

3D User Interface Design

An introduction to
3D user interface design issues
for virtual environments

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Introduction

- Goal of 3D UI design is
 - Help user perform system tasks effectively
 - Avoid causing discomfort
 - Avoid causing frustration
 - *Performance - Usability - Usefulness*
- Not easy due to several factors
 - 2D/3D input, simulator sickness, human perception, complexity, precision, lack of standards for best practices

Introduction

- Universal interaction tasks (Bowman)
 - Navigation
 - Travel - motor component
 - Wayfinding - cognitive component
 - Selection
 - Manipulation
 - System control

Travel

- Travel is the manner in which a user moves between two locations in a virtual world
 - Most common form of interaction in 3D software systems

Travel

- Why does a user navigate?
 - Explore environment
 - Search for something specific when its location is not known
 - Go to a known location
 - Systematically learn about the environment
 - Position the “view” while performing a task

Travel Metaphors

- Steering-based
 - User continuously steers in the motion direction
 - Follow direction of focus
 - Follow a virtual pointing finger or hand
 - Steer with some sort of steering wheel or joystick
 - even a virtual one, based on gestures
 - Walking, flying, orbiting are different ways of moving, with different constraints imposed
 - Useful when the user wants to become acquainted with an environment

Travel Metaphors

- Target-based
 - User specifies a target and the system takes the user to the location of the target
 - User enters coordinates
 - User selects targets from a list
 - Object names
 - Viewpoints
 - User selects (or points at) an object
 - Quick and efficient when the user knows where he/she wants to go (or thinks he/she knows...)

Travel Metaphors

- Other useful metaphors include
 - Route planner
 - User draws a route on an overview map
 - system takes the user along the route
 - System may automatically identify an optimal route based on some user-defined criteria
 - Hand-held camera
 - Quick and accurate for controlling a camera within a limited space (e.g. motion sensor used to represent a physical camera)
 - But if user needs to use both hands then will need assistance

Wayfinding

- To aid the user acquire an understanding of an environment it is helpful to assist the user in constructing a cognitive map of the space, by providing
 - Maps
 - Landmarks
 - Audio
 - Temporarily widen field of view

Selection and Manipulation

- Selection: Pick one or more objects
- Manipulation: Modify object attributes

Selection

- Why?
 - To prepare to manipulate a specific object
 - To move closer to an object
 - To activate behaviour associated with an object
 - To retrieve information about an object

Selection

- How?
 - Point at an object (ray-casting)
 - “Touch” an object (3D hand)
 - But can also
 - Select from a list
 - Search for specific attributes

Selection

- What needs to be taken into account?
 - Distance from user
 - Size of target
 - Other objects in the way
 - When to select a target (e.g. pick command, on intersection)
- What can we do to make selection easier?
 - Dynamically change the size of the target area depending on its distance from the user and/or disallow selecting distant objects
 - Support “X-ray vision” and clicking *through* other objects
 - Use highlighting or audio feedback to identify potential and active selections

Manipulation

- Why?
 - To position objects
 - To navigate
 - To modify an object's attributes
 - e.g. Change it's form, scale, etc.
 - To press/touch/pull an object to trigger an event

Manipulation

- How?
 - Ray-casting
 - Virtual hand
 - Tangible interface techniques
 - Gestural interfaces
- What should be taken into account?
 - Distance from the viewer
 - Precision required
 - Amount of rotation or translation permitted

Manipulation

- What can be do to make manipulation easier?
 - Virtual hand is natural to use, but limits to interacting with near objects and is difficult to control with a 2D input device
 - Ray-casting is easy to implement for both 2D and 3D input
 - But precise 3D manipulation can be a challenge with a 2D input device
 - Can introduce temporary constraints to aid the user
 - E.g. Only rotate around one axis at a time
 - Tangible interface techniques e.g. using physical props can support complex manipulations
 - Gestural interfaces imprecise but may be more *natural*
 - Can combine different techniques

System Control

- “System control” is all other interaction related to the virtual environment
 - e.g. Selecting system configuration options, loading files, changing modes, etc.
 - i.e. commands to change state or mode
- For a typical desktop 3D system, we can use choose to use standard 2D menus and UI components OR we can implement a more immersive fullscreen 3D experience

System Control

- It is most common to implement graphical menus and UI components of some kind
- Can also be appropriate to incorporate
 - Voice control
 - Gesture recognition
 - Physical props
- It is most important that we do not disrupt the user's workflow (or playflow)

