Guidelines for Developing 3D UIs

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▶Lecture Outline

- Application areas for 3D UI's
- Challenges for 3D UI's
  - Input
  - Output
  - Human
- Guidelines for 3D UI's
- General observations
- Summary & outlook

▶3D UI's in Games

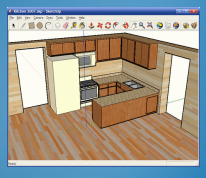
- Desktop or "Couch"
- Largely static scenes
  - Scripted/restricted interaction
- Subgenre: Virtual Worlds

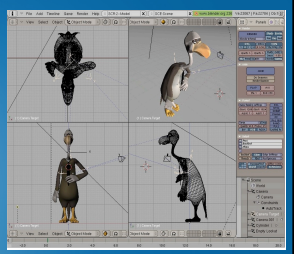
▶3D Window Managers

- Desktop
- Manage applications, files, resources

▶3D UI in CAD

- Desktop
- Content creation
- Need to support *many* operations





▶3D UI in VR/AR

- Goal: immersion
- Often non-desktop
- Mostly static scenes

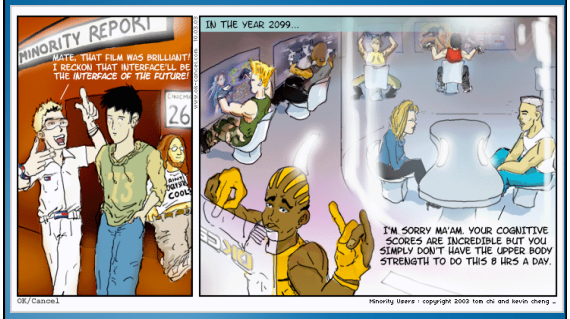
▶Challenges

- 3 main categories
  - Input
  - Output
  - Human Issues

▶Input

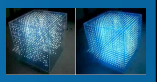
- Desktop 3D devices (Spaceball, Phantom, ..)
  - Very sensitive, limited motion, desk clutter
- Free-space 3D devices
  - Hand jitter, fatigue, lack of precision
  - OK for movements, not for pointing
    - Gesture recognition not reliable
  - Acceptable for head tracking
- Game controllers
  - Very limited DOF, ~ for pointing

▶OK/Cancel on Minority Report



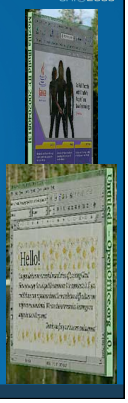
▶Output - Displays

- Stereo
  - Glasses – dark, can't see others
  - Autostereo – neck strain
  - HMD's – neck strain, can't see others
- 3D displays
  - Seeing front and back of object simultaneously?
- Field of view
  - Spatial navigation OK with natural fov: 110°
  - Monitors and HMDs: only 30-40°



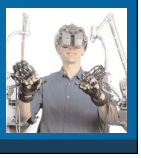
▶Output – 3D Graphics

- 3D graphics hardware
  - 3D text is *significantly* less readable
    - Perspective distortion
    - Anti-aliasing = blurring
    - Limited by pixel resolution
- Hence, less information density in 3D!
  - Critical for business apps
    - Icons not an alternative



▶Human Issues 1

- Humans not naturally good at full 3D
  - Astronauts, divers, fighter pilots …
    - Extensive training
  - Aid: scaffolding (sculptor, builder, …) or connections (plumber, …)
- No "natural" mapping for full 3D rotations
  - Except bimanual operation
    - Needs tracking of hands and *fingers*
      - With high precision and haptic feedback



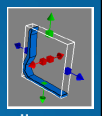
▶Human Issues 2

- People interact only with *visible* objects
  - Strong preference
- Depth perception not that accurate

- Navigation
  - 3D spatial memory not much better than 2D
  - Easier/faster to teleport/search
    - Google Earth

▶Human Issues 3

- Latency/lag
  - Latency detrimental on performance
    - Jitter in latency much worse
  - Noise not good either
    - Smoothing introduces latency!
- User Interface Mappings
  - UI very often thin layer above math
    - E.g. handles, wireframe, ortho view, etc.
  - Most humans don't understand these easily



▶How to Fix?

