CSE 165: 3D User Interaction

Lecture #14: 3D UI Design

Announcements

- Homework 3 due tomorrow 2pm
- Monday: midterm discussion
- Next Thursday: midterm exam

3D UI Design Strategies

Thus far…

- 3DUI hardware
  - Output
  - Input
- Universal 3DUI tasks
  - Selection
  - Manipulation
  - Navigation
  - System control
  - Symbolic input

But: The combination of techniques and devices alone does not guarantee an enjoyable experience!

3DUI Design

- Microlevel: implementation
  - 3D interaction programming: hard!
  - Testing: difficult and hard to automate
  - Tweaking UI parameters: important but time consuming
- Macrolevel: guidelines
  - Strengths and limitations of human psychology/physiology
  - Common sense
  - Rules of thumb
  - Example: people naturally use 2 hands, so using 2 hands in a 3D UI might improve usability/performance

3DUI Design

- Two main strategies
  - Designing for humans
    - Match design to human strengths
  - Inventing 3D interaction techniques
    - Creative exploration of 3D UIs

Designing for Humans - Feedback

- Feedback is critical to usable 3D interfaces
  - User feedback is any information conveyed to the user to help understand
    - system state
    - result of operation
    - status of task
- Feedback control mechanism
  - Example: turning a knob produces feedback by
    - External sources: the knob
    - Internal sources: user's body
- Want to have appropriate feedback levels
- Ensure compliance (agreement) between different levels/types of feedback

Designing for Humans – Feedback in Multiple Dimensions

- Sensory dimensions
  - Visual, auditory, tactile, olfactory
  - Proprioceptive: relative position of neighboring parts of the body
  - Kinesthetic: bodily motion
- Want to try to give multi-dimensional feedback
  - Can be difficult due to technology (e.g., haptic devices)
  - Sensory feedback substitution
    - Example: visual/audio cues compensate for missing haptic feedback
- System-based feedback
  - Reactive – from sensory dimensions
  - Instrumental – generated by devices
  - Operational – changes in virtual world

Designing for Humans – Compliance

- Main principle in design feedback
- Want different feedback dimensions in sync
  - Maintain spatial and temporal correspondence between multiple feedback dimensions
- Feedback displacement is bad!
  - Example: hand and virtual object move in different directions

Designing for Humans – Spatial Compliance

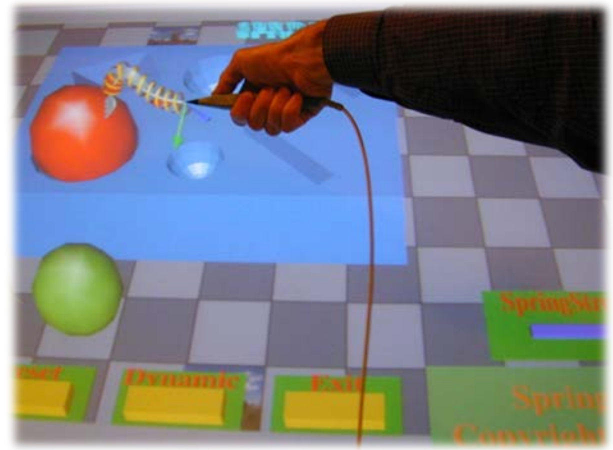
- Directional compliance – virtual object should move in the same direction as manipulated by input device
- Nulling compliance – when user returns device to initial pose, virtual object returns to corresponding initial pose
- Instrumental and operational feedback also require spatial compliance
  - Example: real and virtual hand should be aligned

