Interaction Techniques for Immersive Virtual Environments: Design, Evaluation, and Application

Doug A. Bowman

GVU Center, Georgia Tech

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The VE is its own UI, right?

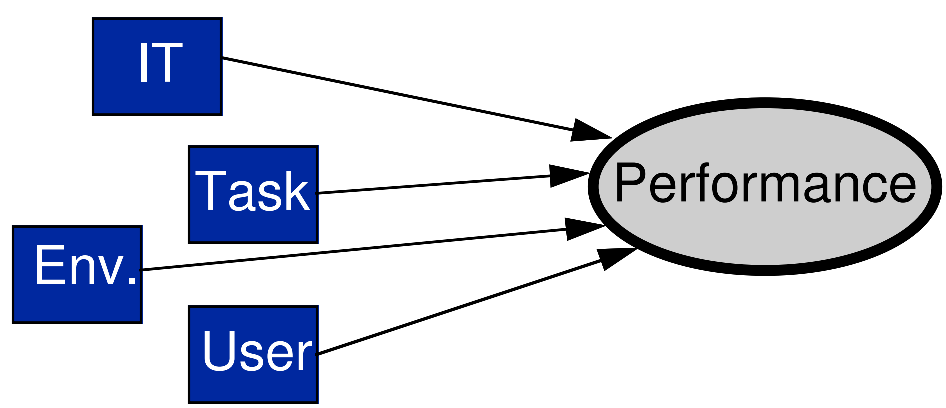
- Myth: “VEs should act like the physical world, which has no user interface.”
- Fact: This is an unrealizable and improper goal for VEs
- Useful goals:
  - user productivity
  - effective applications
  - give users new abilities

Motivation: VE Interfaces

- Technology alone is not enough
- 3D vs. 2D interaction
- Non-traditional input/output
- Imprecise technology
  - input devices (glove, joystick, trackers)
  - output devices (HMD, audio)
- Goal: usable and efficient interfaces in this problematic environment

How to evaluate ITs?

- Guideline-based evaluation
- Usability studies
- Formal experiment
- Testbed evaluation:



Tasks that need ITs

- Travel
- Object selection
- Object manipulation
- Issuing Commands
- Domain-specific tasks

Travel: "You CAN get there from here"

- Move from the current location to the desired location
- Three dimensions of a travel technique:
  - » Direction/Target Selection

    (gaze-directed, point at target, steering wheel, ...)
  - » Velocity/Acceleration Selection

    (constant vel., by gesture, foot pedals, ...)
  - » Conditions of Input

    (button to start and stop, automatic stop, continuous movement, ...)

Evaluating VE travel ITs

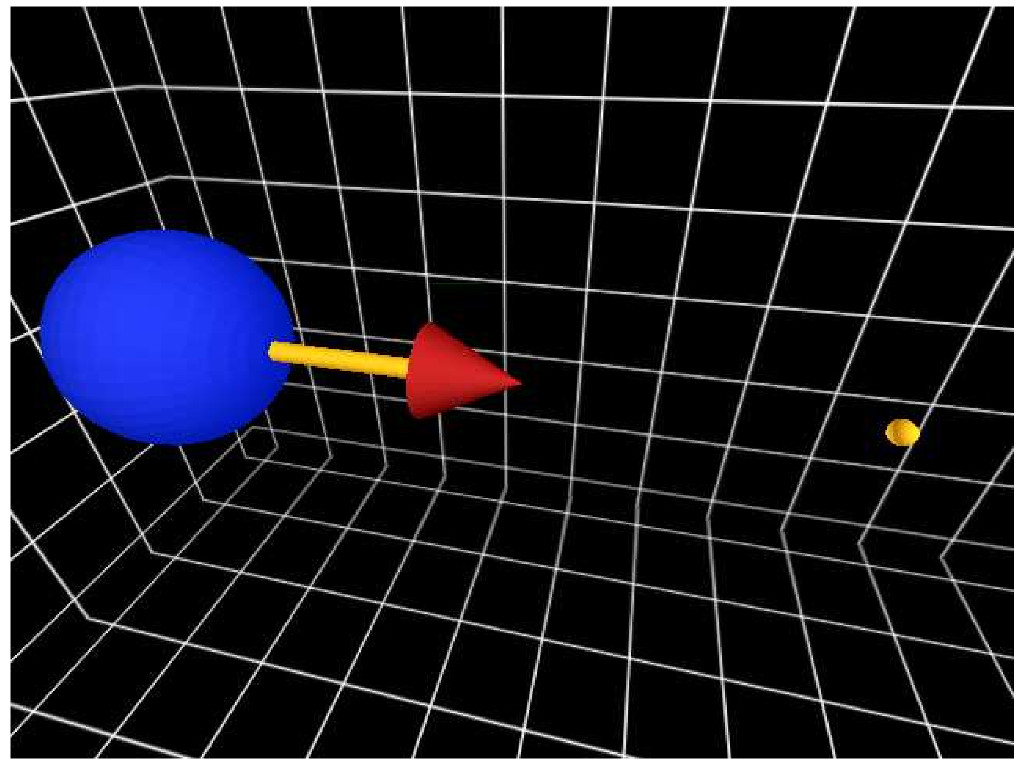
- Quantitative, statistical analysis
- Want generalizable results
- Indirect mapping:

