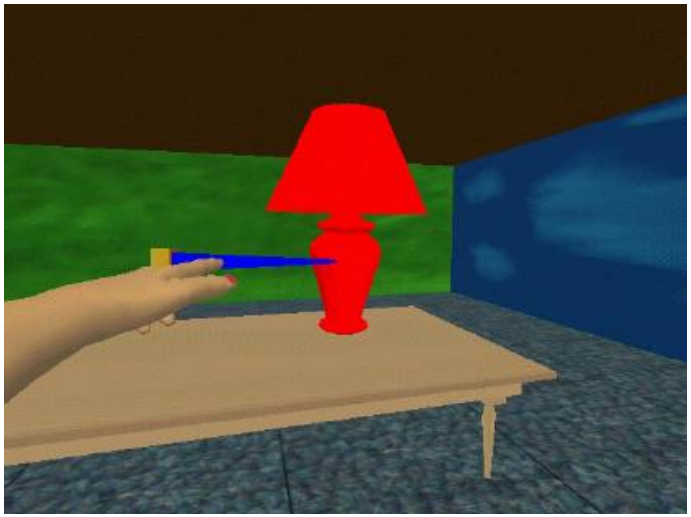
Use Interface Metaphors





- 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
- Ray Casting
  - Select objects through ray from head/hand
- Vehicle Movement
  - Move through VR environment through vehicle movement

Example: Handle Bar Metaphor

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

How are These Used?

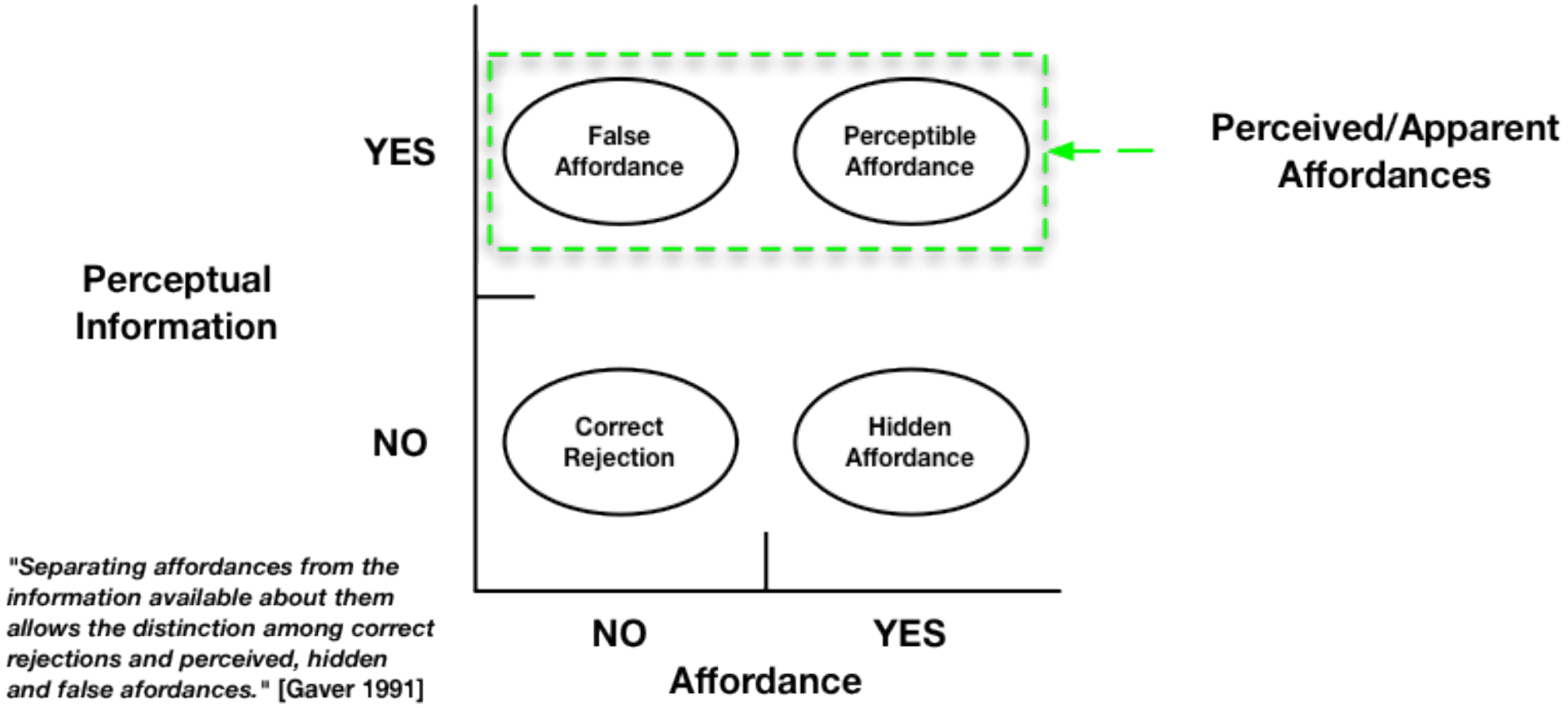
Affordances

”… 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)

Perceived vs. Actual Affordances

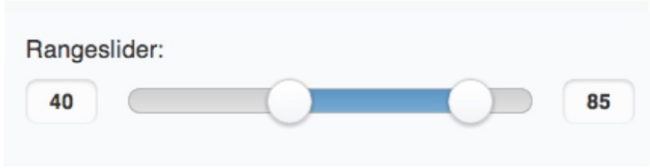


"Separating affordances from the information available about them allows the distinction among correct rejections and perceived, hidden and false afordances." [Gaver 1991]

- Perceived affordance should match actual affordance

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



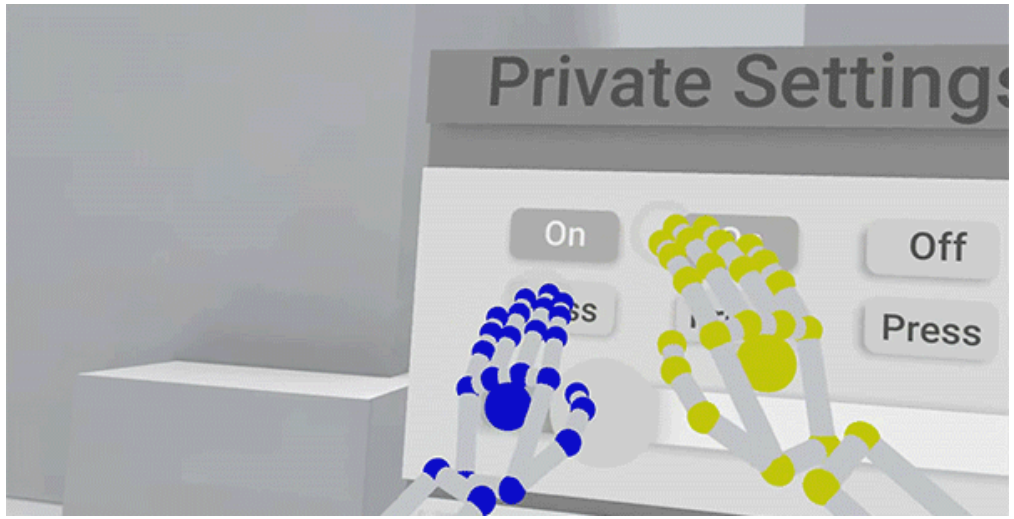
Affordances in VR

Familiar objects in Job Simulator

Object shape shows how to pick up

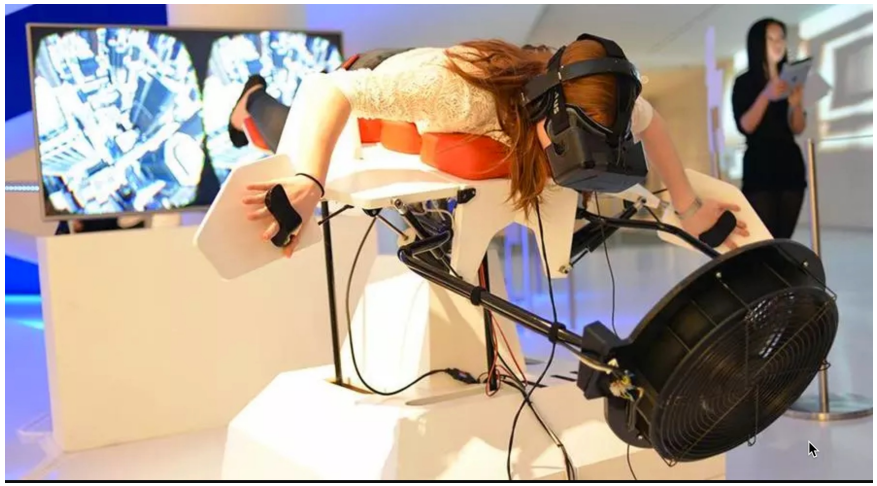
- Design interface objects to show how they are used
  - Use visual cues to show possible affordances
  - Perceived affordances should match actual affordances
  - Good cognitive model - map object behavior to expected

Examples of Affordances in VR



Virtual buttons can be pushed

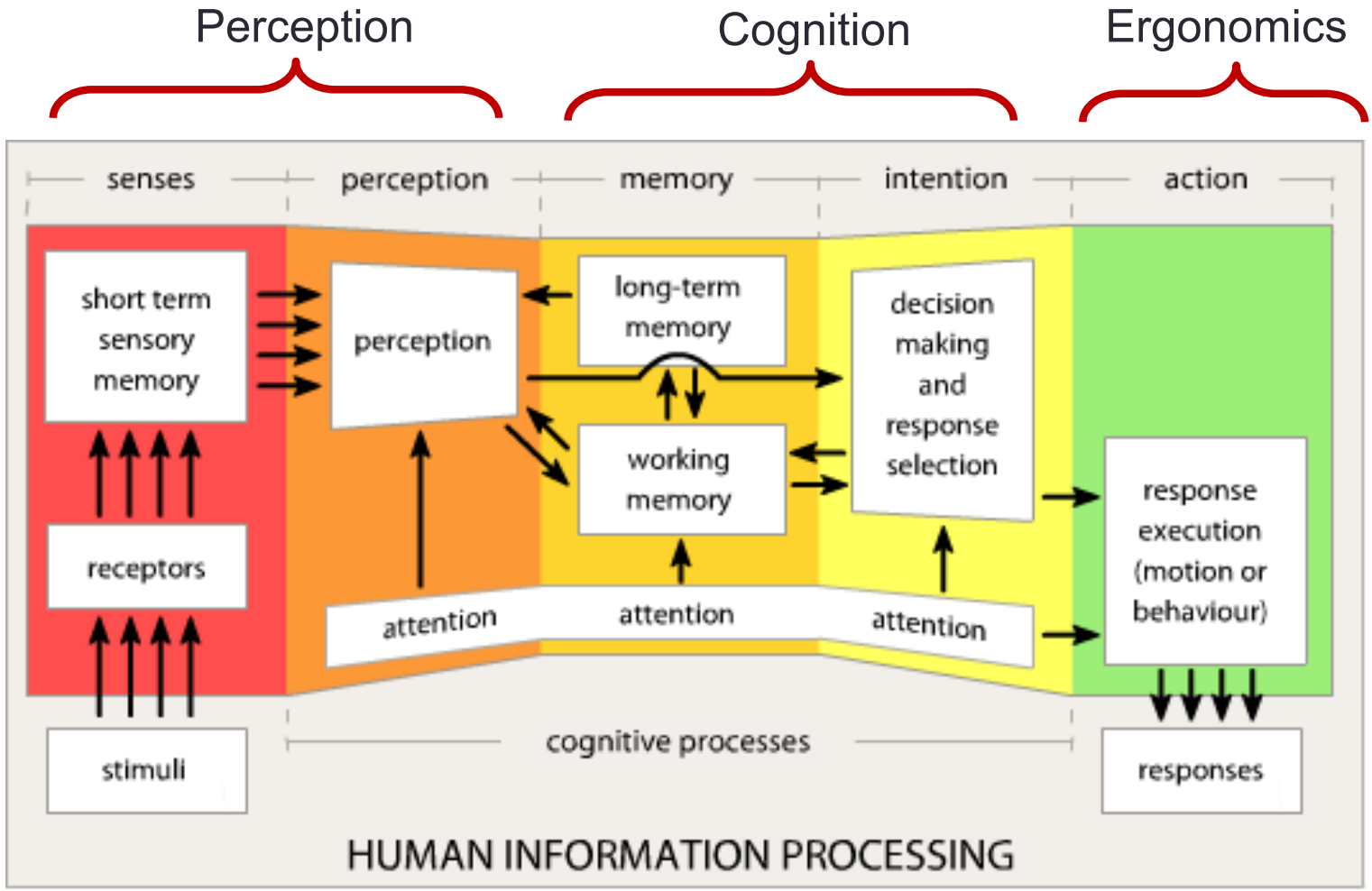
Virtual doors can be walked through



Flying like a bird in Birdly

Virtual objects can be picked up

Human Information Processing



- High level staged model from Wickens and Carswell (1997)
  - Relates perception, cognition, and physical ergonomics

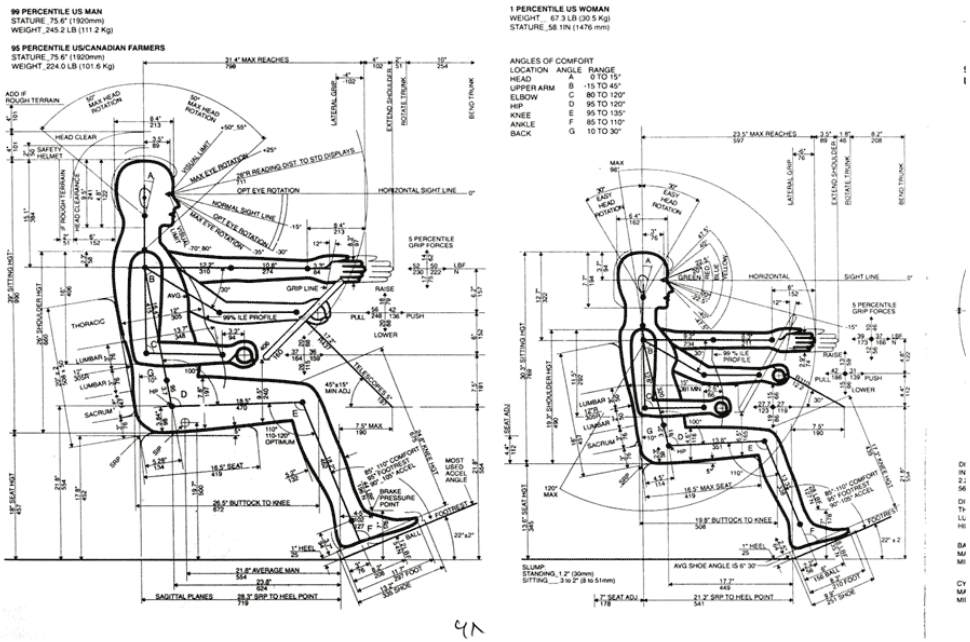
Design for Perception (see Lecture 2)

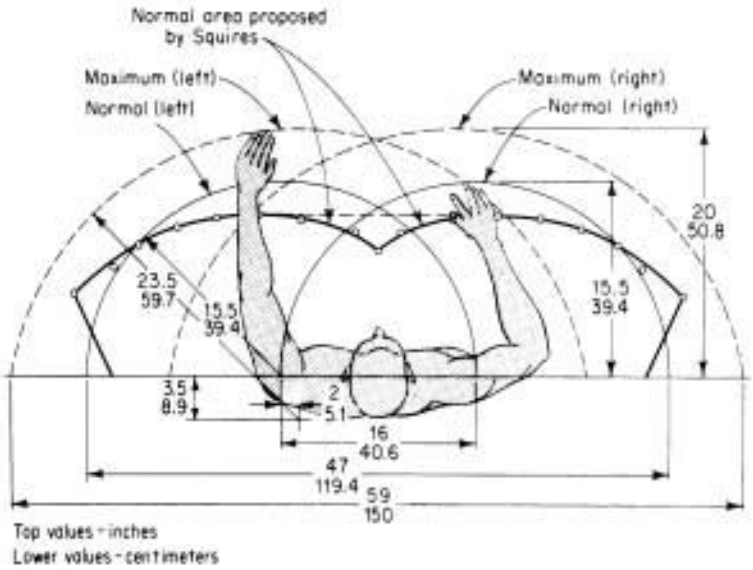
- Need to understand perception to design VR
- Visual perception
  - Many types of visual cues (stereo, oculomotor, etc.)
- Auditory system
  - Binaural cues, vestibular cues
- Somatosensory
  - Haptic, tactile, kinesthetic, proprioceptive cues
- Chemical Sensing System
  - Taste and smell

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
- Situational Awareness
  - Model of current state of user's environment
    - Used for wayfinding, object interaction, spatial awareness, etc..
  - Provide cognitive cues to help with situational awareness
    - Landmarks, procedural cues, map knowledge
    - Support both ego-centric and exo-centric views

