PA201
Virtual Environments

Lecture 5

Virtual Reality User Interface Design

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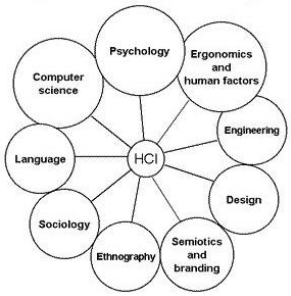
HCI Principles

Definition

- *"Human–computer interaction (commonly referred to as HCI) researches the design and use of computer technology, focused on the interfaces between people (users) and computers. Researchers in the field of HCI both observe the ways in which humans interact with computers and design technologies that let humans As a field of research, human-computer interaction is situated at the intersection of computer science, behavioral sciences, design, media studies, and several other fields of study."*

https://en.wikipedia.org/wiki/Human%E2%80%93computer_interaction

The Field of HCI



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What is HCI?

- Human-Computer Interaction

Advanced HCI?

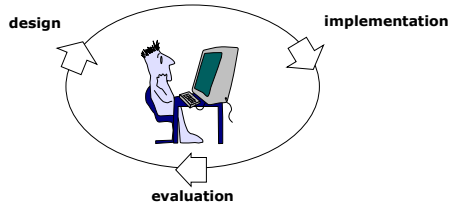



HCI Importance

- Cheaper/available computers/workstations meant people more important than machines
- Excellent interface ideas modeled after human needs instead of system needs (user centered design)
- Evolution of ideas into products through several generations
  - Pioneer systems developed innovative designs, but often commercially unviable
  - Settler systems incorporated (many years later) well-researched designs
- People no longer willing to accept products with poor interfaces

HCI Discipline

A discipline concerned with the:



of interactive computing systems for human use

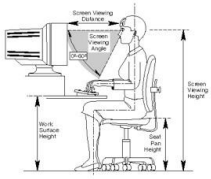
HCI Discipline Definition

- "*Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.*"

Association for Computing Machinery (ACM)

Three paradigms of HCI

- The Three Paradigms of HCI Harrison, Tatar and Sengers, CHI 2007



Human Factors

Classical Cognitivism Information

Embodied Cognition Interaction

Three paradigms of HCI .

	1st HCI Paradigm Human Factors Engineering	2nd HCI Paradigm Classical Cognitivism Information	3rd HCI Paradigm Embodied Cognition Interaction
Metaphor of Interaction	Interaction as Man-Machine Coupling	Interaction as Information Transfer	Interaction as Phenomenologically Situated
Central Goal for Interaction	Optimise fit between man and machine	Optimise accuracy and Efficiency of Information Transfer	Support of Situation Action in the World
Typical Questions of Interest	How can we fix specific problems that arise in Interaction?	What mismatches arise in communication between humans and computers? How can we accurately model what people do? How can improve the efficiency of HCI?	What existing situated activities should we support? How do users appropriate technology? How can we support interaction with constraining it by what a computer can do/understand? What is the wider context roles, politics and values?

Three paradigms of HCI ..

	1st HCI Paradigm Human Factors Engineering	2nd HCI Paradigm Classical Cognitivism Information	3rd HCI Paradigm Embodied Cognition Interaction
Appropriate Disciplines for Interaction	Engineering, Programming, Ergonomics	Laboratory and Theoretical Behavioural Science	Ethnography, Action Research Ethnomethodology, Interaction Design, User Centred Design
Desirable Methodologies	Cool Hacks	Verifiable Quantitative design and evaluation methods that can be applied regardless of context	A palette of situated design and evaluation strategies
Legitimate kinds of Knowledge	Pragmatic Objective Details	Objective facts and models with general applicability	Thick Description of Context and Stakeholder Concerns.
How do you know something is True?	You Tried it out and it worked	You confirm or refute your hypothesis based on a statistical analysis of the evidence	You argue about the relationship between your data and what you seek to understand

Three paradigms of HCI …

	1st HCI Paradigm Human Factors Engineering	2nd HCI Paradigm Classical Cognitivism Information	3rd HCI Paradigm Embodied Cognition Interaction
Values	Reduce errors and make it work. Ad Hoc is OK. Cool Hacks that exploit a specific instance are desired	Optimisation. Strive for Objective, Abstract, Quantitative, Generalizable Knowledge wherever possible. Principled evaluation is *a priori* better than ad hoc, since design can be structured to suite this paradigm. Structured Design better than un-structured. Reduce Ambiguity Top Down View of Knowledge.	Construction of meaning is intrinsic to and unfolds from interaction. What goes on around systems is more interesting than what's happening at the interface. "Zensign" - what you don't build is as important and what you do build. Goal is to grapple with the full complexity around the system. Knowledge can not just be a powerful abstraction but can be embedded in the world as hidden context and tacit skill which is revealed through engagement

Which HCI Paradigm is Correct?