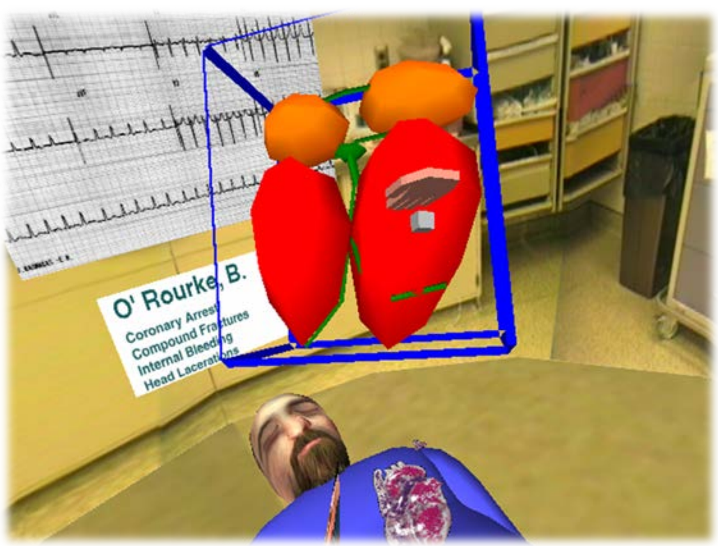
Designing for Humans – Temporal Compliance

- Latency – typical problem
  - Temporal delay between user input and sensory feedback
  - Incompliance with internal feedback
- Variable latency can be even more problematic
- Solutions?
  - Reduce scene complexity
  - Faster hardware
  - Predictive tracking

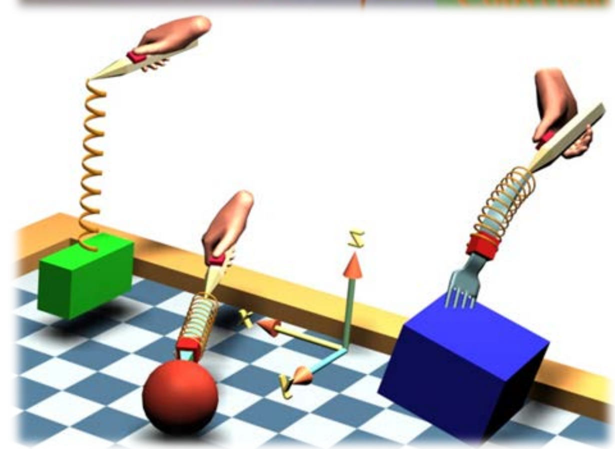
Designing for Humans – Feedback Substitution

- Cannot always support all sensory feedback dimensions
- Typical approach is to substitute





Highlighting object about to be selected



Spring Manipulation Tools, Michal Koutek, TU Delft

Designing for Humans – Passive Haptics

- Match shape and appearance of virtual object with physical prop
  - User both sees and feels
- Advantages
  - Inexpensive haptic/tactile feedback
  - Establish perceptual frame of reference
- Disadvantages
  - Scalability
  - Performance improvements have not yet been measured

Designing for Humans – Constraints

- Constraints:
  - Are a relation between variables that must be satisfied
    - Example: a line should stay horizontal
  - Define geometrical coherence of scene
  - Can make interaction simpler and improve accuracy

Designing for Humans – Constraint Types

- Physically realistic constraints
  - Collision detection and avoidance
  - Gravity
  - Application dependent
- DOF reduction
  - Simplify interaction (example: constrain travel to ground)
- Dynamic alignment tools
  - Grids and snapping, guiding surfaces
- Intelligent constraints
  - Deal with semantics
    - Example: lamp can only stand on horizontal surfaces

Designing for Humans – Two Handed Control

- Also known as bimanual input
- Transfer everyday manipulation experiences to 3DUI
- Can increase user performance on certain tasks
- Active topic of research

Designing for Humans – Guiard's Framework

- Tasks are
  - Unimanual: throwing darts
  - Bimanual symmetric
    - Synchronous: pulling a rope
    - Asynchronous: typing on keyboard
  - Bimanual asymmetric (cooperative): holding a cell phone with one hand, operating it with the other
- Division of labor (hand roles) for asymmetric scenario:
  - Nondominant hand dynamically adjusts spatial frame of reference for dominant hand
  - Dominant hand produces precision movements, nondominant hand performs gross manipulation
  - Manipulation is initiated by nondominant hand

Designing for Different User Groups

- Age
- Prior 3DUI experience
- Physical characteristics: arm length, etc.
- Perceptual, cognitive, motor capabilities
  - Color recognition
  - Stereo vision
  - Spatial abilities

Designing for User Comfort

- Weight of equipment
- Keep users in proper physical space
- Hygiene and public installations
- Keep sessions short (30-45min max) to prevent sickness, fatigue