Deisgn for Physical Ergonomics



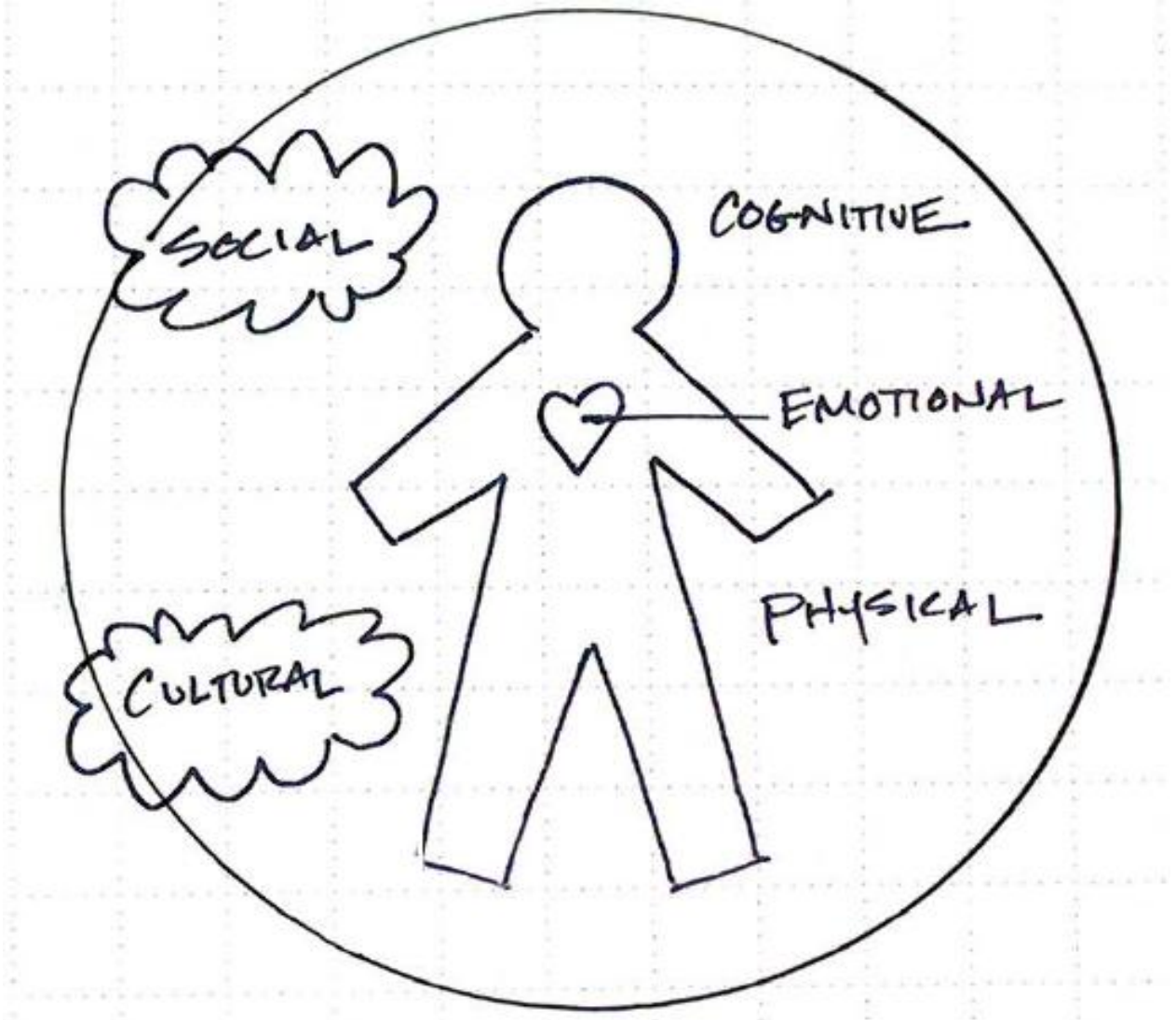


- Design for the human motion range
  - Consider human comfort and natural posture
- Design for hand input
  - Coarse and fine scale motions, gripping and grasping
  - Avoid “Gorilla arm syndrome” from holding arm pose

Designing for Different User Groups

- Design for Difference Ages
  - Children require different interface design than adults
  - Older uses have different needs than younger
- Prior 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

Consider the Whole User Needs

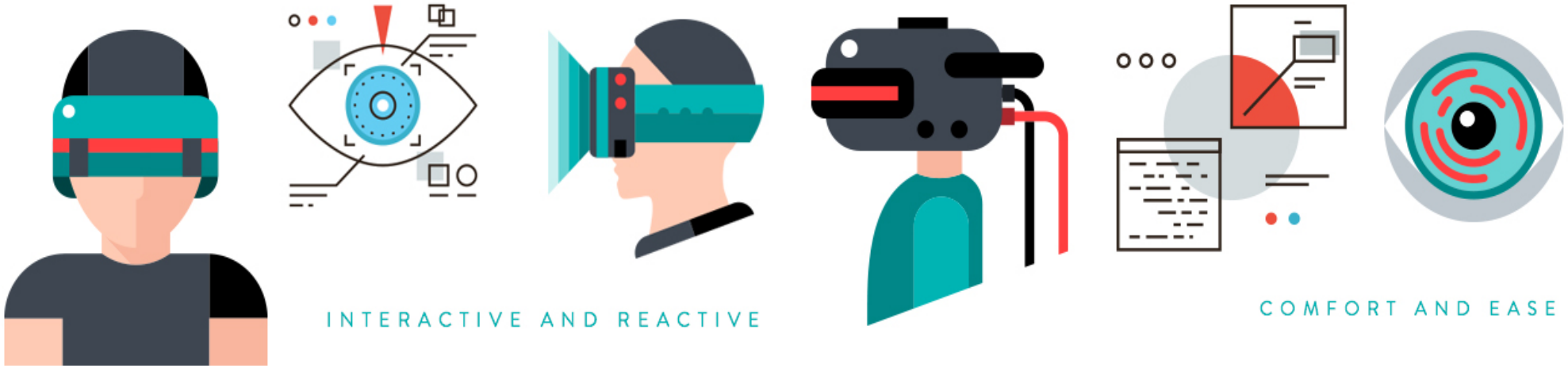


Whole User Needs

- Social
  - Don’t make your user look stupid
- Cultural
  - Follow local cultural norms
- Physical
  - Can the user physically use the interface?
- Cognitive
  - Can the user understand how the interface works?
- Emotional
  - Make the user feel good and in control

Would you wear this HMD?

UX Guidelines for VR



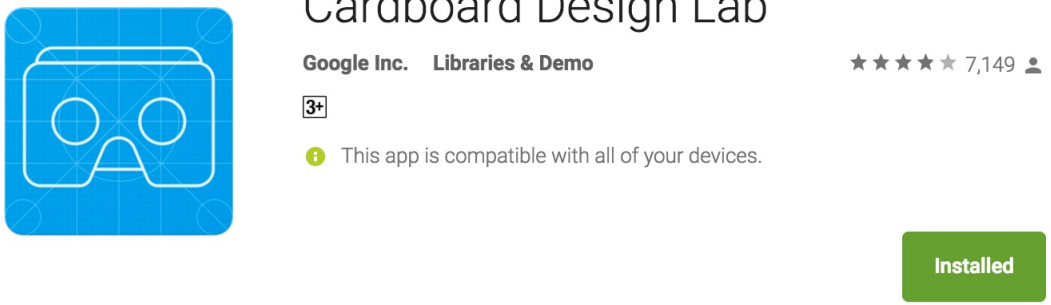
- The Four Cores of UX Design for VR
  - Make interface Interactive and Reactive
  - Design for Comfort and Ease
  - Use usable Text and Image Scale
  - Include position audio and 3D sound

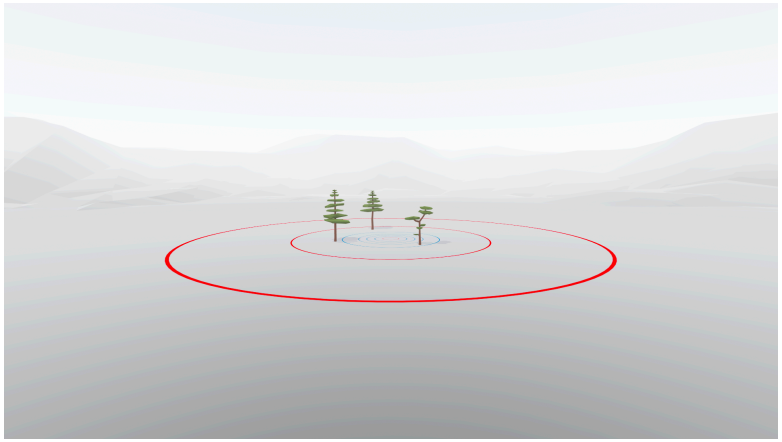
https://www.dtelepathy.com/blog/philosophy/ux-guide-designing-virtual-reality-experiences

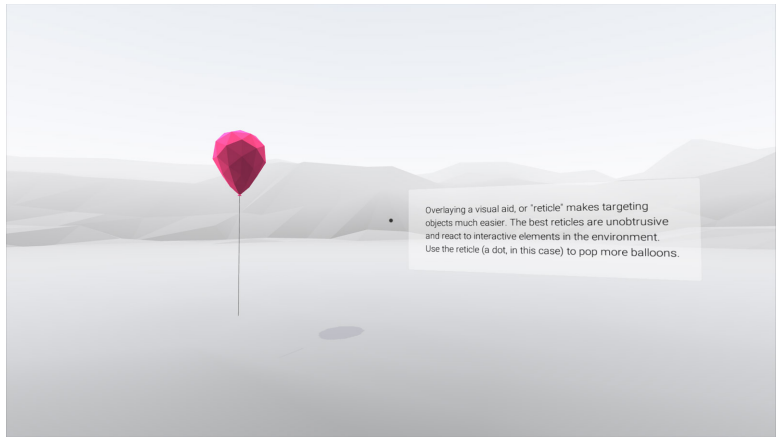
UX Challenges

- Problems to be Addressed
  - 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

Cardboard Design Lab





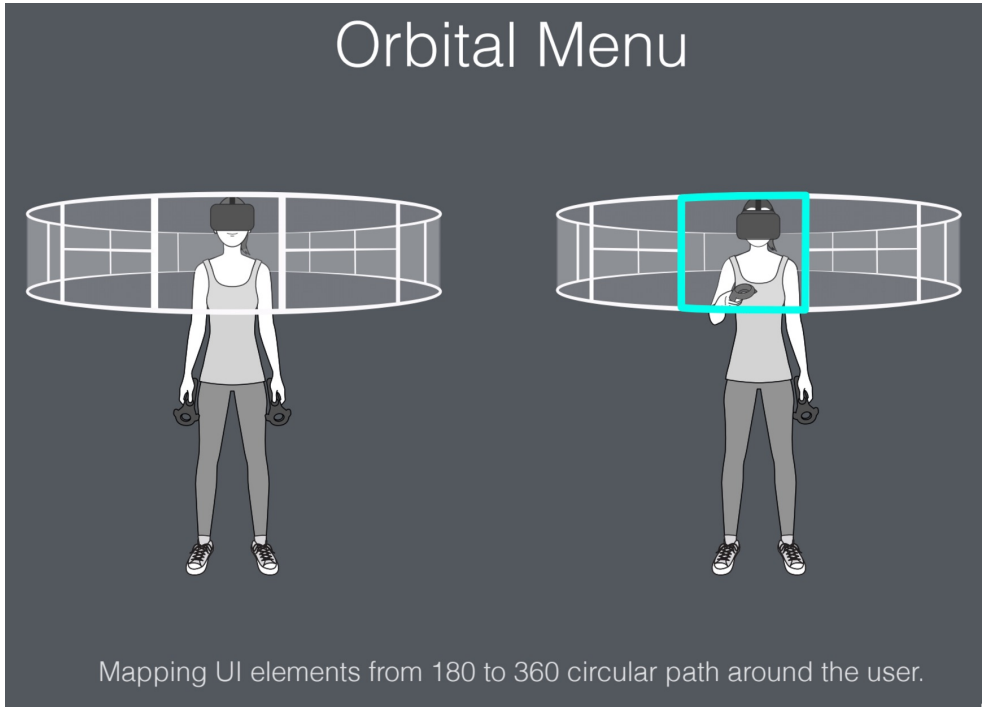


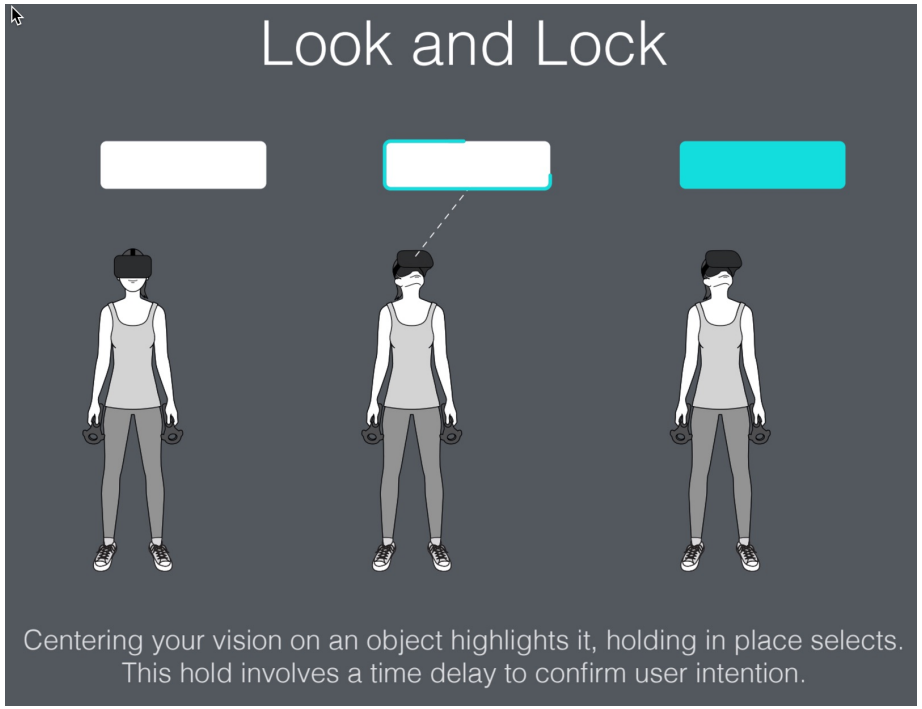
- Mobile VR App providing examples of best practice VR designs and user interaction (iOS, Play app stores)

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

Design Guidelines (from 3D UI book)

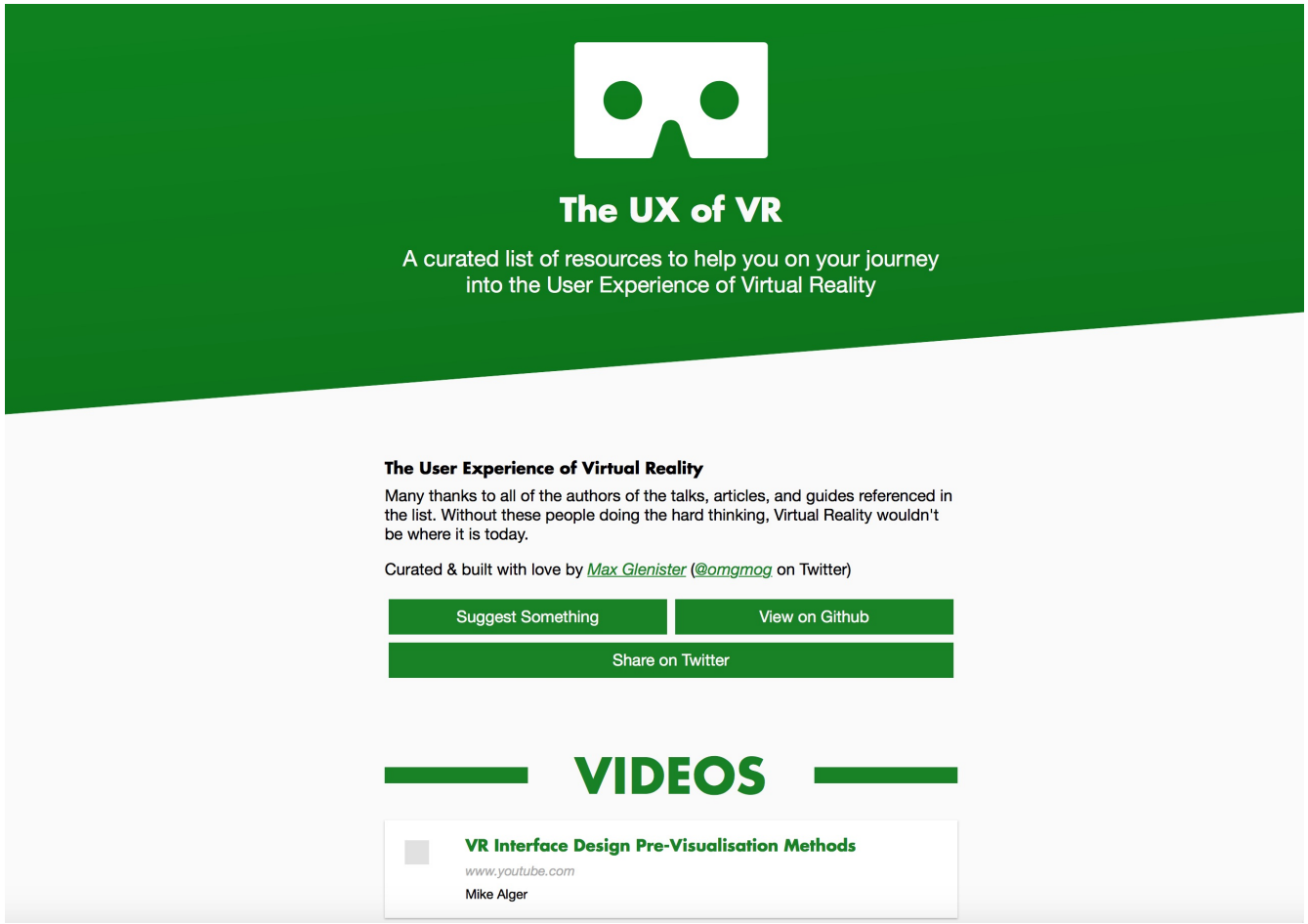
- Design for comfortable poses
- Design for relatively short sessions and encourage breaks
- Use constraints, use and invent magical techniques
- Consider real world tools and practices as a source of inspiration for 3D user interface design
- Consider designing 3D techniques using principles from 2D interaction
- Consider using physical props and passive feedback, particularly in highly specialized tasks
- Ensure temporal and spatial compliance between feedback dimensions