- The key question is not which of the paradigms is "correct" but what different perspectives, strengths, weaknesses, insights and tools they offer and when they are appropriate to apply

Classical Cognitive Information Epoc

Embodied/Situated Interaction Epoc

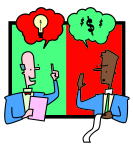
User Interface Design

What is User Interface Design?

- The process of designing effective and user friendly interfaces for software systems and applications
  - Applies in all computer science
  - Other disciplines as well
    - i.e. Hardware design

Why Interface Design Process?

- 63% of large software projects go over cost
- Managers gave four usability-related reasons
  - Users requested changes
  - Overlooked tasks
  - Users did not understand their own requirements
  - Insufficient user-developer communication and understanding



Why Interface Design Process? .

- Usability engineering is software engineering
  - Pay a little now, or pay a lot later!
  - Far too easy to jump into detailed design that is:
    - founded on incorrect requirements
    - has inappropriate dialogue flow
    - is not easily used
    - is never tested until it is too late

Foundations for designing interfaces

- Understanding users and their tasks
  - Task-centered system design
    - How to develop task examples
    - How to evaluate designs through a task-centered walk-through

Foundations for designing interfaces .

- Designing with the user
  - User centered design and prototyping
    - methods for designing with the user
    - low and medium fidelity prototyping
  - Evaluating interfaces with users
    - the role of evaluation in interface design
    - how to observe people using systems to detect interface problems

Foundations for designing interfaces ..

- Designing visual interfaces
  - Design of everyday things
    - What makes visual design work?
  - Beyond screen design
    - Representations and metaphors
  - Graphical screen design
    - The placement of interface components on a screen

Foundations for designing interfaces …

- Principles for design
  - Design principles, guidelines, and usability heuristics
    - Using guidelines to design and discover usability problems

The User Interface

- Users usually judge a software application based on its interface rather than its functionality
  - A poorly designed interface can cause a user to make catastrophic errors
  - Poor user interface design is the main reason why so many software systems are never used

Many Types of Interfaces

- Command
- Speech
- Data-entry
- Form fill-in
- Query
- Graphical
- Web
- Pen
- Augmented reality
- Gesture

Graphical User Interfaces (GUIs)

- GUIs allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation
  - Opposed to text-based interfaces, typed command labels or text navigation
- GUIs can be found in hand-held devices and many applications exist
  - i.e. Augmented reality

GUI Characteristics

Characteristic	Description
Windows	Multiple windows allow different information to be displayed simultaneously on the user's screen.
Icons	Icons different types of information. On some systems, icons represent files; on others, icons represent processes.
Menus	Commands are selected from a menu rather than typed in a command language.
Pointing	A pointing device such as a mouse is used for selecting choices from a menu or indicating items of interest in a window.
Graphics	Graphical elements can be mixed with text on the same display.

https://www.ics.uci.edu/~taylor/ics52_fq01/UISlides.pdf

GUI Advantages

- They are easy to learn and use
  - Without experience can use the system quickly
  - Can switch quickly from one task to another
  - Can interact with several different applications
  - Information remains visible in its own window when attention is switched
- Fast, full-screen interaction is possible with immediate access to anywhere on the screen

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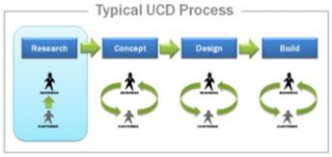
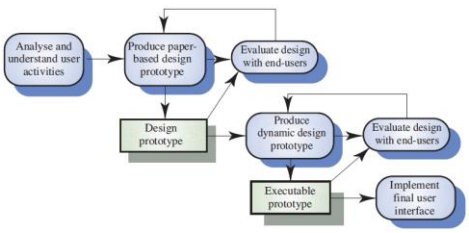
User-Centred Design

- In user-centred design the needs of the user are paramount and where the user is involved in the design process
- User interface design always involves the development of prototype interfaces



User Interface Design Process



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User Interface Design Principles

- User interface design must consider the needs, experience and capabilities of the system users
  - Principles underlie interface designs although not all are applicable to all designs
- Designers should:
  - Be aware of people's physical and mental limitations (e.g. limited short-term memory)
  - Recognise that people make mistakes

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User Interface Design Principles .