Experiment 1: Absolute Motion

- Task: move from starting point to target
- Map direction selection technique to speed and accuracy
- Gaze-directed steering: move in direction you’re looking
- Pointing: move in direction indicated by your hand
- These are equally good for this task

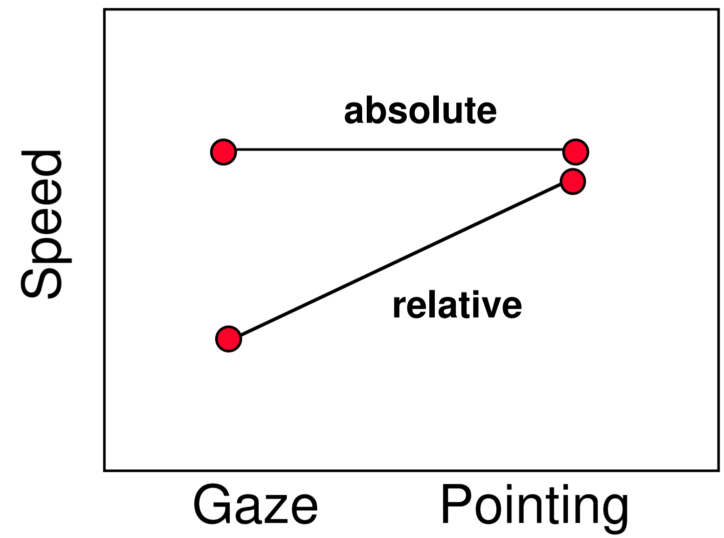
Experiment 2: Relative Motion

- Task: move to invisible target relative to an object
- Same 2 techniques
- Now pointing is superior to gaze



Problem: Dependencies

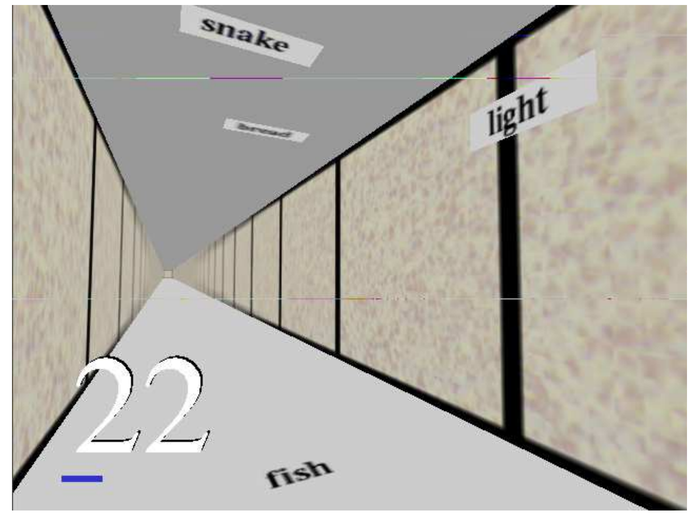
- Performance depends on both technique & task

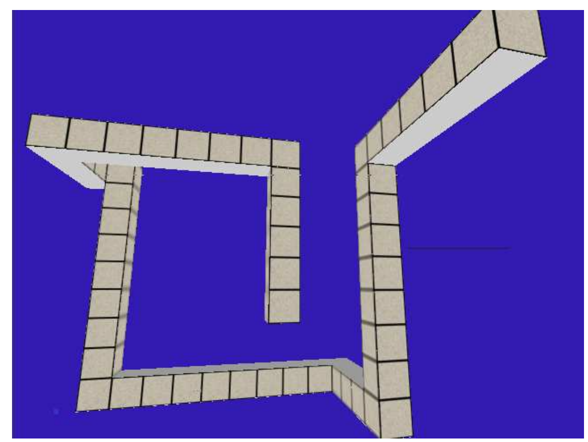


- Option 1: Evaluate within an application
- Option 2: Include other factors in performance model: testbed evaluation

Experiment 3: Info gathering

- Does travel IT affect cognitive load?
- Task: gather as much info as possible
- Variables:
  - IT: gaze, pointing, torso
  - Environment: 1-, 2-, or 3-dimensional
  - System: collision detection





Selection and Manipulation

- Choose objects and move them around
- Often viewed as one interaction, but selection can be used by itself
- IT Categories:

-arm-extension	- dollhouse
-ray-casting	- user/env. scaling
-image-plane	- indirect