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/

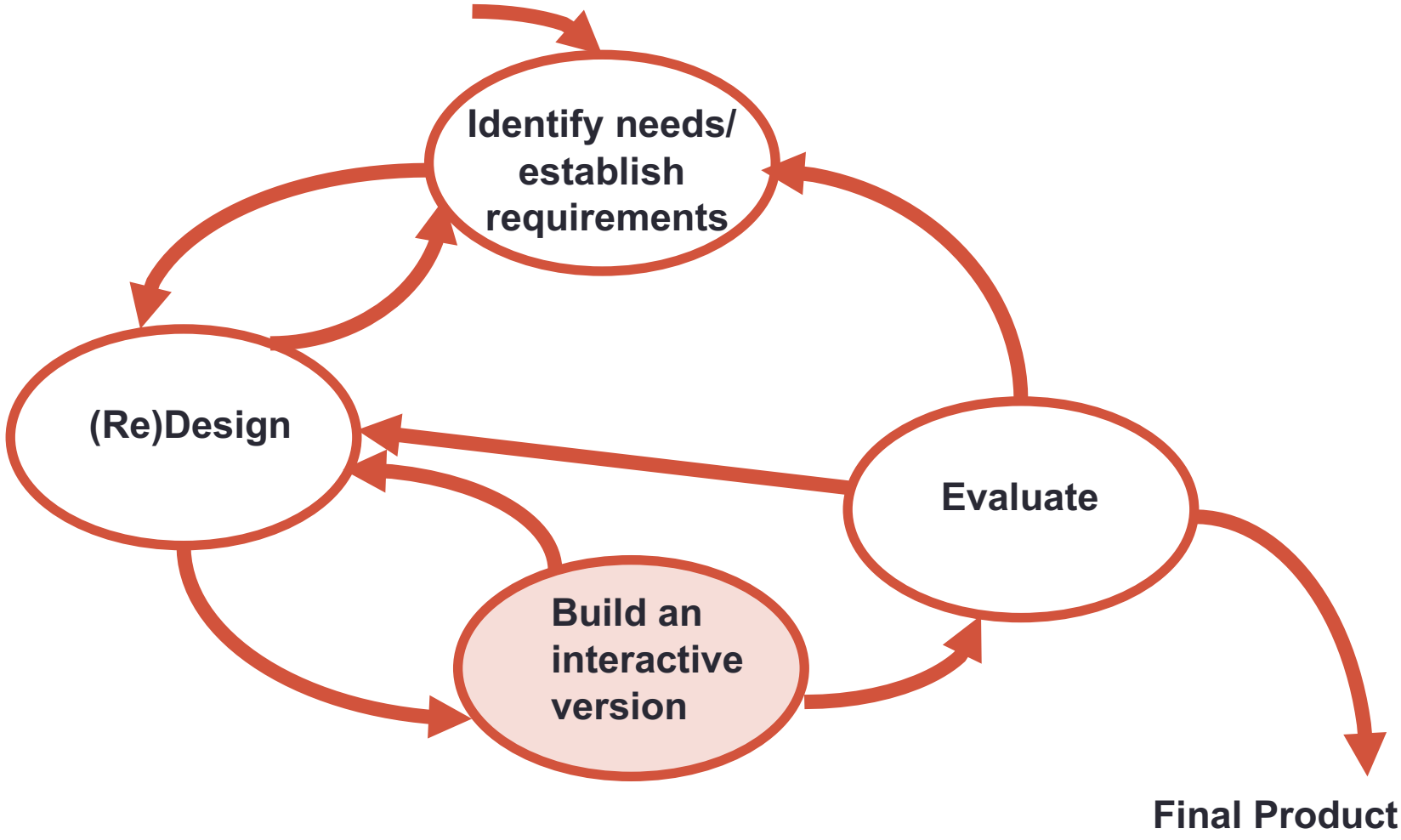
UX of VR Website - www.uxofvr.com



- Many examples of great design ideas
- Videos, books, articles, slides, code, etc..

PROTOTYPING

Interaction Design Process



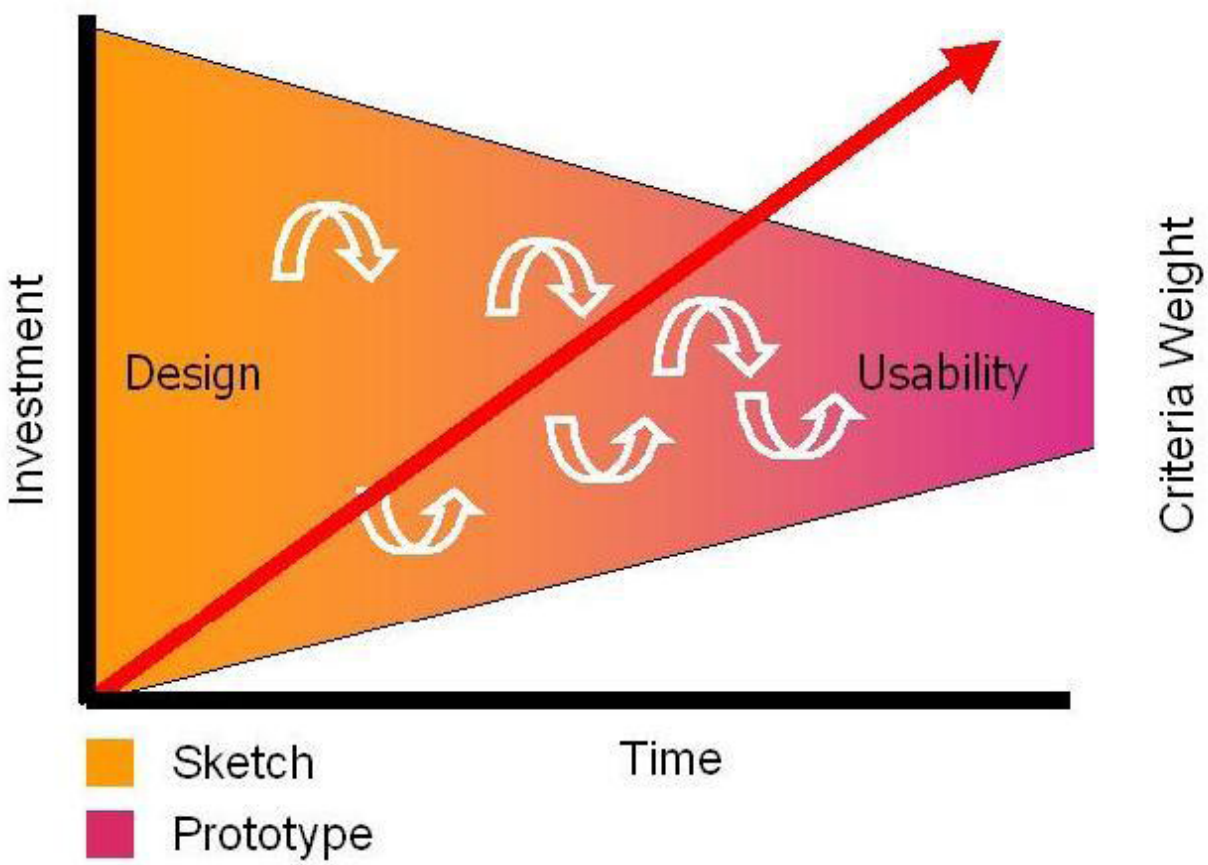
How can we quickly prototype Virtual Reality experiences with little or no coding?

Why Prototype?

- Quick visual design
- Capture key interactions
- Focus on user experience
- Communicate design ideas
- “Learn by doing/experiencing”

From Sketches to Prototypes

- Sketches: early ideation stages of design
- Prototypes: capturing /detailing the actual design

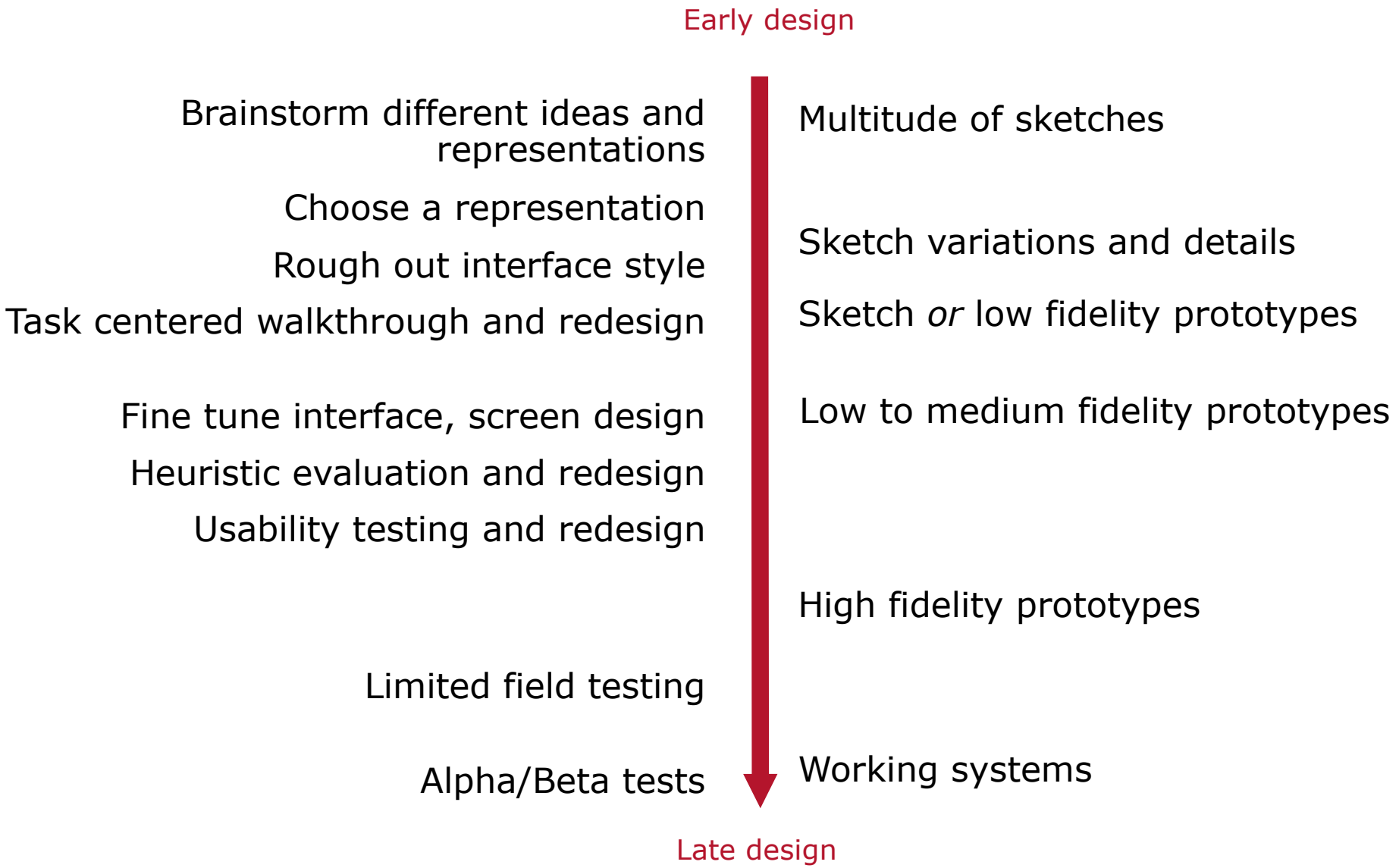


Sketch vs. Prototype

Sketch	Prototype
Invite	Attend
Suggest	Describe
Explore	Refine
Question	Answer
Propose	Test
Provoke	Resolve
Tentative, non committal	Specific Depiction

The primary differences are in the intent

From Sketches to Prototypes



Typical Development Steps

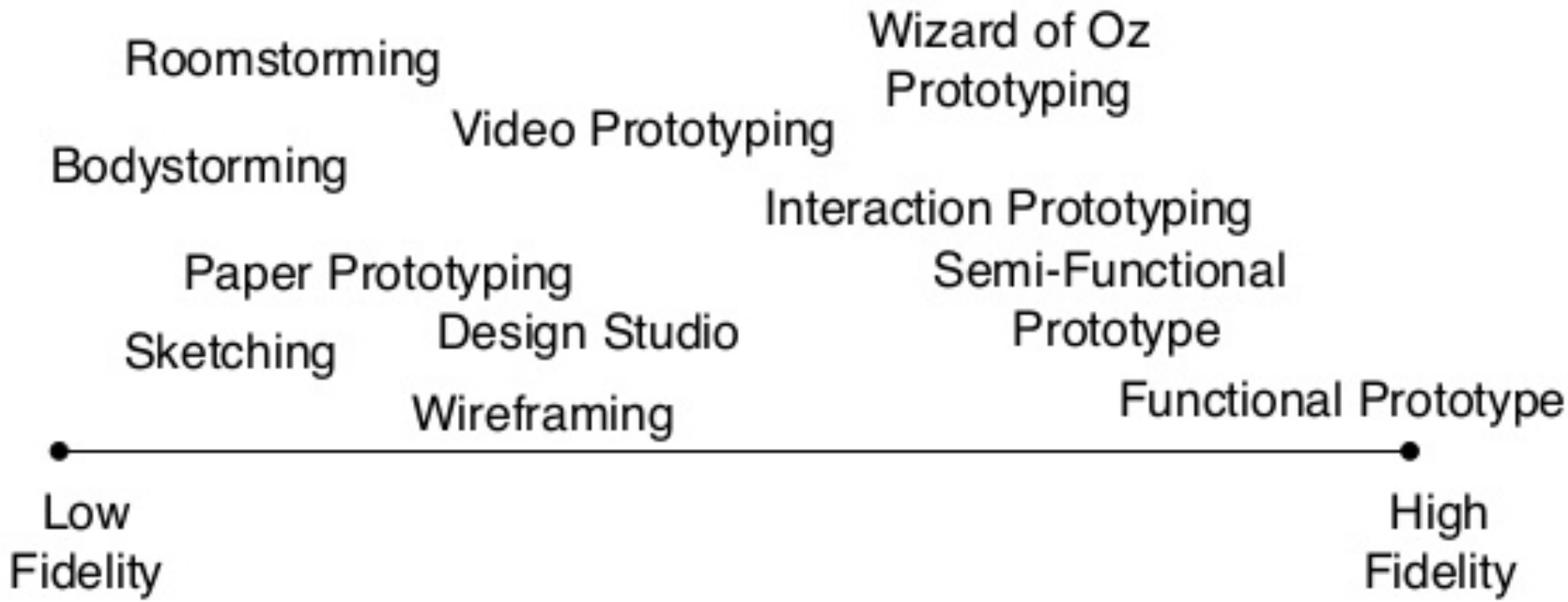
- Sketching
- Storyboards
- UI Mockups
- Interaction Flows
- Video Prototypes
- Interactive Prototypes
- Final Native Application

Increased Fidelity & Interactivity

Typical Prototyping Tools

- Static/Low fidelity
  - Sketching
  - User interface templates
  - Storyboards/Application flows
- Interactive/High fidelity
  - Wireframing tools
  - Mobile prototyping
  - Native Coding

Design/Prototyping Tools



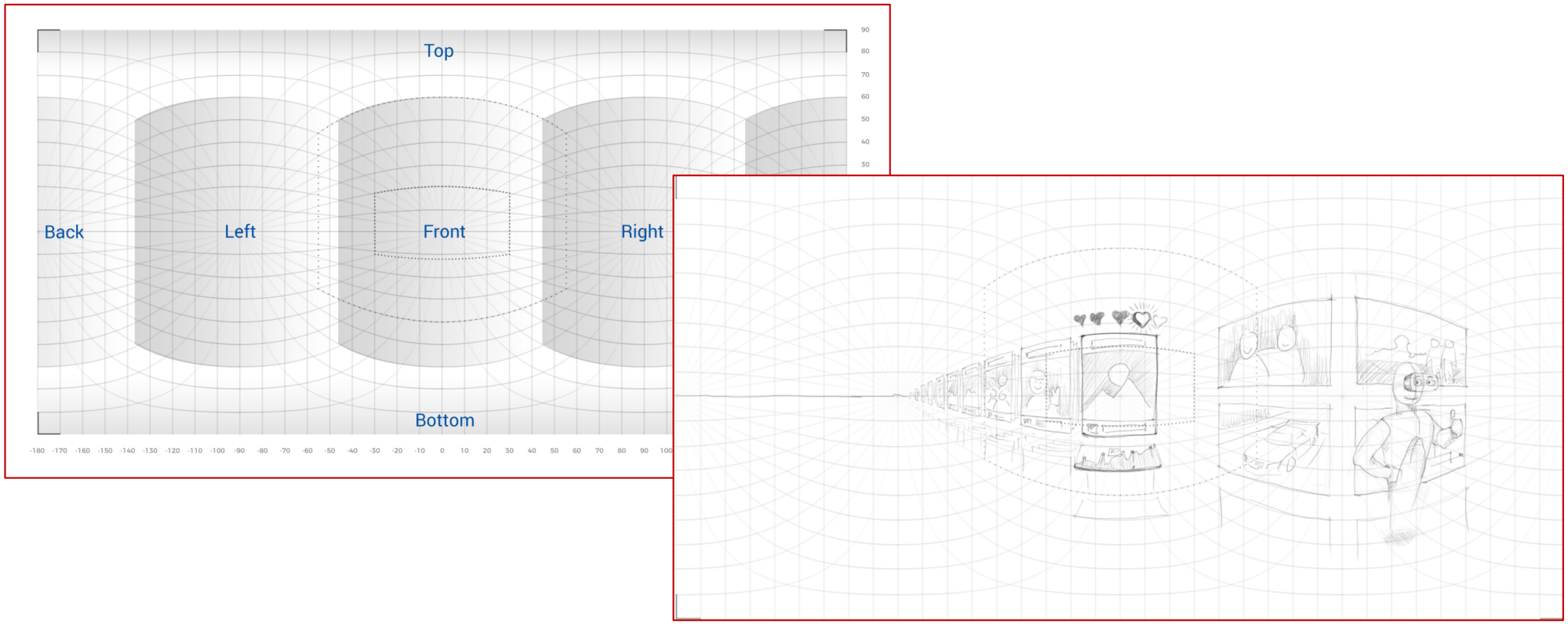
Advantages/Disadvantages

Prototype	Advantages	Disadvantages
Low-fidelity prototype	- low developmental cost - evaluate multiple design concepts	- limited error checking - navigational and flow limitations
High-fidelity prototype	- fully interactive - look and feel of final product - clearly defines navigational scheme	- more expensive to develop - time consuming to build - developers are reluctant to change something they have crafted for hours