Principle	Description
User familiarity	The interface should use terms and concepts which are drawn from the experience of the people who will make most use of the system.
Consistency	The interface should be consistent in that, wherever possible, comparable operations should be activated in the same way.
Minimal surprise	Users should never be surprised by the behaviour of a system.
Recoverability	The interface should include mechanisms to allow users to recover from errors.
User guidance	The interface should provide meaningful feedback when errors occur and provide context-sensitive user help facilities.
User diversity	The interface should provide appropriate interaction facilities for different types of system user.

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Design Principles

- User familiarity
  - The interface should be based on user-oriented terms and concepts rather than computer concepts
    - i.e. An office system should use concepts such as letters, documents, folders etc. rather than directories, file identifiers, etc.
- Consistency
  - The system should display an appropriate level of consistency
  - Commands and menus should have the same format, command punctuation should be similar, etc.
- Minimal surprise
  - If a command operates in a known way, the user should be able to predict the operation of comparable commands

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Design Principles .

- Recoverability
  - The system should provide some resilience to user errors and allow the user to recover from errors
    - This might include an undo facility, confirmation of destructive actions, 'soft' deletes, etc
- User guidance
  - Some user guidance such as help systems, on-line manuals, etc. should be supplied
- User diversity
  - Interaction facilities for different types of user should be supported
    - i.e. Accessibility

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User-System Interaction

- Two problems must be addressed in interactive systems design
  - How should information from the user be provided to the computer system?
  - How should information from the computer system be presented to the user?
- User interaction and information presentation may be integrated through a coherent framework such as a user interface metaphor

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Nowadays Many Mediums

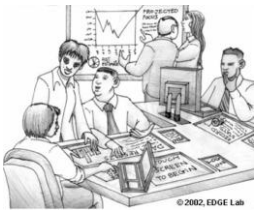
- Mobile and Social Media
- Social Computing
- Virtual and Augmented Reality
- Ubiquitous Computing
- Tangible Computing
- Brain-Computer Interfaces

Mobile and Social Media

- Smart Phones
- Apps vs HTML5
- Location Based Services (LBS)
- Communication and Content Creation
- A post PC era of phones and tablets?
- Constantly changing interactions, social context and place.
- Twitter, Facebook, Foursquare, Google Maps

Social Computing

- Computer Supported Collaborative Working (CSCW)
- Beyond immediate interaction to a web of surrounding relations
- Ethnography, Ethnomethodology
- Actual Practices



Virtual and Augmented Reality

- Virtual Worlds - Simulation, immersion
- Second Life, Massive Multi-player Online Role Playing Games MMORPG
- Virtual Reality - A separate virtual place
- HeadMounted Displays, Caves
- Augmented Reality - The Real World Plus
- Tablets, Phones, Google Glasses

Ubiquitous Computing

- Computers omni-present but "invisible"
- Computers escape from the desktop and disappear
- Wireless, Wearable, Small, Embedded
- RFID tags,
- Micro-controllers, Speckled computing, Machine to Machine
- Internet of Things (IoT)

Interaction Styles

Interaction Styles

- Direct manipulation
- Menu selection
- Form fill-in
- Command language
- Natural language

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Pros and Cons

Interaction style	Main advantages	Main disadvantages	Application examples
Direct manipulation	Fast and intuitive interaction Easy to learn	May be hard to implement. Only suitable where there is a visual metaphor for tasks and objects.	Video games CAD systems
Menu selection	Avoids user error Little typing required	Slow for experienced users. Can become complex if many menu options.	Most general-purpose systems
Form fill-in	Simple data entry Easy to learn Checkable	Takes up a lot of screen space. Causes problems where user options do not match the form fields.	Stock control, Personal loan processing
Command language	Powerful and flexible	Hard to learn. Poor error management.	Operating systems, Command and control systems
Natural language	Accessible to casual users Easily extended	Requires more typing. Natural language understanding systems are unreliable.	Information retrieval systems

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Direct Manipulation Advantages

- Users feel in control of the computer and are less likely to be intimidated by it
- User learning time is relatively short
- Users get immediate feedback on their actions so mistakes can be quickly detected and corrected

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Direct Manipulation Disadvantages

- The derivation of an appropriate information space model can be very difficult
- Given that users have a large information space, what facilities for navigating around that space should be provided?
- Direct manipulation interfaces can be complex to program and make heavy demands on the computer system