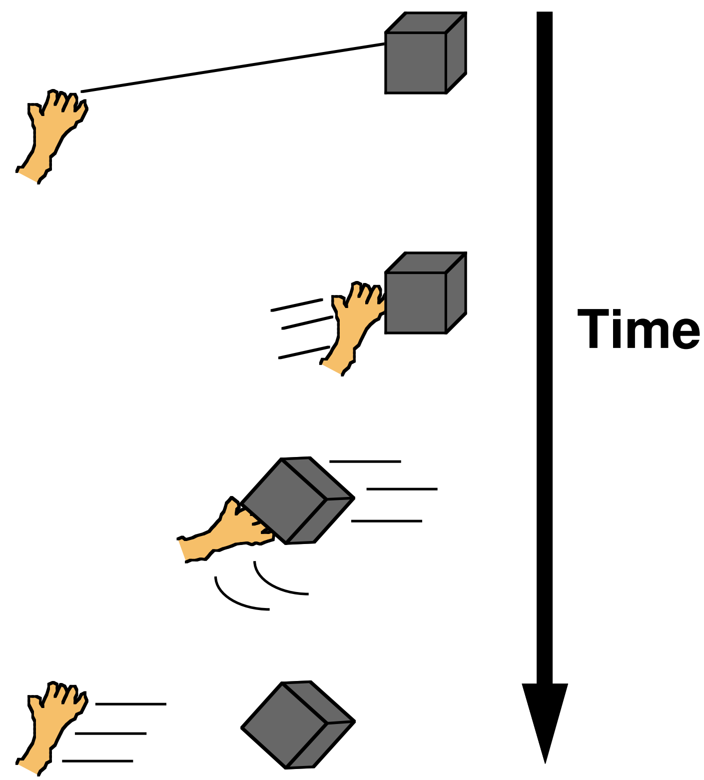
Evaluation of Selection/ Manipulation Techniques

- Informal user study
- Compare arm-extension and ray-casting
- Collect user comments, observe user performance
- No technique was a universal favorite:
  - ray-casting: ease of selection
  - arm-extension: ease of manipulation

Hybrid Technique

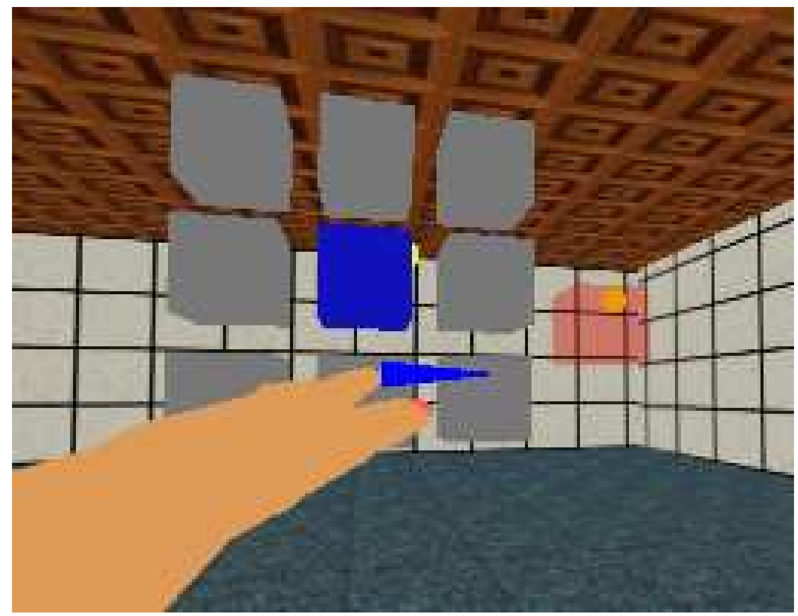
Hand-Centered
Object
Manipulation
Extending
Ray-Casting

- Select: ray-casting
- Manipulate: hand



Formal Testbed Evaluation

- Tasks that test all important aspects of a select/manip. IT
- Selection variables: distance, size, density
- Manip. variables: distance, accuracy, DOFs required

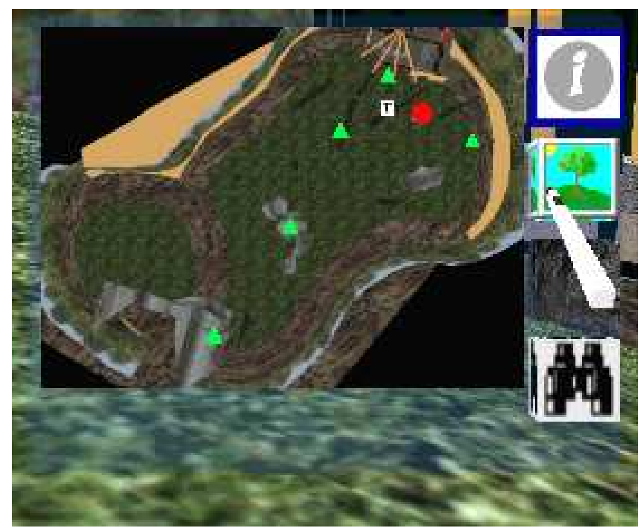


ITs for System Control

- Do VE apps really need commands?
- Not necessarily in traditional sense
- Possibly a large command space
- Alternatives:
  - voice
  - traditional UI elements: menus, tool palettes
  - “natural” metaphors

Application

- Virtual gorilla exhibit: educating children about gorillas and their behavior
- Extend to educate about zoo design
- Involves travel, selection/manip., and system control



Conclusions

- We are far from an understanding of even these few interactions
- Basic UI guidelines still apply
- Evaluation is essential
- Testbed experiments can reveal new information and help form perf. models
- VEs can be functionally complex AND usable with attention to ITs