VR Prototyping Tools

- Low Fidelity
  - Sketched Paper Interfaces – pen/paper, non-interactive
  - Onride Photoshop tool – digital, non-interactive
  - InstaVR - 360 web based tool, simple interactivity
  - SketchBox – create VR interface inside VR
- High Fidelity
  - Entiti – template based VR with visual programming
  - A-Frame – web based VR tool using HTML
  - EditorVR – Unity wrapper inside VR
  - Unity/Unreal Game Engine – programming needed

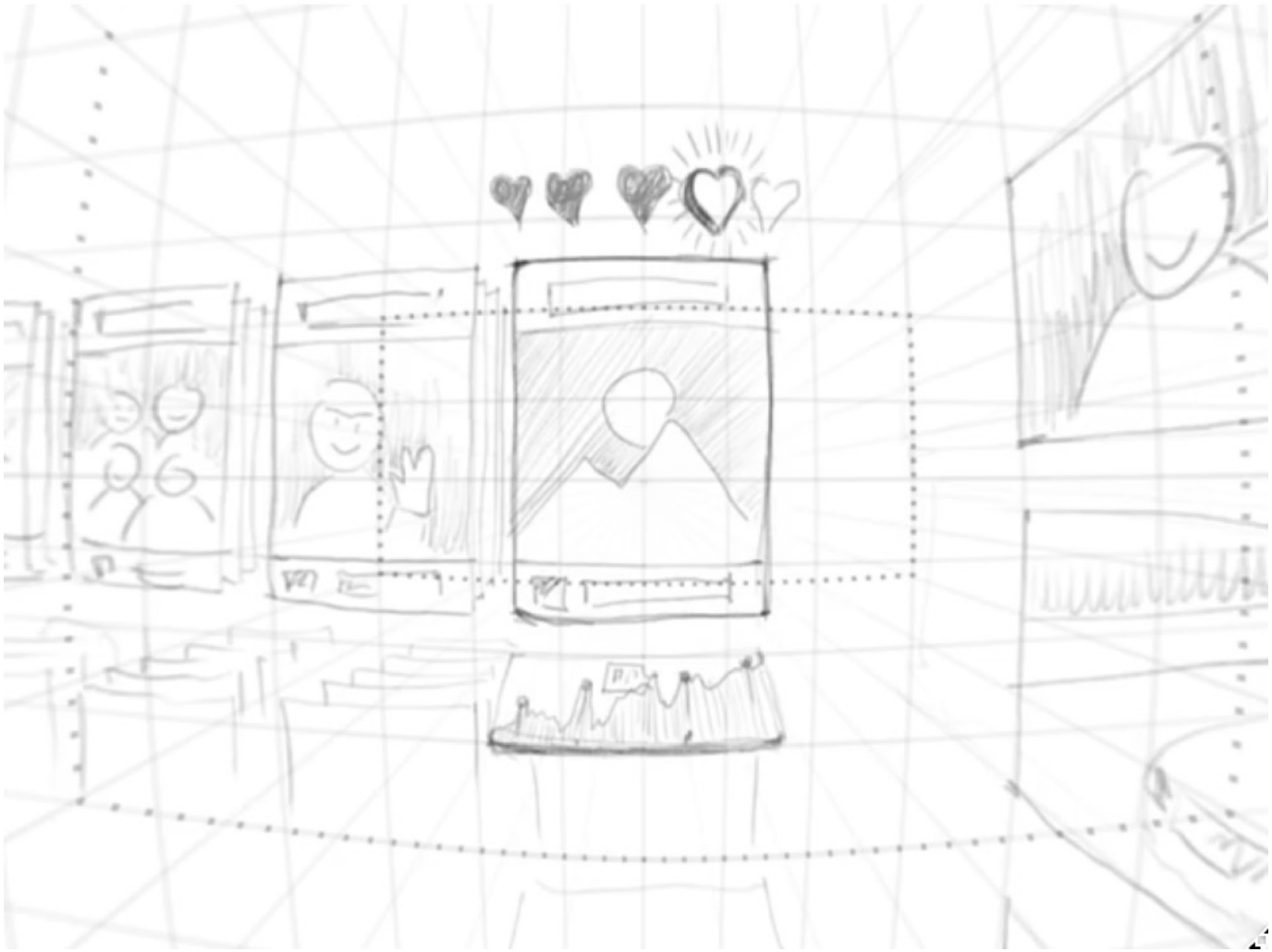
Sketching VR Interfaces



- Download 360 panorama template grid
- Draw interface ideas into grid
- Scan into 360 photo viewer for VR HMD

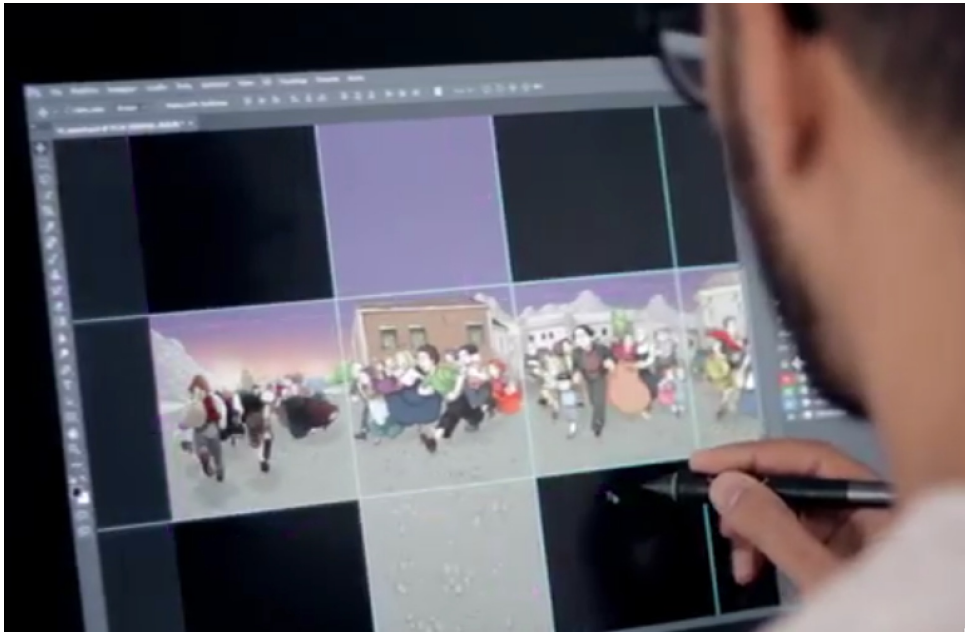
See https://virtualrealitypop.com/vr-sketches-56599f99b357

Example Sketched VR Interface



- https://www.youtube.com/watch?v=BmMh6-jPWOc

ONIRIDE - 360° Art Plugin for Photoshop

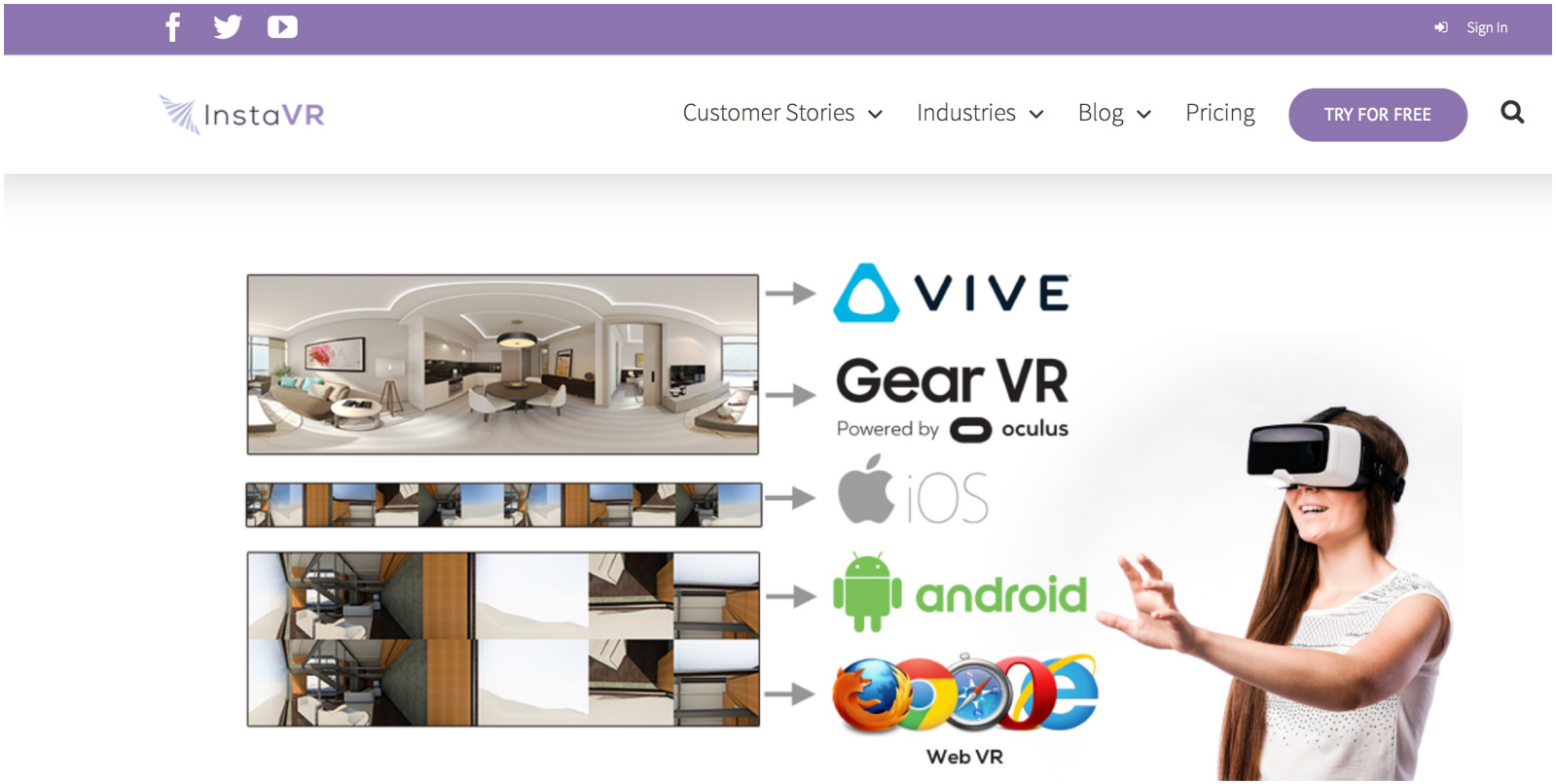


- Draw 360 panorama’s directly in Photoshop
- Preview in Photoshop, export to VR
- See http://www.oniride.com/360art

OnRide Demo

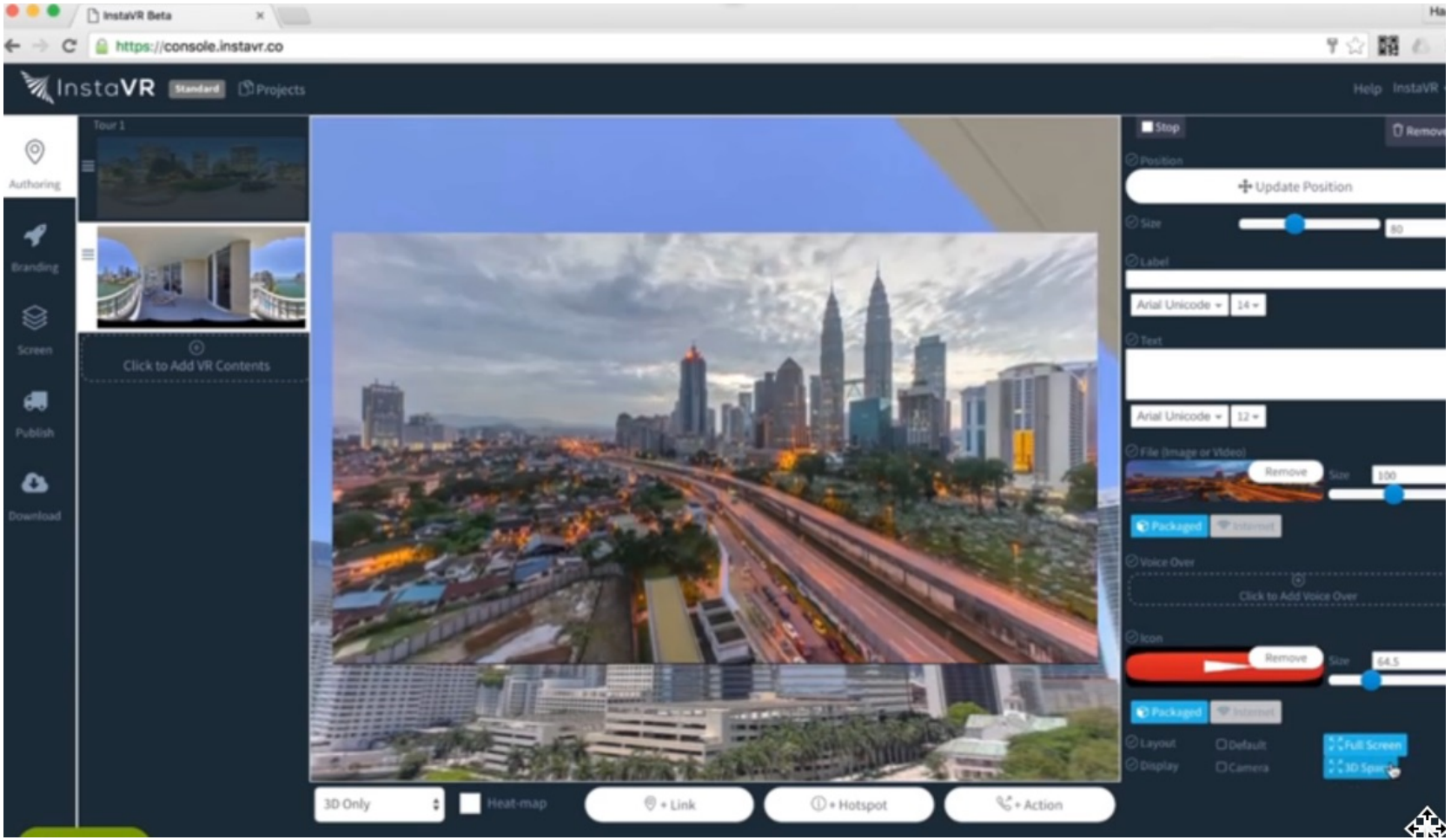
- https://www.youtube.com/watch?v=1P1EfGizal0

InstaVR



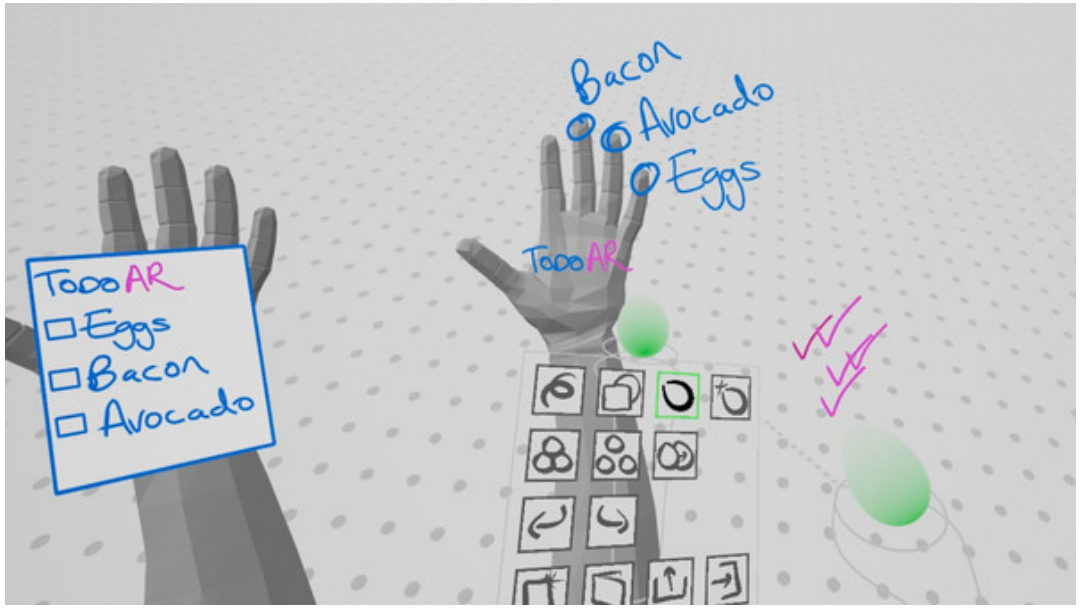
- http://www.instavr.co/
- Free, fast panorama VR, deploy to multi platforms