3DUI Design Strategies

- Designing for humans
  - Match design to human strengths
- Inventing 3D interaction techniques
  - Creative exploration of 3D UIs

Inventing 3D User Interfaces

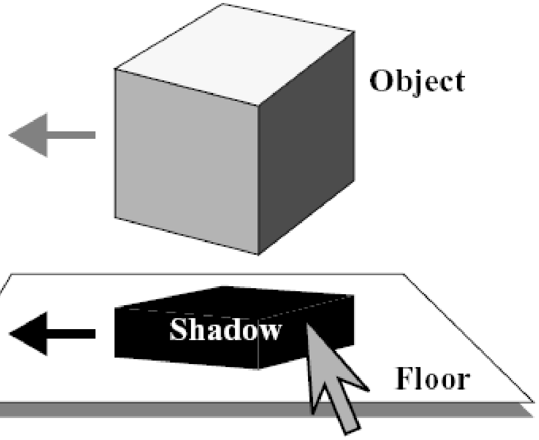
- Realistic (or isomorphic)
  - Borrowing from real world
- Magical (or non-isomorphic)
  - Deviating from the real world and introducing artificial, “magical” techniques
- Continuum between realistic and magical

Inventing 3DUIs – Simulating Reality

- Tried and true approach: replicate real world
  - as closely as possible
  - bring in certain elements
- Important for simulation applications
  - flight simulators
  - medical training
  - phobia treatment
- Dependent on application
- Advantages
  - User can utilize everyday experience
  - Uses system designer's intuition
- Disadvantages
  - Limitations of technology do not allow exact realism
  - Introduces limitations of the physical world into the virtual world

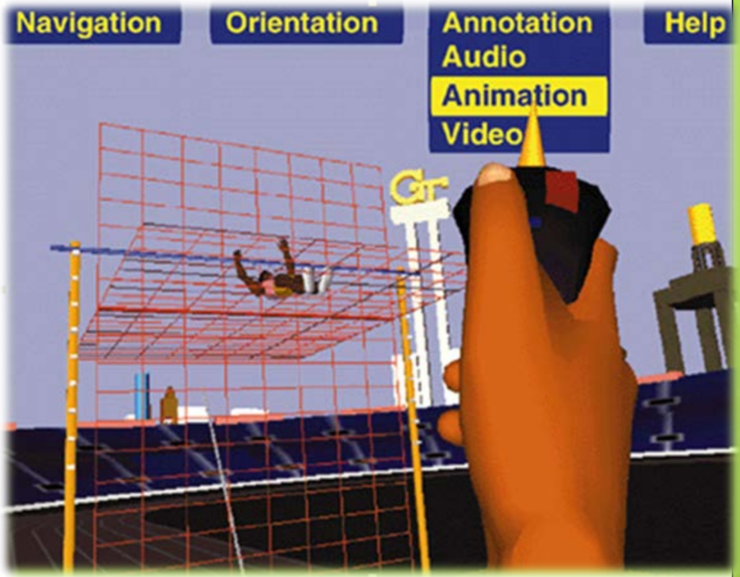
Inventing 3DUIs – Adopting from the Real World

- Adopt artifacts, ideas, philosophies, domains
- Architecture and movies
- Real-world metaphors
- Examples
  - virtual vehicle
  - flashlight
  - shadows



Inventing 3DUIs – Adapting from 2D

- 2D UIs studied extensively
- Most people fluent with 2D interaction
- Can be easier to use than 3D menus
- Approaches
  - 2D overlay
  - 2D widgets in 3D environment
  - 2D interaction with 3D objects
  - UI on separate device (eg, tablet)



Inventing 3DUIs – Magic and Aesthetics

- Real power of 3DUIs
  - better reality
  - alternate reality
- Overcome human limitations
- Reduces effects of technological limitations

http://www.cantonmagicrafters.com/images/rabbit.jpg

Magic: Using Cultural Clichés & Metaphors

- Examples: Flying carpet, Go-Go, WIM
- Advantages:
  - easy to understand if you know the metaphor
  - usually very enjoyable
  - many metaphors are available
  - need not to be learned
- Disadvantages:
  - metaphors can be misleading
  - metaphors are often rooted in culture
  - difficult to come up with good magic metaphors