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Menu Systems

- Users make a selection from a list of possibilities presented to them by the system
- The selection may be made by pointing and clicking with a mouse, using cursor keys or by typing the name of the selection
- May make use of simple-to-use terminals such as touch screens

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Menu Systems Advantages

- Users need not remember command names as they are always presented with a list of valid commands
- Typing effort is minimal
- User errors are trapped by the interface
- Context-dependent help can be provided
  - The user's context is indicated by the current menu selection

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Menu Systems Disadvantages

- Actions which involve logical conjunction (and) or disjunction (or) are awkward to represent
- Menu systems are best suited to presenting a small number of choices
  - If there are many choices, some menu structuring facility must be used
- Experienced users find menus slower than command language

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Command Interfaces

- User types commands to give instructions to the system
  - i.e. UNIX
- May be implemented using cheap terminals
- Easy to process using compiler techniques
- Commands of arbitrary complexity can be created by command combination
- Concise interfaces requiring minimal typing can be created

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Command Interfaces Disadvantages

- Users have to learn and remember a command language
  - Unsuitable for occasional users
- Users make errors in command
  - An error detection and recovery system is required
- System interaction is through a keyboard so typing ability is required

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Command Languages

- Often preferred by experienced users because they allow for faster interaction with the system
- Not suitable for casual or inexperienced users
- May be provided as an alternative to menu commands
  - i.e. Keyboard shortcuts
- In some cases, a command language interface and a menu-based interface are supported at the same time

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Natural Language Interfaces

- The user types a command in a natural language
- Generally, the vocabulary is limited and these systems are confined to specific application domains
  - i.e. Timetable enquiries
- NL processing technology is now good enough to make these interfaces effective for casual users
  - But experienced users find that they require too much typing

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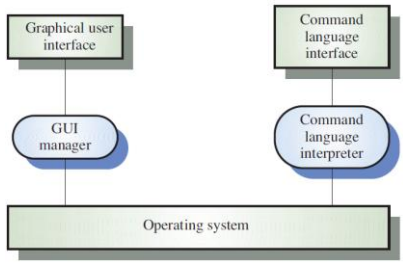
Multiple User Interfaces



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Information Presentation

- Information presentation is concerned with presenting system information to system users
- The information may be presented directly (e.g. text in a word processor) or may be transformed in some way for presentation (e.g. in some graphical form)
- The Model-View-Controller approach is a way of supporting multiple presentations of data

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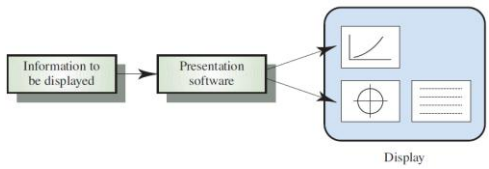
Information Presentation .



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Types of Information

- Static information
  - Initialised at the beginning of a session
    - Does not change during the session
  - May be either numeric or textual
- Dynamic information
  - Changes during a session and the changes must be communicated to the system user
  - May be either numeric or textual

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Information Display Factors

- Is the user interested in precise information or data relationships?
- How quickly do information values change?
- Must the change be indicated immediately?
- Must the user take some action in response to a change?
- Is there a direct manipulation interface?
- Is the information textual or numeric? Are relative values important?

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VR Interaction Styles

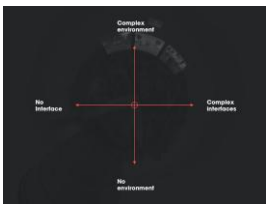
Types of VR Apps

- Generally speaking from a designer's perspective, VR applications are made up of two types of components:
  - Environments
  - Interfaces
- You can think of an environment as the world that you enter when you put on a VR headset
  - The virtual planet you find yourself on, or the view from the rollercoaster that you're riding
- An interface is the set of elements that users interact with to navigate an environment and control their experience

https://www.smashingmagazine.com/2017/02/getting-started-with-vr-interface-design/

Types of VR Apps .

- All VR apps can be positioned along two axes
  - According to the complexity of these components



https://www.smashingmagazine.com/2017/02/getting-started-with-vr-interface-design/

A Process For VR UI Design

- Whereas most designers have figured out their workflow for designing mobile apps, processes for designing VR interfaces are yet to be defined
- Designing for VR should not mean transferring 2D practices to 3D, but finding a new paradigm

https://uxdesign.cc/design-practices-in-virtual-reality-f900f5935826#.d5o5fi71f

A Process For VR UI Design .