Demo - Using InstaVR



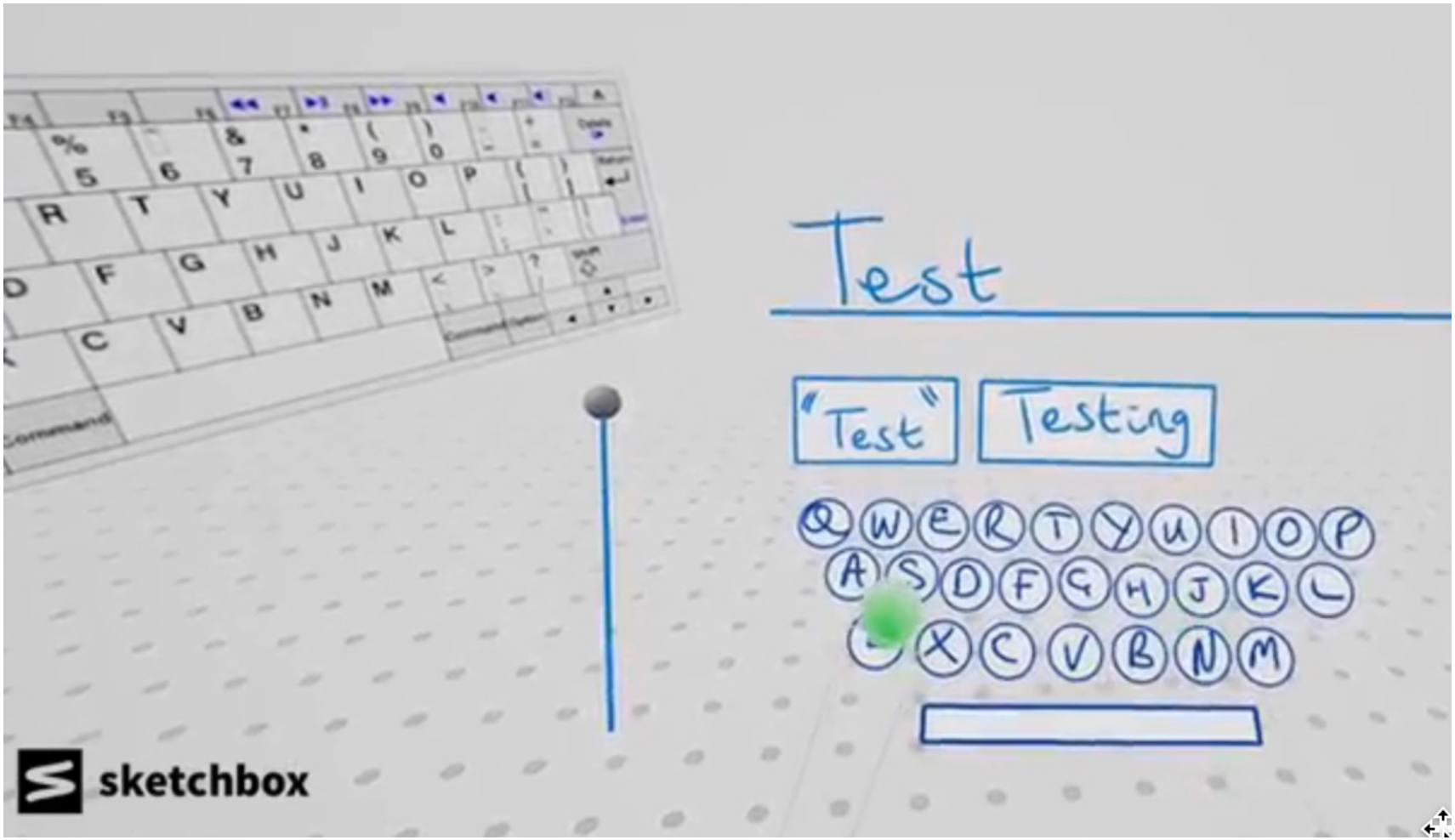
- https://www.youtube.com/watch?v=M2C8vDL0YeA

Sketchbox



- VR design tool - create VR interface inside VR
  - Support for HTC Vive, Oculus Rift
- Easy to use VR sketching tool
- Available from SteamVR
- See https://www.sketchboxvr.com/

Sketchbox Demo

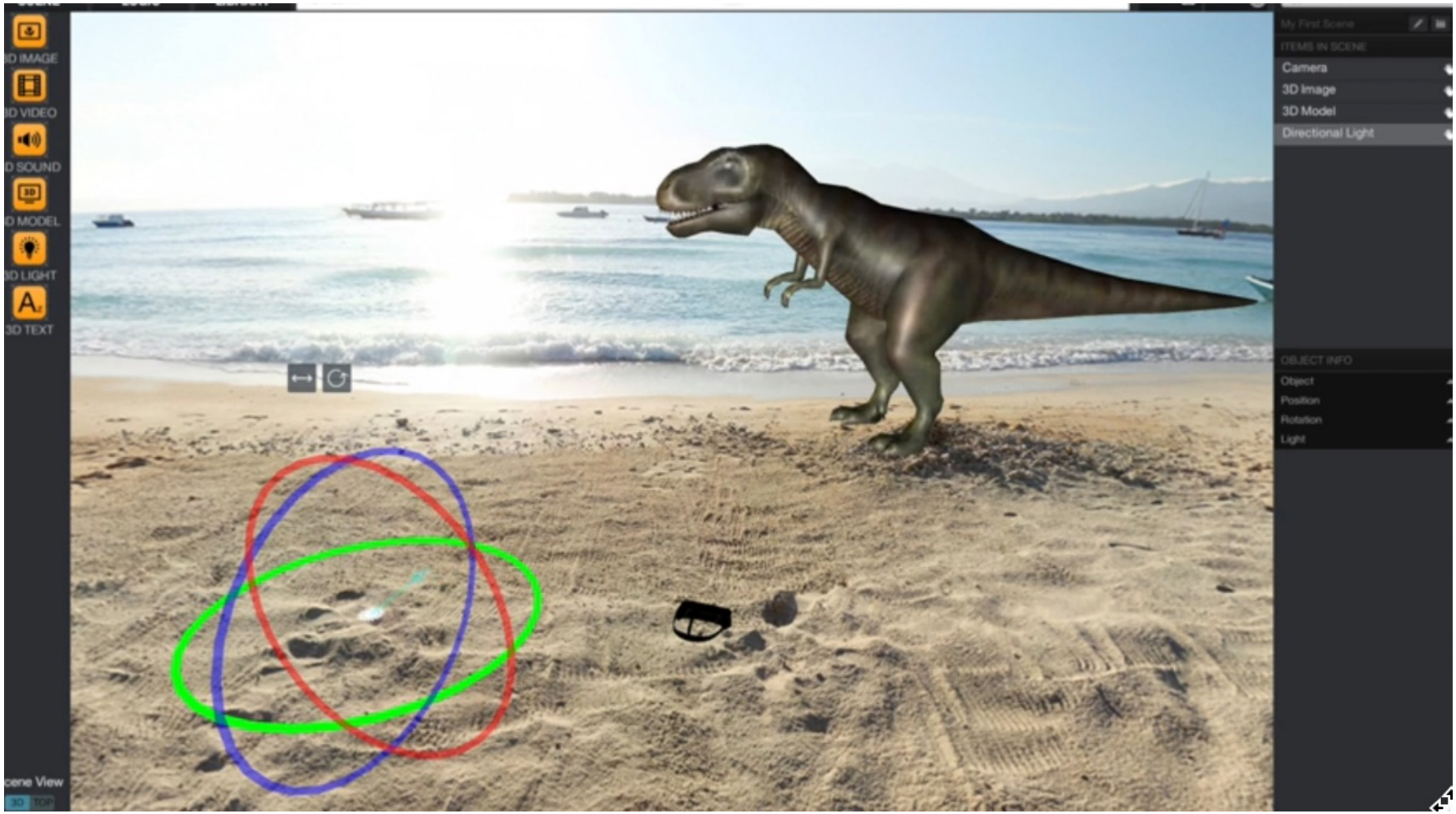


- https://www.youtube.com/watch?v=gWfgewGzaEI

Entiti

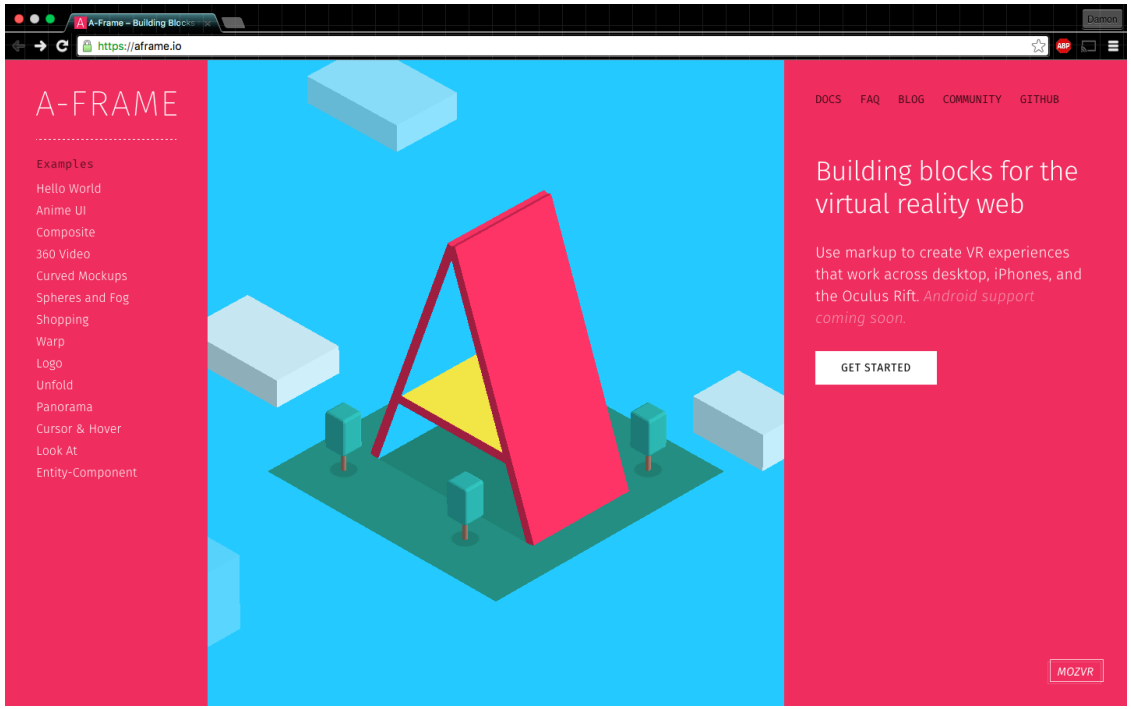
- https://www.wakingapp.com/
- Stand alone application for VR/AR authoring (Windows, Mac)
- Works with Entiti mobile application (Android, iOS)
- Delivers multiple VR experiences – 360 and 3D scenes
- Template based VR, Visual programming for behaviours

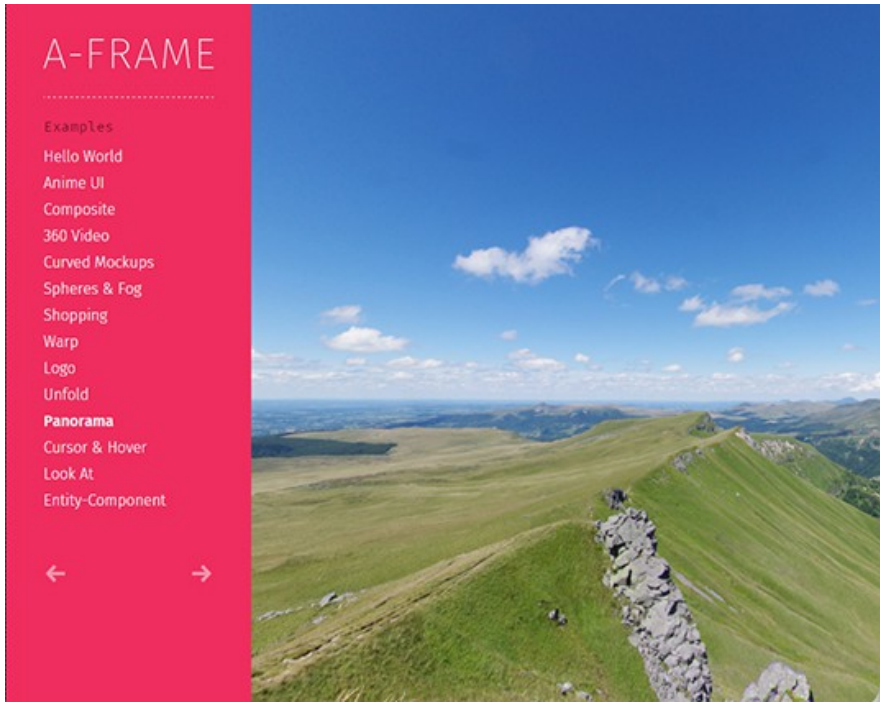
Entiti Overview



https://www.youtube.com/watch?v=SRuYQoT45Tg

A-Frame





- See https://aframe.io/
- Web based VR framework
- Make WebVR with HTML and Entity-Component
- Works on Vive, Rift, Daydream, GearVR, desktop

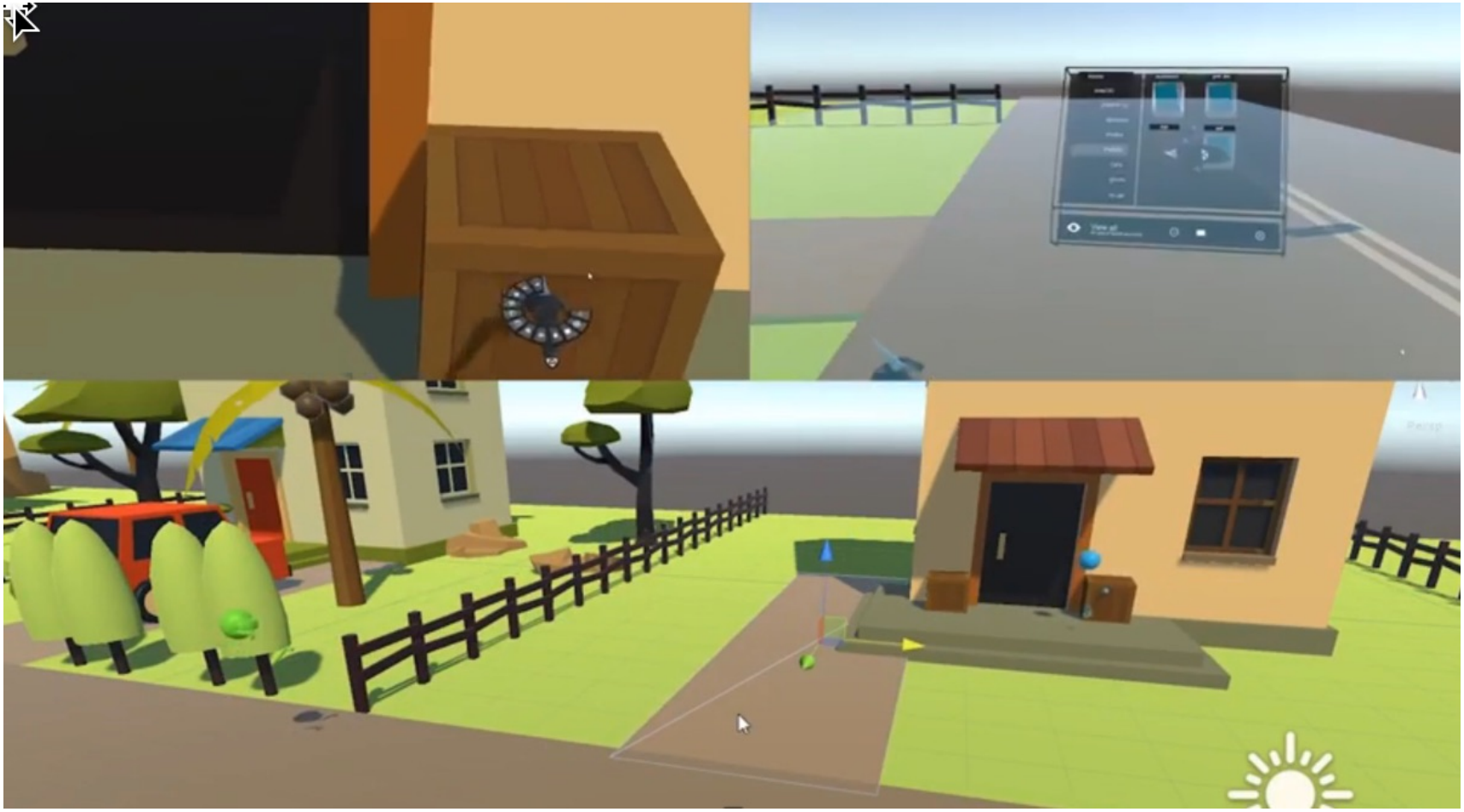
A-Frame Demo

- https://www.youtube.com/watch?v=1MskH9uqOyQ

Unity EditorVR

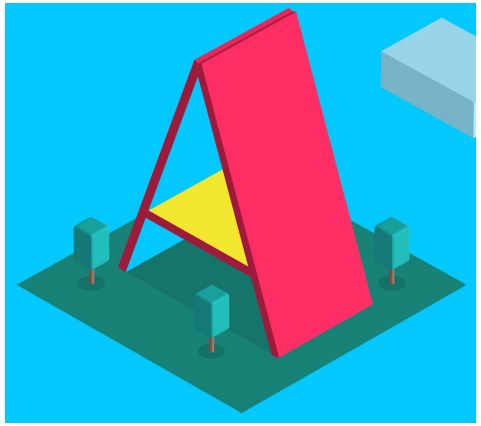
- Edit Unity VR scenes inside VR
- 3D user interface on top of Unity
  - 2 handed interface using HTC Vive
- Support for multi-user input
- Available from https://github.com/Unity-Technologies/EditorVR

