CSE 165: 3D User Interaction

Lecture #18:
3D User Interface Design

Upcoming Deadlines

- Sunday, March 7th at 11:59pm:
  - Homework project 4 due
- Monday, March 8th at 4pm:
  - Discussion Project 4 and Final Exam
- Sunday, March 14th at 11:59pm:
  - Homework project 4 late deadline
- Final Exam
  - 3 hour exam, **no interruptions**
  - To be taken in 24 hour window between 6pm Wed 3/17 and 6pm Thu 3/18

Announcements

- CAPE + TA evaluations

3D UI Presentations

- Juan Ramirez
  - HexTouch: Affective Robot Touch for Complementary Interactions to Companion Agents in Virtual Reality
- Yanxun Li
  - bHaptics' CES 2021 keynote in 3 minutes - world's first native gaming haptic suit

3D UI Design Strategies

Thus far...

- We covered universal 3D UI tasks
  - Selection
  - Manipulation
  - Navigation
  - System control
  - Symbolic input

But: The combination of techniques and devices alone does not guarantee an **enjoyable** 3D UI experience!

3D UI Design – Designing for Humans

- 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
    - Example: people naturally use 2 hands, so using 2 hands in a 3D UI might improve usability/performance

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 – Compliance

- **Compliance** is the main principle in design feedback
- Want different feedback dimensions to be **synchronized**
  - Maintain spatial and temporal correspondence between multiple feedback dimensions
- **Feedback displacement** is to be avoided
  - 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

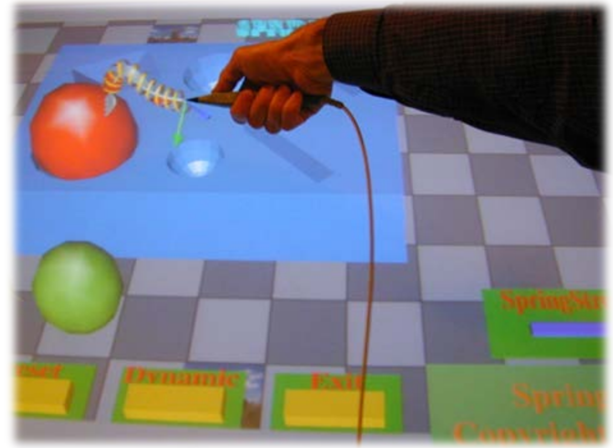
- Latency – typical problem
  - Temporal delay between user input and sensory feedback
- Variable latency can be even more problematic
- Solutions?
  - Reduce scene complexity
  - Faster hardware
  - Predictive tracking

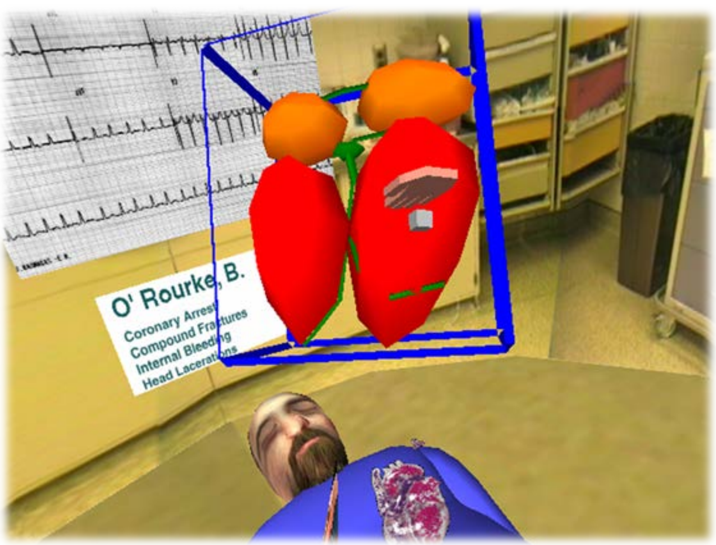
Designing for Humans – Feedback in Multiple Dimensions

- Sensory dimensions
  - Visual, auditory, tactile, olfactory
  - Proprioceptive: position relative to the body
  - Kinesthetic: bodily motion
- Want to try to give **multi-dimensional** feedback
  - Can be difficult due to technology limitations (eg, haptic feedback still in early stages)
  - Sensory **feedback substitution**
    - Example: visual/audio cues compensate for missing haptic feedback

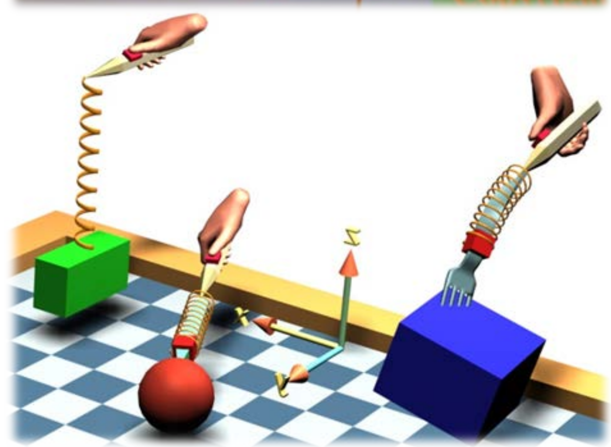
Designing for Humans – Feedback Substitution

- 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
- Advantage
  - Inexpensive haptic/tactile feedback
- Disadvantage
  - Scalability: all users need physical prop

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
- DOF reduction
  - Simplify interaction (example: constrain travel to ground)
- Dynamic alignment tools
  - Grids and snapping, guiding surfaces
- Intelligent constraints
  - Example: lamp can only stand on horizontal surfaces

Designing for Humans – Two Handed Control

- A.k.a. bimanual input
- Transfer everyday manipulation experiences to 3D UI
- Can increase user performance on certain tasks

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

Designing for Different User Groups

- Age
- Prior 3D UI 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