- Sources of inspiration
  - User studies
    - Observe novices
      - – No bias!
  - Use known results from
    - Perception (stereo, hand-eye coord., …)
    - Kinesiology
    - VR/AR research
    - 2D UI
    - 3D games

▶My Take On 3D Interaction

- Students: T. Salzman, G. Smith, J.-Y. Oh, R. Teather, …
- The big picture
  - 2D > Smart 3D > Full 3D
    - Full 3D: standard 3D tracker
    - Smart 3D: intelligent use of 3D tracker
    - 2D: mouse, tablet
  - Not that surprising, but few verifications

▶Guidelines for Smart 3D UI's

- Help for designers
  - Some well known in various communities
    - Add theoretical/experimental underpinning
  - Also, directions for future work
  - Note: these are *guidelines*
    - Not hard requirements!
    - But many successful systems are here to them

▶Guidelines - Objects

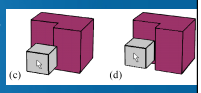
1. Contact assumption
   - Floating objects exception in real world
     - But often default in 3D UI's
     - Training *necessary* to deal with floating objects!
2. Objects should not interpenetrate each other
   - Confusing visual display, can't manipulate, …
     - Real-time collision avoidance easy
     - Enables also sliding contact [Kitamura97]

►Guidelines - Select & Display

3. Interact only with *visible* objects
   - Users navigate for occluded objects [Ware97]
   - 2D view manifold
     - Ray-casting [Poup98,Bowman99]
       - 3D selection with 2D devices
4. Perspective & occlusion strongest depth cues [Wickens & Hollands 2000]
   - With no floating objects, these 2 *sufficient* to judge 3D pos!
     - Stereo *not really* necessary

►Guidelines - Position & Rotate

5. Entire area of visual overlap for object positioning
   - Not only "cursor" position
   - Area based techniques better
     - *Perceptual* evidence
     - [VIDEO]



6. Full 3D Rotations not always required
   - Objects in contact are constrained
     - Simpler UI

►Guidelines - Input & Cognition

7. 2D devices more precise/less latency than 3D/6D
   - Resolution 10-100 times better
   - Latency 40-50ms more than mouse
   - Latency and jitter matter a lot [Teather]
     - Surprisingly, effect of hand support matters less
8. 2D/2.5D tasks cognitively simpler than 3D
   - Almost all real world tasks are 2D or 2.5D

►Guidelines – General & Navigation

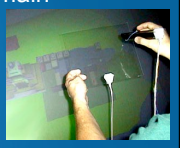
9. Simulate reality only if necessary
   - Bad if objects fall down & roll under table
   - "Stacks" are important
     - Manipulate base obj for whole stack, … [SESAME]
     - [VIDEO]
10. Navigation is rarely 6DOF
    - Walking=2.5+2DOF – 0.5 is jump/crouch
    - Flying=2+2DOF – inertia makes it simpler
    - Full 6DOF only with training!

►Summary: Two "Worlds"

2D & Constrained 3D	"Full" 3D
▪ Most human tasks ▪ Lots of experience	▪ Few human tasks ▪ Training required!
▪ Common in VR/AR ▪ Polygonal models	▪ Challenge for VR ▪ Volumetric models
▪ UI can be simplified ▪ Easy to use	▪ Needs complex UI ▪ Training necessary

►Conclusions

- Choose right approach for domain
  - E.g. Personal Interaction Panel vs. gloves



- My goal: 3D UI's close to 2D performance
  - Similar ease-of-use, ease-of-learning
  - Will greatly enhance *adoption* of 3D UI's