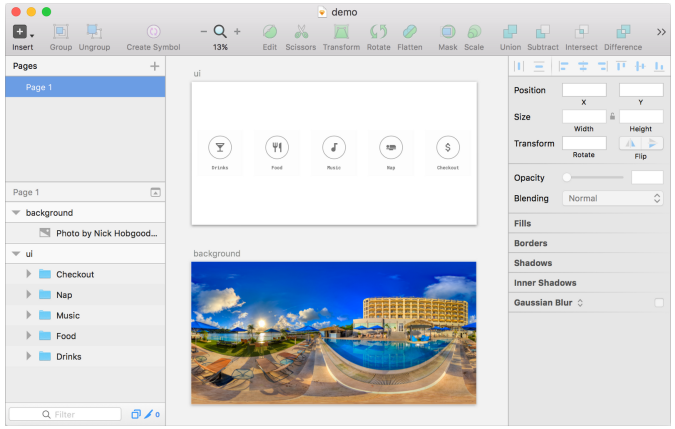
Demo: Unity EditorVR



- https://www.youtube.com/watch?v=ILe2atyofqM

More Prototyping Tools



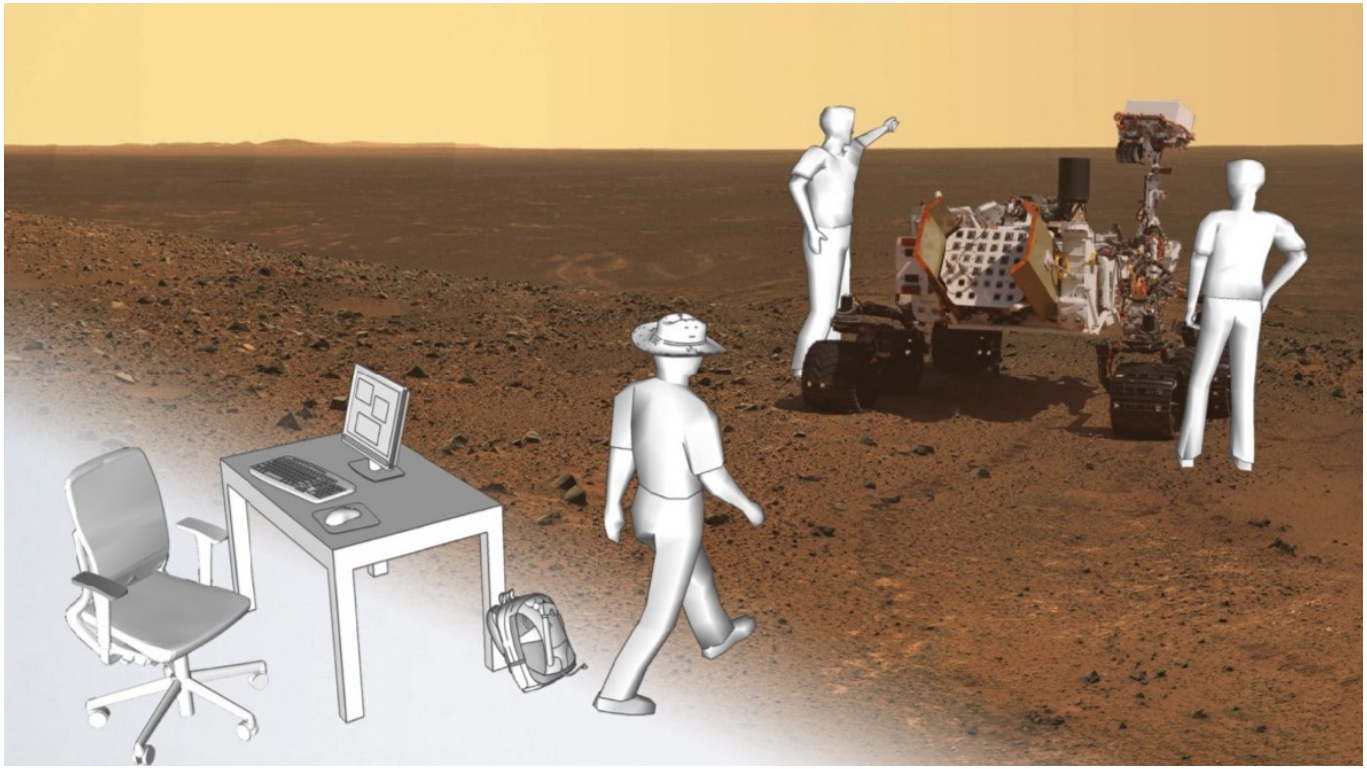


- List of 24 prototyping tools
  - Tools for prototyping 3D VR experiences
  - Tools for prototyping 360 degree experiences
  - Web based Tools for 3D prototyping
  - 3D modeling tools in VR

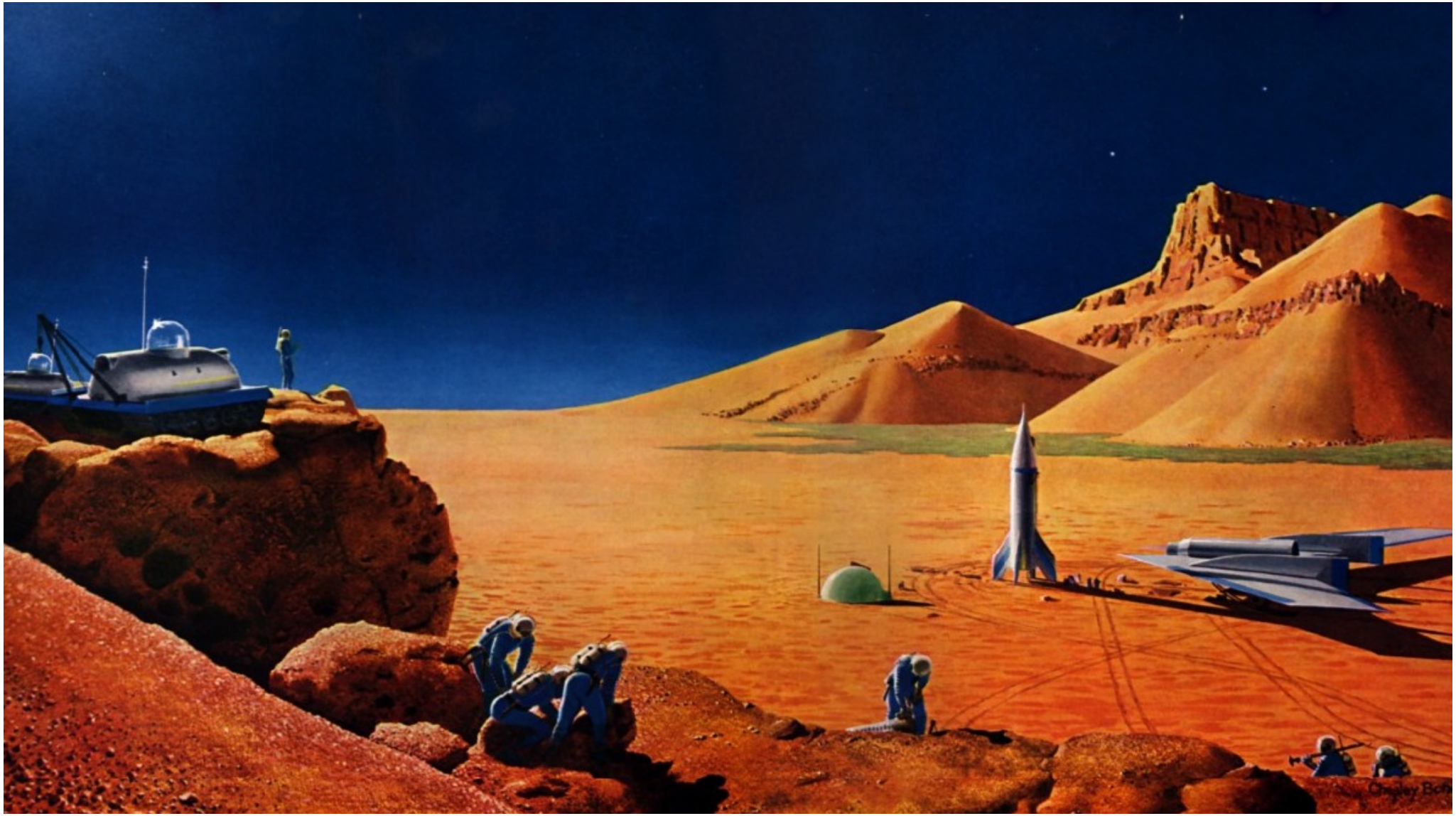
See http://bit.ly/2wx3i6H

EXAMPLE:
CONCEPT TO DEMO

NASA Hololens AR/VR Concept Demo

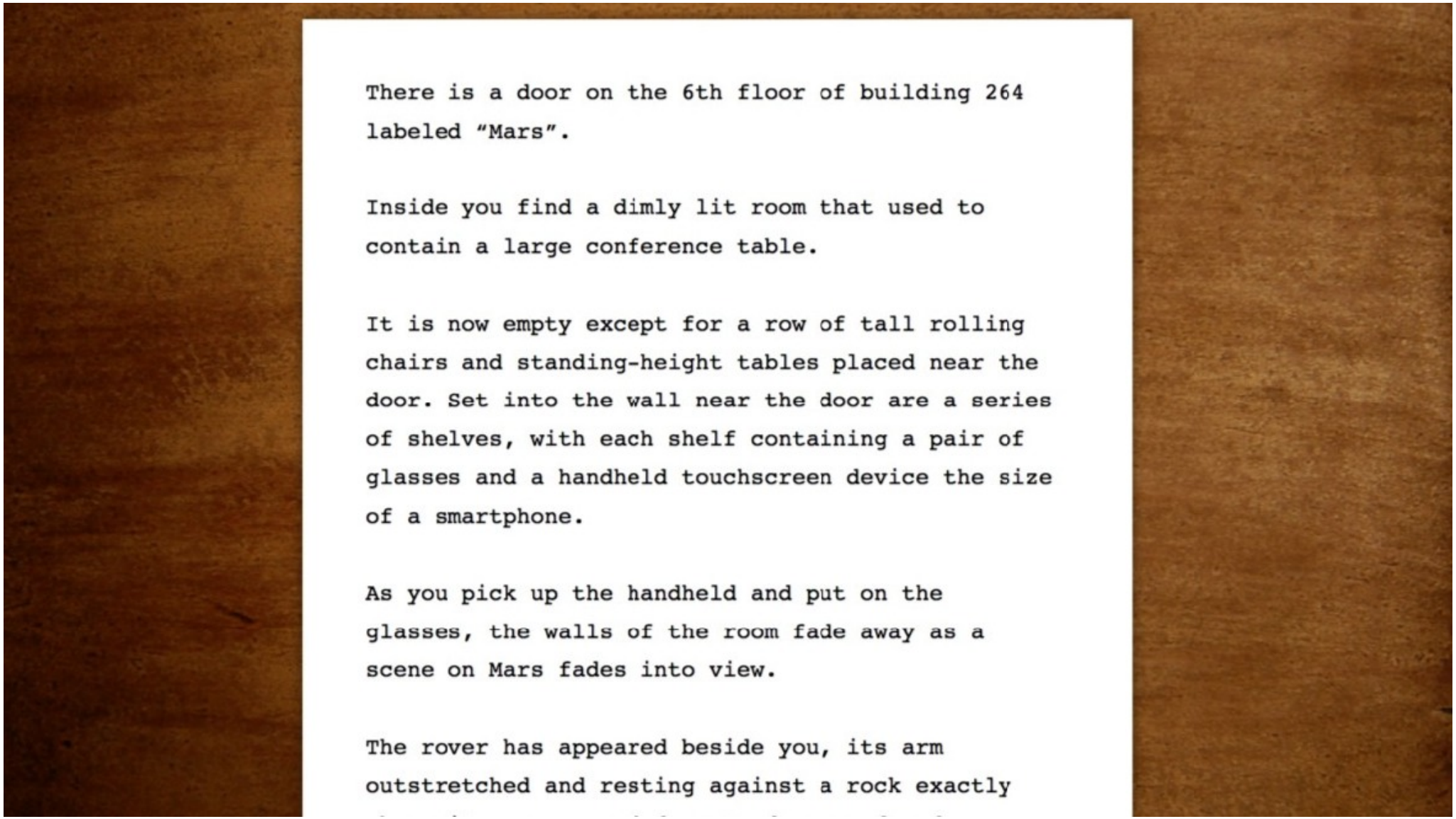


- **Vision:** Work on Mars from your office
- Story and sketches based on vision
- Led to working Demo

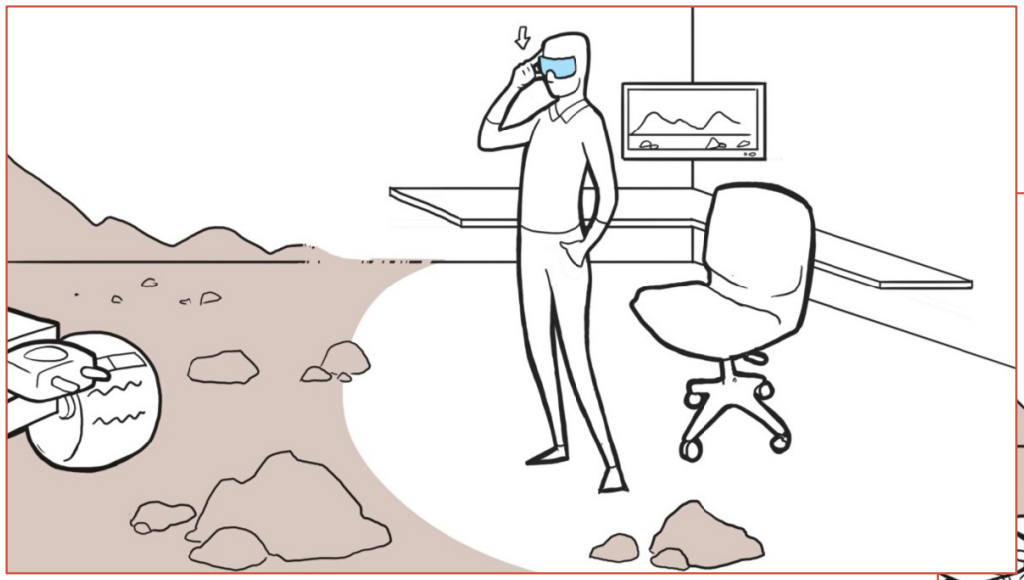


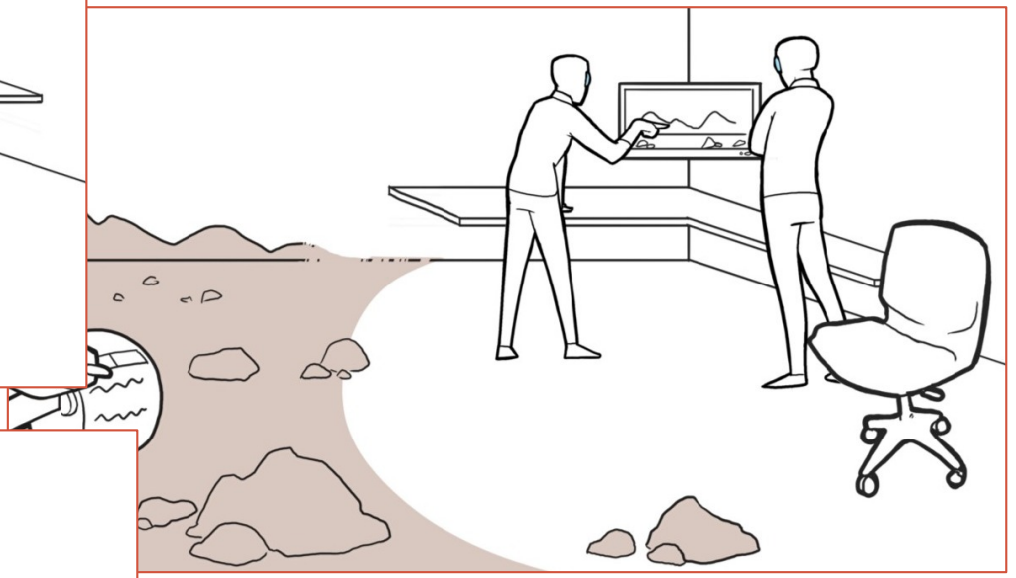
Chesley Bonestell (1940s)