- Designers should expand their expertise to different fields in order to be able to create fully controlled experiences, guiding users in VR by shaping the virtual environment in such way
  - Such as psychology, architecture, sound design, lighting design and physics

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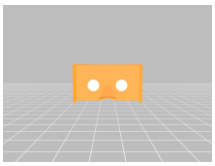
VR Design Solutions

Role of the Ground

- Users can find themselves in such situation in poorly designed VR experiences, causing inevitable motion sickness
- The ground to horizon relationship is as important in VR
  - Similar to our physical reality



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Atmosphere

- Atmospheric (aerial) perspective can help users to understand the scale of the virtual environment, therefore making the experience more natural
  - The gradual fading of the landscape is a clear cue for depth and distance

Masaccio using atmospheric perspective to create the illusion of depth

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Terrain Features

- Ground is rarely an open environment
- A path affords pedestrian motion from one place to another, between other terrain features
- An obstacle is an animal-sized object that affords collision
- A barrier is a specific kind of obstacle that is usually blocking vision as well as movement

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Terrain Features .

- A water margin prevents pedestrian locomotion
- A brink, the edge of a cliff
- A step is a layout of adjacent steps which afford both descent or ascent
- A slope may or may not afford pedestrian locomotion dependent on the angle and texture of the ground

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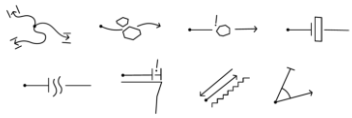
Terrain Features ..

- Using these features in a controlled manner, as the building blocks when designing the virtual environment, will result in (natural) VR experiences guided by human intuition



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User and Soundscapes

- In virtual reality changing the environment entirely is effortless
  - Although for the user these sudden and overwhelming changes can cause sickness and confusion
- A gentle introduction to the new environment can be achieved by fading-in the ambient soundscape of the place at first, then the image
- This allows to build a mental image of the environment via sound
  - Lowering the shock factor

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Video

- https://player.vimeo.com/video/138951063

Guiding the User with Objects

- Navigating the user via a certain path in a cluttered environment can be difficult without using conventional wayfinding UI elements
- The usage of these elements could break the immersion of the experience
  - However subtle changes in the environment, such as growing flowers at the openings of a field in order to draw the users attention to the correct path, could still maintain the genuineness of the place

Red flowers in Firewatch guiding the player towards the correct direction

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Contextual Reticle

- In non-tracked VR reticles are used in order to show the user the specific point where they gaze
  - e.g. Gear VR, Google Cardboard
- It helps to orient in space by showing the centre of focus
- It is also used for movement and interacting with objects
- These specific tasks demand different reactions from the reticle

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Contextual Reticle .

- Idle state
  - The idle state reticle should be as minimal as possible, giving only a hint where the centre is
- Movement
  - The reticle should be activated when the user looks at any place that is approachable
  - When doing so, the reticle should transform into a larger pointer, highlighting the selectable area with a circle projected over it from the user's perspective

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Contextual Reticle ..

- Interacting with objects
  - When the user turns his/her attention to an interactive object the reticle should react accordingly
- Reticle colouring
  - The reticle should adapt its colour to the brightness level of its background, by switching between light and dark modes in order to stay visible in all lighting conditions
- Objects as reticle
  - Replacing the reticle with specific 3D items can be an easy cue for the interaction
    - e.g. a key as the reticle whilst opening a lock

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Interactive Objects

- If not all objects are interactive, users should be hinted which objects they can interact with
- The contextual reticle can be a help in this case, but in some cases, in order to avoid confusion, the interactive objects should change, too
- This could be a minor change in the shading of the object or even a subtle sound describing its behaviour whilst looking at it
  - e.g. subtile click in case of light switches

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VR Design Patterns

Introduction to VR Design Patterns

- UX experts used to design forms, websites and smartphone applications
  - Now they need to re-learn the trade to design interfaces and interactions in virtual reality
- Many of the traditional UI elements simply do not work in VR, and a significant part of the existing UX toolkit is simply inappropriate
- To begin with, designing for a flat surface - our laptop or phone screens - is very different from designing for a spherical world with the user at its centre
  - Luckily there are people researching UI and UX in VR, and there are a few tried and tested patterns

http://realityshift.io/blog/ui-ux-design-patterns-in-virtual-reality

Curved Design

- Take an element as simple as a rectangle, a picture or a video player
- Put it into a VR environment, and it just doesn't work, especially if it's too wide or tall
- The edges of a flat surface will be further away from the user's eye focus, making them blurry and hard to read
- The solution is curved design
  - You need to stop thinking about the canvas as a surface, and imagine it as a sphere

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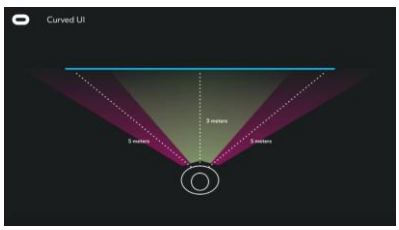
Curved Design .