Menus for System Control

- Controls in an overlay (“HUD”) can work well
 - But can disrupt the 3D experience in an immersive environment
 - Consider allowing the user to toggle display of menus
- Floating 3D menus may be preferable, but
 - Can obstruct the user’s view
 - Can be difficult to read/see depending on the angle
 - Can be difficult to select from using 3D input devices

2D interaction in 3D worlds

- It is often useful to apply 2D interaction techniques to 3D environments
 - For desktop VR, where the user typically has only a keyboard and mouse, it is always a challenge to implement rich 3D interaction using 2D input devices (and the keyboard)
 - Even if you have access to 3D input technologies, applying 2D interaction techniques can be useful in some situations
 - Working in 2D is easier physically and cognitively

2D interaction in 3D worlds

- 2D input is often much more precise than 3D input due to the limitations of typical 3D input devices
 - Resolution/accuracy, latency, jitter...
- It is generally easier to select objects with a 2D mouse than a 3D mouse
 - Generally more difficult to manipulate 3D objects with 2D mouse
- Introducing constraints can make a 3D system easier to use
 - e.g. Restricting travel to terrain following rather than flying
 - When you need to include the additional dimension then you will often need to do so in an “unnatural” manner

2D interaction in 3D worlds

- Tablets computers can be used as input devices with secondary displays (e.g. for system control)
 - Need to be well-integrated with the rest of the (3D) system so that the user experiences it as a natural extension to the main 3D view

Design Methods

- Quite a lot of research has been done on 3D UIs
 - Many different requirements
 - Many different input technologies and techniques
 - No common understanding of a 3D UI paradigm...
- General guidelines resulting from research can only be considered as recommendations and not rules
- Good 3D UI design is challenging
 - Requires knowledge and creativity

Design Method

- Systematically consider the users' requirements for performing tasks in the virtual environment
- Use familiar interaction techniques when they appear to be appropriate (e.g. from games, 3d modelling tools, etc.)
- Use appropriate guidelines and usability research results
- Innovate: be creative!
- Use an iterative process with lots of informal testing
 - e.g. Focussing on task performance and subjective usability

Research

- Guidelines are established as a result of formal experiments, user studies, and usability evaluations, where we look at factors such as
 - Task performance
 - Subjective usability
 - Mental workload
 - Situation awareness
 - Sense of presence

Research

- Typical findings include...
 - Teleport type functions are useful but can result in the user losing a sense of location and/or direction
 - Can counter this by animating the transition
 - Perspective & occlusion are most important depth cues
 - Stereoscopic 3D does not necessarily contribute to improved task performance overall, but can contribute to a user more rapidly attaining a sense of presence
 - Users often underestimate distances
 - Visible grids can help users estimate distances

Summary

- Good 3D UI design is challenging
- Applications are diverse and often have complex user input needs to meet system goals
 - Users will often need some form of training
- Designers often need to be creative in identifying good solutions
- Iterative design methods are recommended
- Guidelines are useful but there are no standard solutions for all 3D applications!

Extra Slides

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3D UI Guidelines

- Useful sources of general guidelines:
 - Schneiderman in “*Why Not Make Interfaces Better than 3D Reality*”
 - IEEE Computer Graphics & Applications Nov/Dec 2003
 - Bowman in “*Interaction Techniques For Common Tasks In Immersive Virtual Environments*” (1999)
 - PhD thesis, and incorporated into book on “3D User interfaces: Theory and Practice” published in 2005

Guidelines

Schneiderman

- Use occlusion, shadows, perspective, and other 3D techniques carefully
- Minimise the number of navigation steps for users to accomplish tasks
- Keep text readable
 - better rendering, good contrast with background, and no more than 30-degree tilt

Guidelines

Schneiderman

- Avoid unnecessary visual clutter, distractions, contrast-shifts, and reflections
- Simplify user movement
 - Keep movement planar, avoid surprises such as going through walls
- Prevent errors
 - Surgical tools that cut only where need, ...

Guidelines

Schneiderman

- Simplify object movement
 - Facilitate docking, follow predictable paths, limit rotations
- Organise groups of items in aligned structures to allow rapid visual search
- Enable users to construct visual groups to support spatial recall
 - Placing items in corners or tinted areas

More Guidelines

Schneiderman

- Provide overview so users can see the big picture
 - Plan view display, aggregated views
- Allow teleportation
 - Rapid context shifts by selecting destination in an overview
- Offer x-ray vision so users can see into or beyond objects
- Provide history keeping
 - Recording, undoing, replaying, editing

More Guidelines

Schneiderman

- Support semantic zooming and movement
 - Simple action brings object front and centre
- Enable landmarks to show themselves even at a distance
- Develop novel 3D icons to represent concepts that are more recognisable and memorable