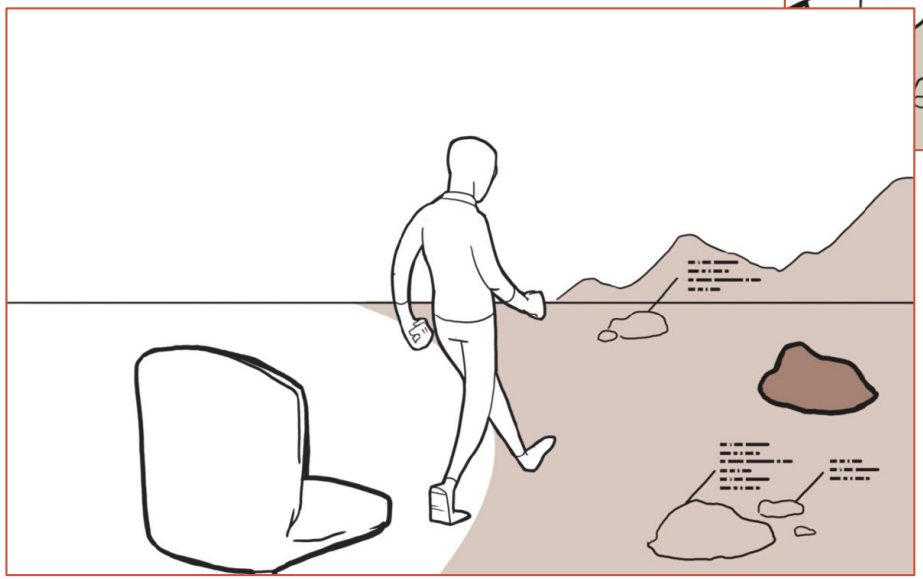
Hololens Story



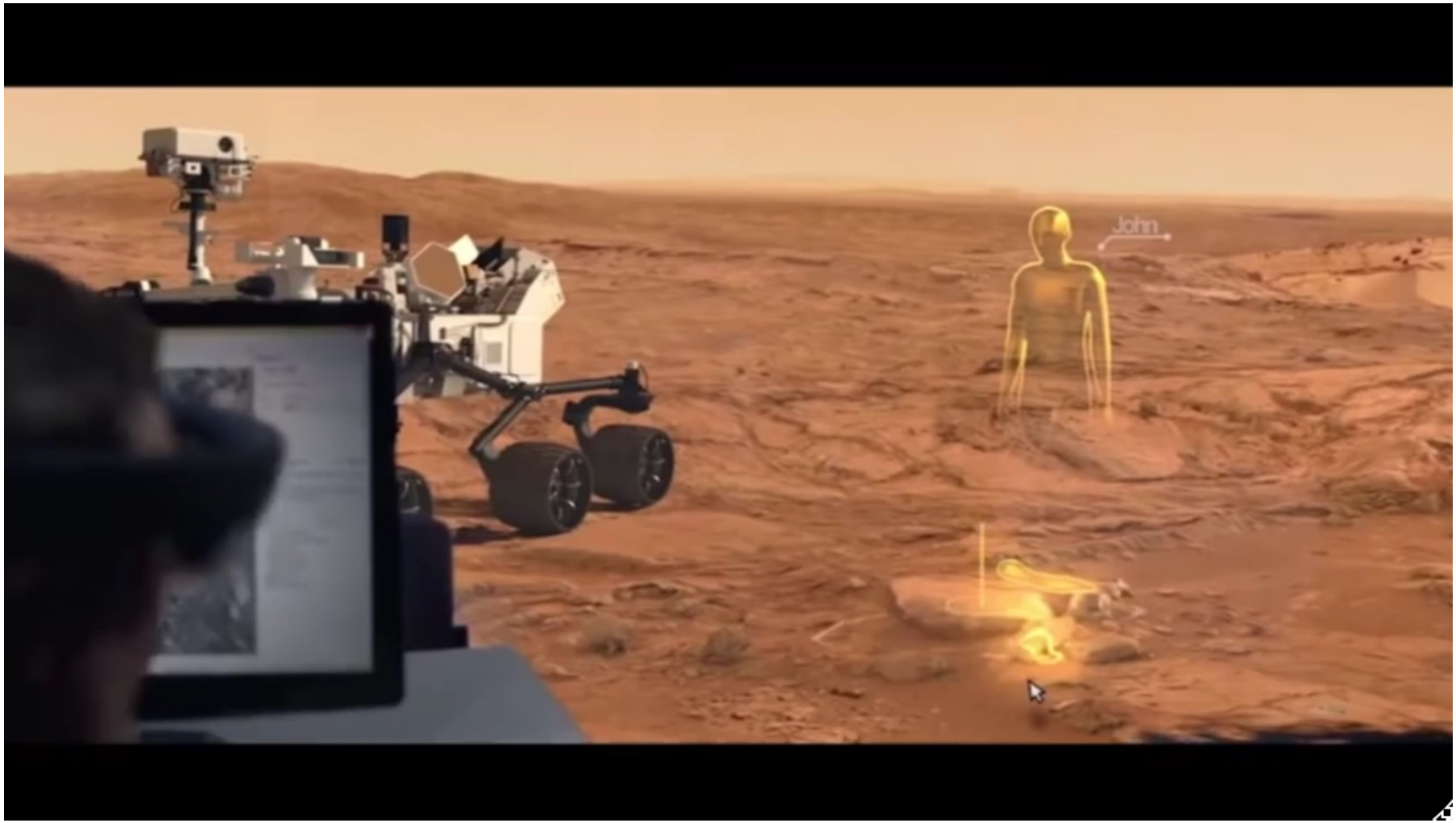
HoloLens Concept Sketches







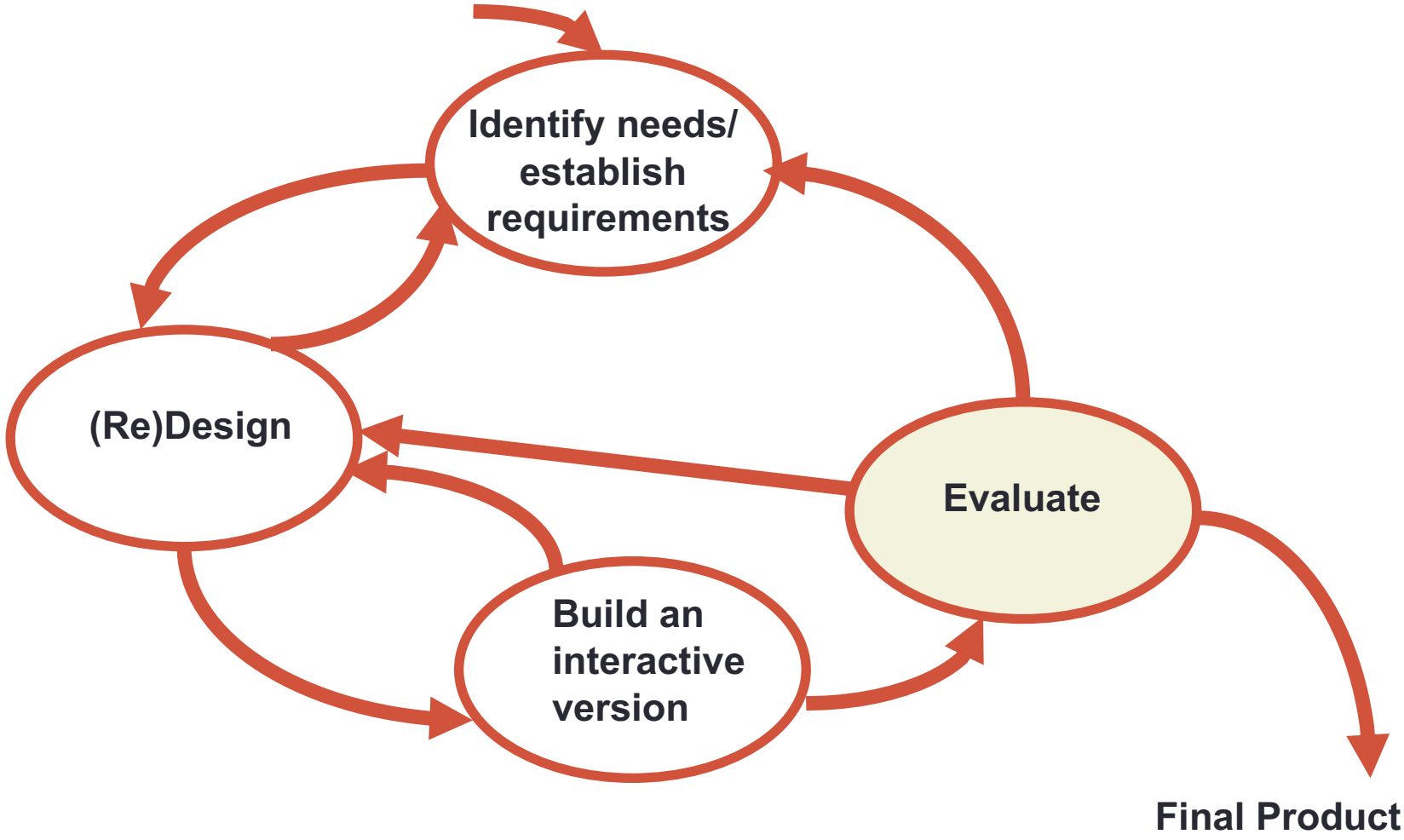
Final NASA HoloLens OnSight Demo



https://www.youtube.com/watch?v=o-GP3Kx6-CE

EVALUATION

Interaction Design Process

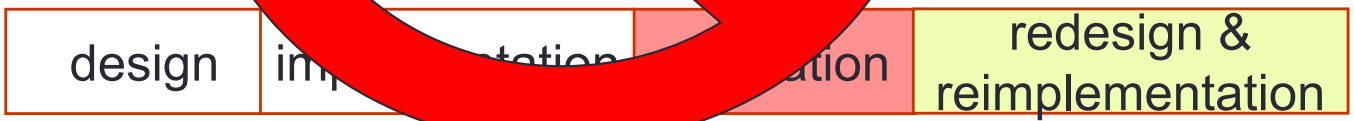


What is evaluation?

- Evaluation is concerned with gathering data about the usability of a design or product by a *specified group of users* for a *particular activity* within a *specified environment* or *work context*

When to evaluate?

- Once the prod as been d eloped
  - pros : rapid d elopm t, small ev ation cost
  - cons : rectifyi problem



- During design and development
  - pros : find and rectify problems early
  - cons : higher evaluation cost, longer development

Four Evaluation Paradigms

- ‘quick and dirty’
- usability testing (lab studies)
- field studies
- predictive evaluation

Quick and Dirty

- **‘quick & dirty’ evaluation:** informal feedback from users or consultants to confirm that their ideas are in-line with users’ needs and are liked.
- Quick & dirty evaluations are done any time.
- Emphasis is on fast input to the design process rather than carefully documented findings.

Usability Testing

- Recording typical users' performance on typical tasks in controlled settings.
- As the users perform tasks they are watched & recorded on video & their inputs are logged.
- User data is used to calculate performance times, errors & help determine system usability
- User satisfaction questionnaires & interviews are used to elicit users' opinions.

Laboratory-based studies

- Laboratory-based studies
  - can be used for evaluating the design, or system
  - are carried out in an interruption-free usability lab
  - can accurately record some work situations
  - some studies are only possible in a lab environment
  - some tasks can be adequately performed in a lab
  - useful for comparing different designs in a controlled context

Laboratory-based studies

Controlled, instrumented environment

Field/Ethnographic Studies

- Field studies are done in natural settings
- The aim is to understand what users do naturally and how technology impacts them.
- In product design field studies can be used to:
  - identify opportunities for new technology
  - determine design requirements
  - decide how to introduce new technology
  - evaluate technology in use.

Predictive Evaluation

- Experts apply their knowledge of typical users, often guided by heuristics, to predict usability problems.
- Can involve theoretically based models.
- A key feature of predictive evaluation is that users need *not* be present
- Relatively quick and inexpensive

Characteristics of Approaches

	Usability testing	**Field studies**	**Predictive**
Users	do task	natural	not involved
Location	controlled	natural	anywhere
When	prototype	early	prototype
Data	quantitative	qualitative	problems
Feed back	measures & errors	descriptions	problems
Type	applied	naturalistic	expert

Evaluation Approaches and Methods

Method	Usability testing	Field studies	Predictive
Observing	x	x	
Asking users	x	x	
Asking experts		x	x
Testing	x		
Modeling			x

DECIDE:
A framework to guide evaluation

- *D*etermine the *goals* the evaluation addresses.
- *E*xplore the specific *questions* to be answered.
- *C*hoose the *evaluation paradigm* and *techniques* to answer the questions.
- *I*dentify the *practical issues.*
- *D*ecide how to deal with the *ethical issues*.
- *E*valuate, interpret and present the *data.*

USABILITY TESTING

Pilot Studies

- A small trial run of the main study.
  - Can identify majority of issues with interface design
- Pilot studies check:
  - that the evaluation plan is viable
  - you can conduct the procedure
  - that interview scripts, questionnaires, experiments, etc. work appropriately
- Iron out problems before doing the main study.

Controlled Experiments

- Designer of a controlled experiment should carefully consider:
  - proposed hypothesis
  - selected subjects
  - measured variables
  - experimental methods
  - data collection
  - data analysis

Subjects

- The choice of subjects is critical to the validity of the results of an experiment
  - subjects group should represent expected user population expected user population
- Consider subject factors such as:
  - age group, education, skills, culture, technology background
- The sample size should be large enough (10+) to be statistically representative of the user population

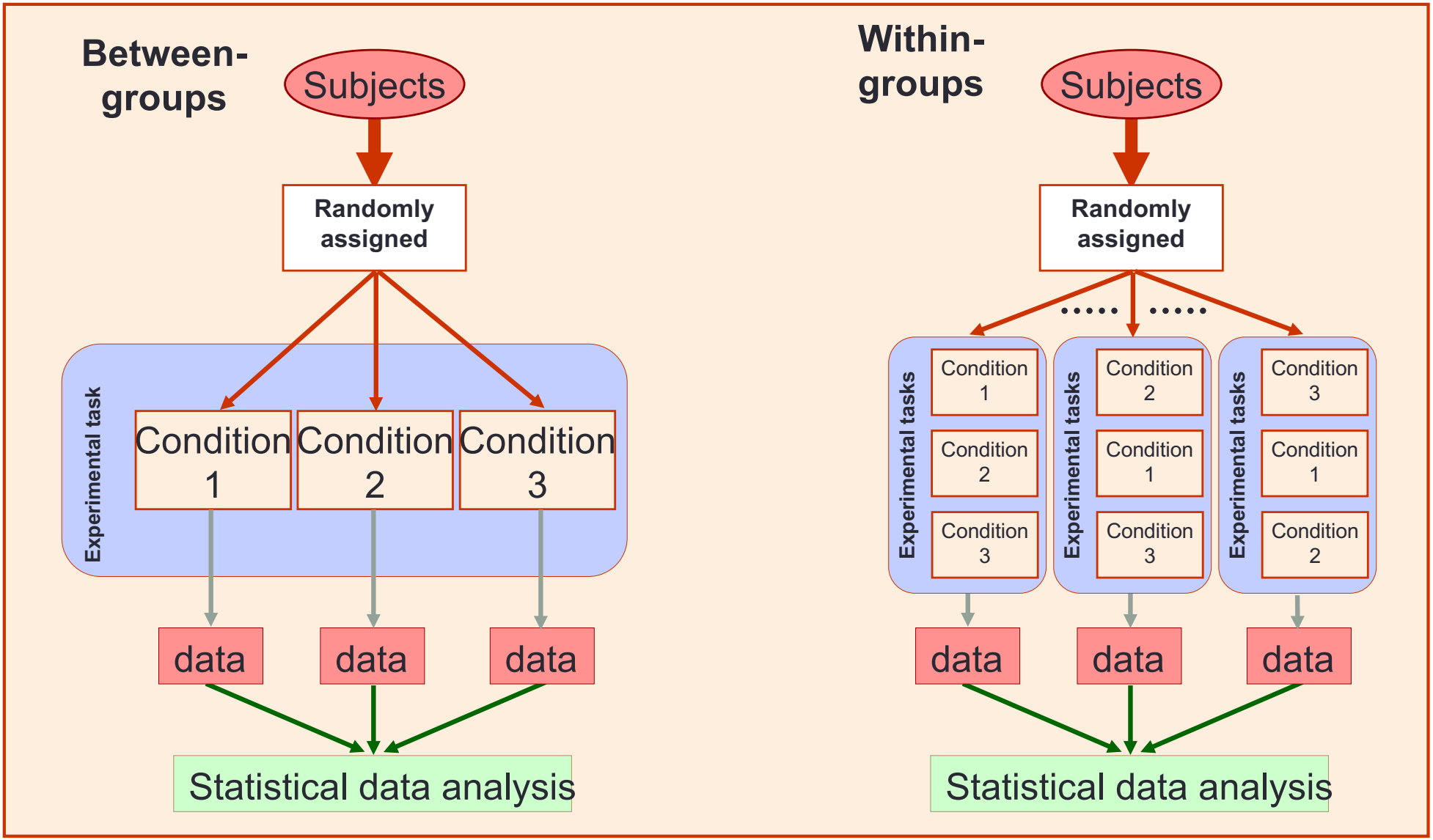
Hypothesis and Variables

- Hypothesis: prediction of the experiment outcome
- Experiments manipulate and measure variables under controlled conditions
- There are two types of variables
  - independent: variables that are manipulated to create different experimental conditions
    - e.g. number of items in menus, colour of the icons
  - dependent: variables that are measured to find out the effects of changing the independent variables
    - e.g. speed of menu selection, speed of locating icons