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Narrowing the Field

- In VR placing any meaningful control element to the periphery of the field of vision is a bad idea
  - It's simple biology: your vision is simply not sharp enough on the edges.
- We are used to think in a landscape or portrait format on the web, and on smartphones
- Neither work particularly well in VR, as they force the user to tilt their head too much
  - Instead, controls should be placed inside a 1:1 rectangle area

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Narrowing the Field .

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Using Z Zones and Depth

- Objects that are too close to your eyes will get blurry
- Just raise your hand and start moving it towards your face - you simply can't maintain focus when it's closer than a few inches
- Objects, and especially controls should never be placed too close to the user
- On the other hand people are much better in telling the distance between two objects in close distance, than between two objects far away
- If the distance is important from an interaction point of view, the objects should be placed reasonably close to the user's eyes

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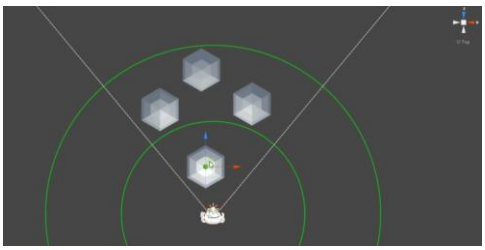
Using Z Zones and Depth .



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Motion Flow

- In virtual reality the camera is mapped to the player's head, with it's focus being at the centre
  - Unless you use eye tracking
- This means you never ever should change the environment against the head movements, or force the user turn their head involutarily
  - Both leads to motion sickness, and being nauseated

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Motion Flow .

- Of course sometimes you want to guide the user through the user interface, towards the direction where something is happening
  - This is where subtle tools like motion flow comes into play
  - Pressing a button can trigger the button to extend, or slowly start moving, gently guiding the user to turn their head
  - We are implying a direction, guiding their eye to the next point of interest

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Moving Interface

- It's the opposite of motion flow, when we don't urge the user to look in a specific direction, but rather move the new elements directly to the field of view
- Standing the centre of a sphere means you don't see, and you don't know about UI elements changing behind your back
- Sometimes it's better to put them right in the front of the user

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Capturing Attention

- The long evolution of the Homo Sapiens trained us to pay attention to lights and movement
  - This evolutionary skill is perfect to capture focus in a virtual reality environment
- A great example is the game demo Lost by Oculus
  - They use fireflies in a dark forest to lead the eyes of the user
- We expect to see more subtle, clever plays on light and shadow in VR applications and games

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Capturing Attention .

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Anchor Objects

- Virtual reality causes dizziness for a lot of people
- Chances are if you had a bad experience with VR you won't try it again
  - And definitely won't try it the third time
- We are used to standing or sitting still while the world is moving around us, a good example being driving
- It's not causing nausea, because we have a visual anchor, the car dashboard
- Establishing such an anchor object in the virtual space is something interface designers should consider
- Research suggests even a virtual nose can help

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Anchor Objects .

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Holophonic Sound

- Holophonic means 3D sound
- The idea is that with listening through the right equipment you can tell if the sound is coming from above, below, or from behind your back
  - And not just left and right, as with the stereo systems
- Holophonic sounds are amazing in games, but they very well might be used for VR control interfaces
  - Imagine a video start playing outside of your view, and you will hear 'exactly' where the sound comes from

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Conclusions

- Virtual reality and user interface design are emerging as a new medium with the potential of having as strong an impact in society
- Nowadays can build the foundations of interface, experience and interaction design specific for this medium
  - Without taking already existing solutions for granted

Videos

- VR Interface Design Pre-Visualisation Methods
  - https://www.youtube.com/watch?v=id86HeV-Vb8
- UI/UX design for WebVR
  - https://www.youtube.com/watch?v=ZOaOYTOpwyM
- Google I/O 2015 - Designing for virtual reality
  - https://www.youtube.com/watch?v=Qwh1LBzz3AU
- Designing For Virtual Reality
  - https://www.youtube.com/watch?v=hM1AnOqaE-w

Questions