Experimental Methods

- It is important to select the right experimental method so that the results of the experiment can be generalized
- There are mainly two experimental methods
  - between-groups: each subject is assigned to one experimental condition
  - within-groups: each subject performs under all the different conditions

Experimental Methods



Data Collection and Analysis

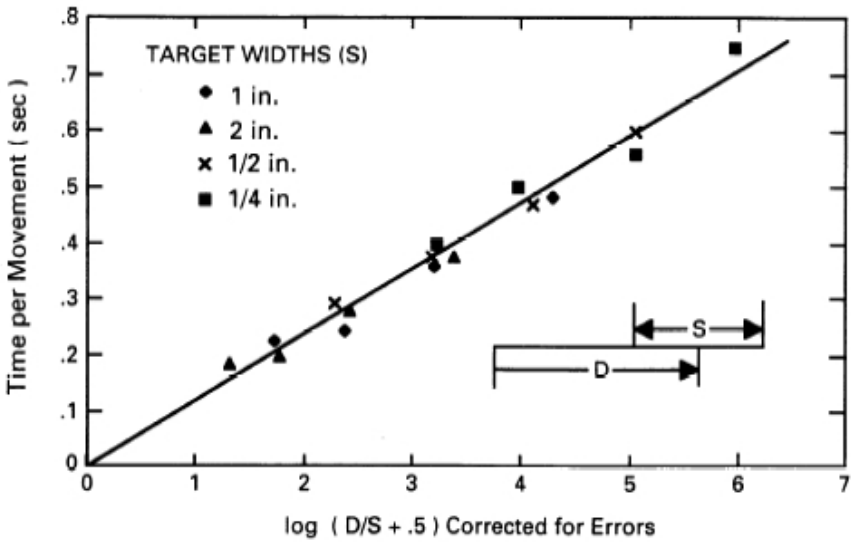
- The choice of a method is dependent on the type of data that needs to be collected
- In order to test a hypothesis the data has to be analysed using a statistical method
- The choice of a statistical method depends on the type of collected data
- All the decisions about an experiment should be made before the experiment is carried out

Data Types

- Subjective (Qualitative)
  - Subjective survey
    - Likert Scale, condition rankings
  - Observations
    - Think Aloud
  - Interview responses
- Objective (Quantitative)
  - Performance measures
    - Time, accuracy, errors
  - Process measures
    - Video/audio analysis

How easy was the task

1	2	3	4	5
Not very easy				Very easy



Example: VR Navigation using Head Tilt

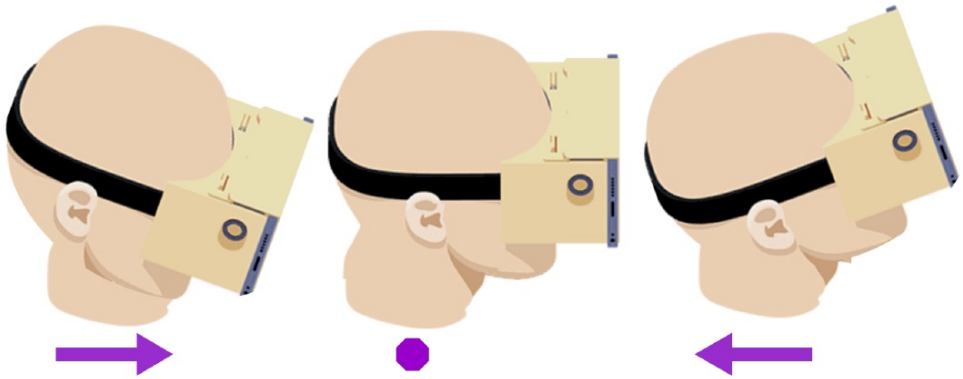
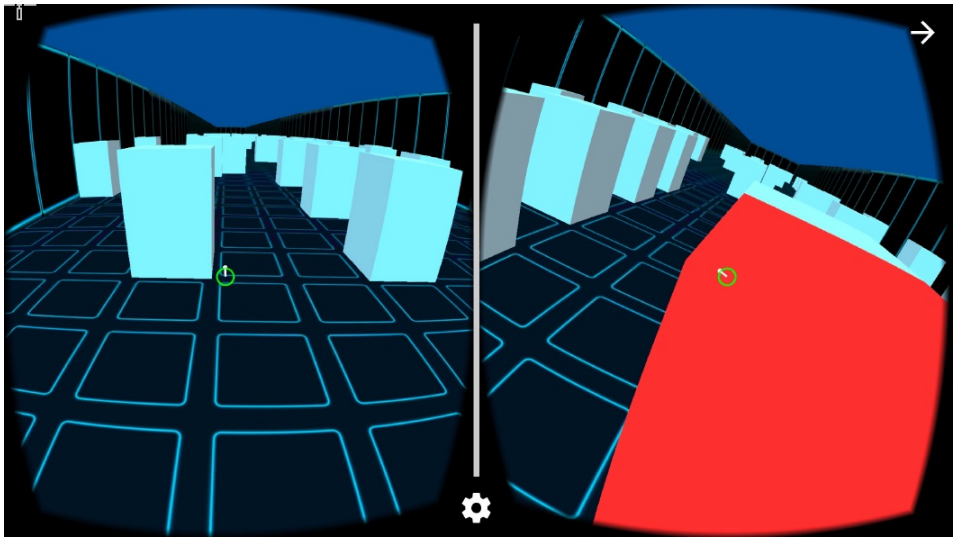


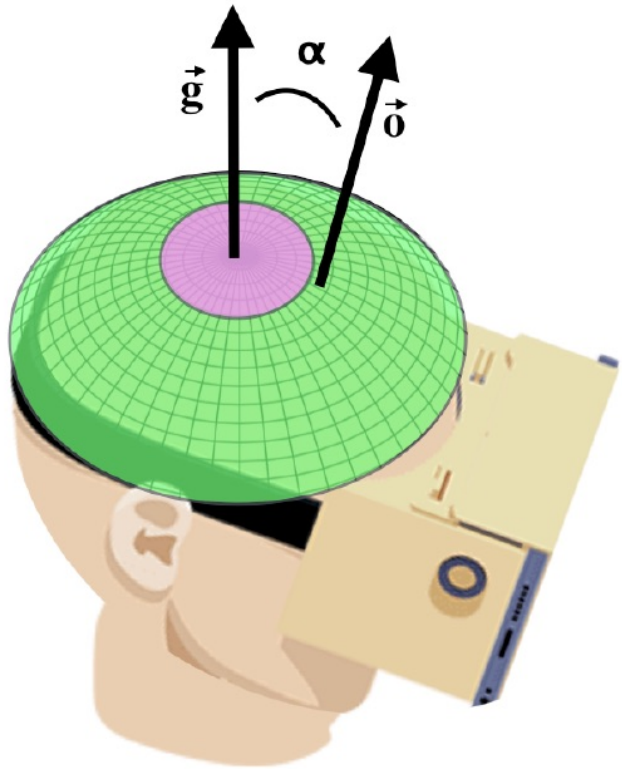
Figure 1. Head tilt is used to indicate the direction of travel

- CHI 2017 paper from Tregillus, Al Zayer, and Folmer
- Problem
  - Navigation in mobile VR difficult due to limited input options
- Solution
  - Use head tilt to provide simulated joystick input

Tregillus, S., Al Zayer, M., & Folmer, E. (2017, May). Handsfree Omnidirectional VR Navigation using Head Tilt. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 4063-4068). ACM.

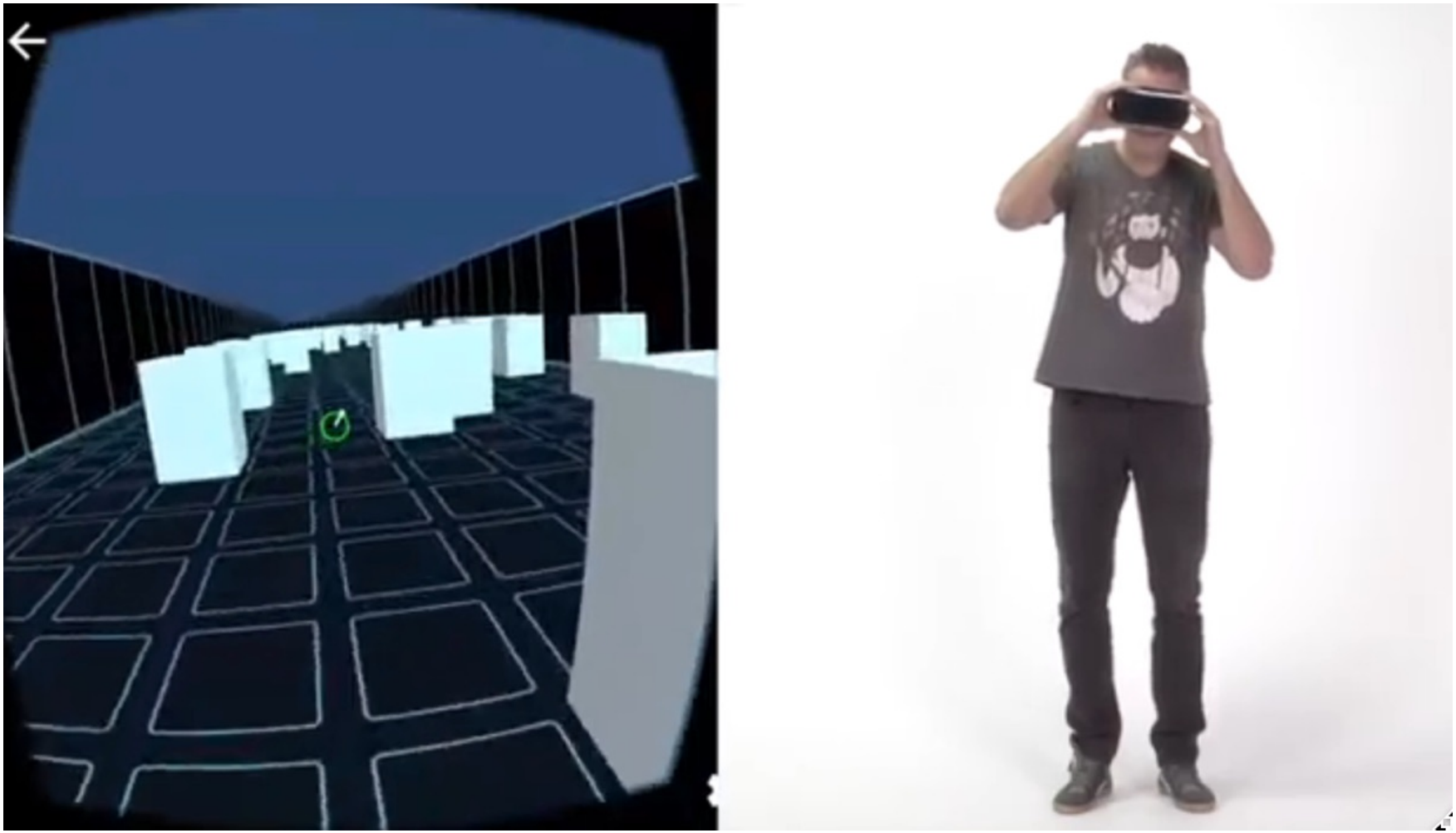
Implementation





- Calculate head tilt angle
  - Difference between vertical head vector and gravity vector
  - Once head tilt is greater than threshold, move forward
- However using head tilt alone prevents looking around
  - Head tilt navigation triggered when walking detected (from IMU)
- Implemented in Unity and Google Cardboard SDK/Viewer

Demo Video



- https://www.youtube.com/watch?v=e6fyfnVTAYs

User Study

- Goal: To compare head tilt input to joystick input for navigation in mobile VR
- Conditions
  - TILT: Head tilt input only
  - WIP-TILT: Head tilt + using walking to trigger tilt input
  - Joystick: Joystick input
- Measures
  - Quantitative: Performance time, Number of obstacles hit
  - Qualitative: Simulator sickness (SSQ), user preferences

Experiment Design

- 25 Subjects (6 female, 19 male)
- Within subjects design
  - All subjects do all conditions
  - Experience conditions in counterbalanced order
- For each condition
  - Training then navigate through 5 virtual corridors
  - At end of condition take SSQ survey
  - Rate condition on Likert scale for efficiency, accuracy, etc.
- After all conditions
  - Interview subjects for more feedback

Results: Performance, Sickness

	TILT	WIP-TILT	joystick
Time(s)	31.22 (5.2)	45.36 (20.9)	44.83 (20.1)
Obstacles(n)	5.05 (4.8)	6.35 (4.1)	7.06 (5.4)
Nausea	26.83 (34.4)	29.22 (18.9)	30.41 (28.4)
Oculomotor	19.42 (23.0)	17.06 (12.8)	21.79 (24.0)
Disorientation	30.45 (29.7)	28.71 (32.7)	35.67 (49.8)
SSQ-total	28.28 (30.8)	27.58 (17.0)	32.26 (34.6)

- Performance time, Obstacles hit, SSQ sickness scores
- Use one way ANOVA test for significance between conditions
  - TILT significantly faster and more accurate than WIP-TILT, joystick
  - No significant difference between sickness scores
  - Using $p < 0.05$ significance

Results: User Preference

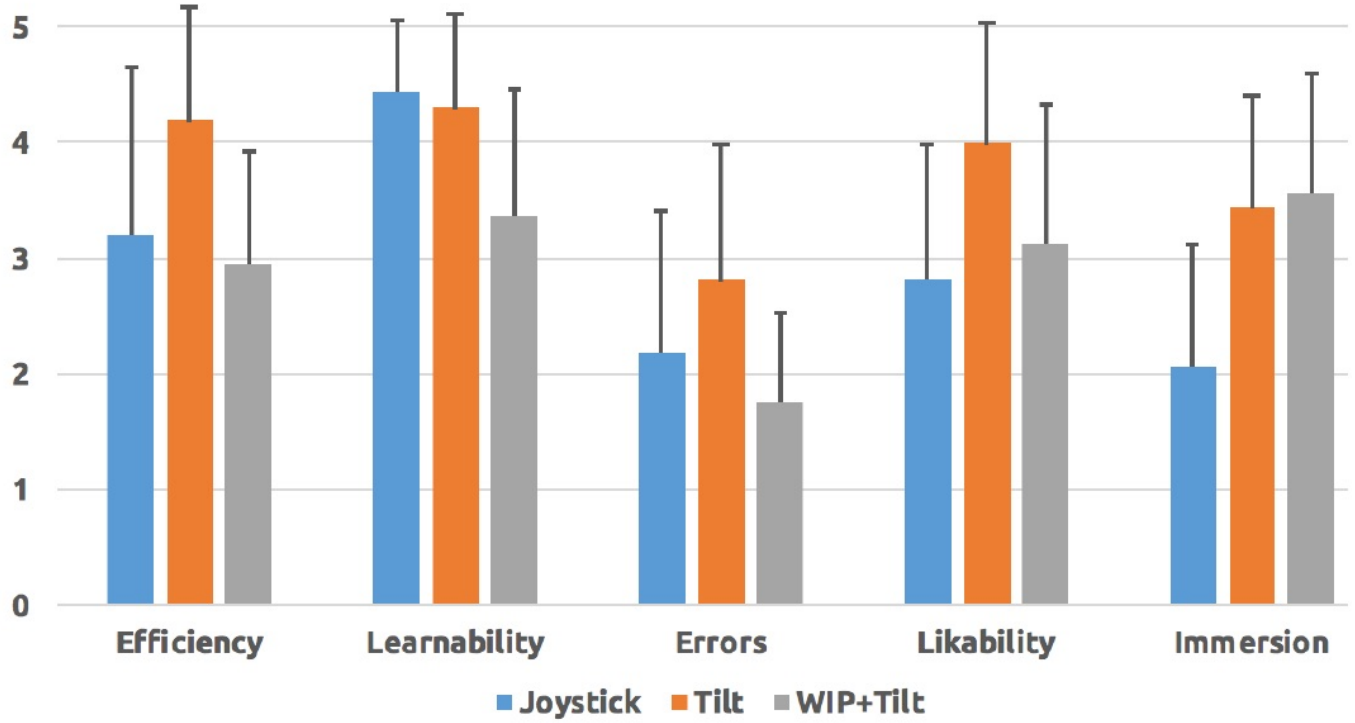


Figure 5. Avg Likert scores and standard deviation for each method

- One way ANOVA comparing Likert scores (1 – 7)
  - significant diff. between TILT and WIP-TILT for efficiency, learnability, errors, likeability and immersion
  - significant diff. between TILT and joystick for learnability and immersion

Discussion

- TILT
  - Performed fastest because user didn’t need to walk in place
  - Liked condition best, except for immersion
  - TILT not ideal for VR applications where user needs to look around
- WIP-TILT
  - Slower than TILT, more difficult to learn due to walking
  - User felt most immersive due to proprioceptive input
- Shows that head tilt could be viable input for mobile VR

Lessons Learned About Expt. Design

- Decide on type of experiment
  - Within subject vs. between subject
- Have well designed task with measurable outcomes
- Use both qualitative and quantitative measures
  - Performance + user preference
- Have enough subjects for significant results
- Use the appropriate statistics
  - Compare conditions + perform post hoc analysis
- Provide subject training on task
- Observe user behavior and interview subjects

CONCLUSION

Conclusion

- Interaction Design methods can be used to develop effective Virtual Realty interfaces
- Needs Analysis
  - Several methods available for determining user needs
- Design
  - Use metaphors and affordances, good UI guidelines
- Prototyping
  - Many rapid prototyping tools available
- Evaluation
  - Use multiple methods for best evaluation

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