3D User Interface Travel Techniques

Lecture #10: Travel

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Introduction

- Travel: moving from current location to new target location or in the desired direction
- Wayfinding: cognitive process of determining and following a route between an origin and destination
- Techniques classified by metaphor:
  - Walking
  - Steering
  - Selection-based travel
  - Manipulation-based travel

3D Travel Tasks

- Exploration: browsing the environment with no explicit goal for movement
- Search: traveling to a specific goal or target location
  - Naïve search: the user does not know the position of the target or path in advance
  - Primed search: the user has visited the target before or has some knowledge of its position
- Maneuvering: small precise movements

3D Travel Tasks

Additional Travel Task Characteristics

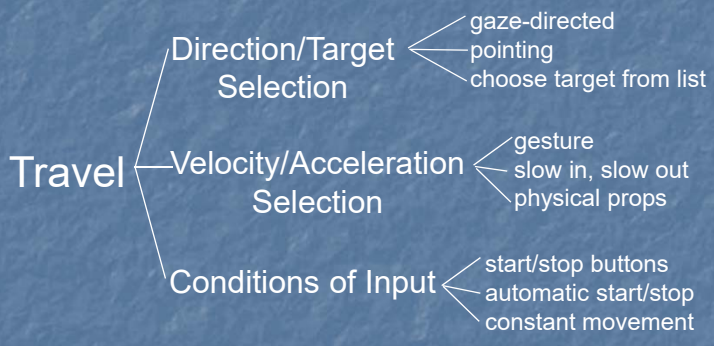
- Distance to be traveled
- Amount of curvature or number of turns in the path
- Visibility of the target from the starting location
- Number of DOF required for the movement
- Required accuracy of the movement
- Other primary tasks that take place during travel

Classifications for 3D Travel

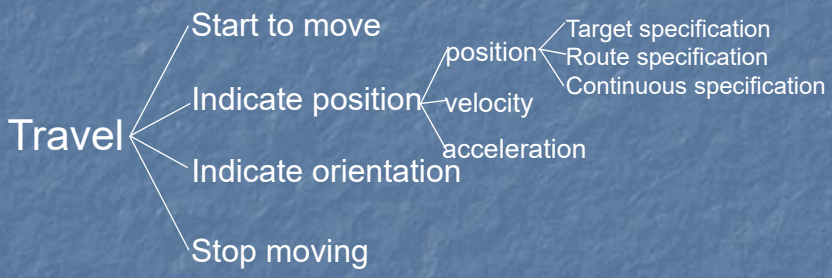
Technique Classifications

- Active versus passive
- Physical versus virtual
- Using task decomposition
- By metaphor

A Technique Classification – Component Decomposition



Alternate Technique Classification – User Control Level



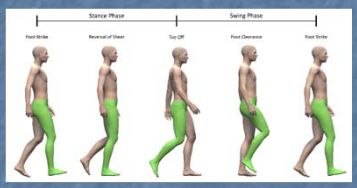
Walking Metaphors

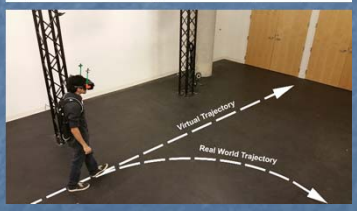
- Walking is the most natural travel technique
- But it's not always practical or feasible
  - Technological limitations
  - Space limitations
- Categories based on human gait
  - Full gait: involve biomechanics of full gait cycle
  - Partial gait: mimic only some biomechanics
  - Gait negation: negate the user's forward locomotion

Walking Metaphors

Full Gait Techniques

- Real walking
- Redirected walking
- Scaled walking

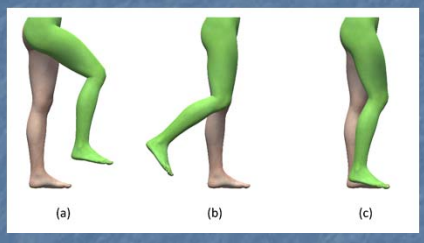




Walking Metaphors

Partial Gait Techniques

- Walking in place
- Human joystick



Walking Metaphors

Gait Negation Techniques

- Treadmills
- Passive omnidirectional treadmills
- Active omnidirectional treadmills
- Low-friction surfaces
- Step-based devices

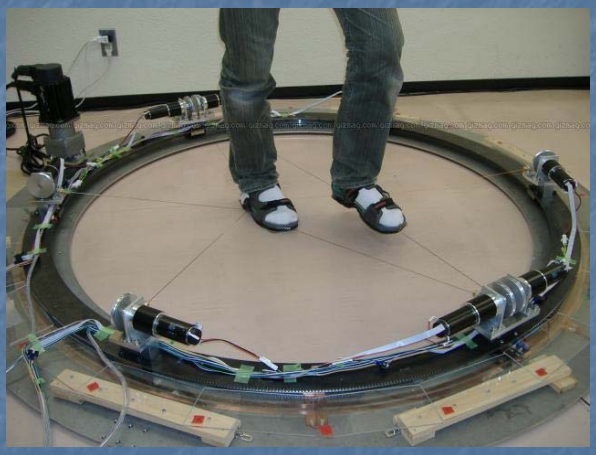
Physical Locomotion Devices

Omni-Directional Treadmill

GaitMaster II

Large Scale Tracking

Physical Locomotion Devices



String Walker

Physical Locomotion Devices

http://www.virtuix.com/

Steering Metaphors

- Most common virtual technique metaphor
- Steering refers to continuous control of the direction of motion by the user
- Travel direction is specified either
  - Through spatial interactions, or
  - With physical steering props

Steering Metaphors

Spatial Steering Techniques

- Gaze-directed
- Hand-directed (Pointing)
- Torso-directed
- Lean-directed

Steering Metaphors

Physical Steering Props

- Cockpits
- Cycles

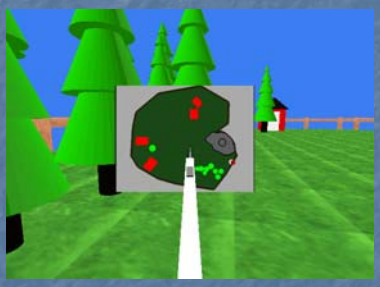
Selection-Based Travel Metaphors

- Depend on the user selecting either a target to travel to or a path to travel along
- Simplify travel by not requiring details
- Techniques take care of the actual movement
- Extremely easy to understand and use

Selection-Based Travel Metaphors

Target-Based Travel Techniques

- Representation-based
- Dual-target



Map-based Travel Implementation

- Must know
  - map scale relative to world: *s*
  - location of world origin in map CS: $o=(x_o, y_o, z_o)$
- On button press:
  - if stylus intersects user icon, then each frame:
    - get stylus position in map CS: *(x, y, z)*
    - move icon to *(x, 0, z)* in map CS

Map-Based Travel Implementation (cont.)

- On button release:
  - Get stylus position in map CS: *(x, y, z)*
  - Move icon to *(x, 0, z)* in map CS
  - Desired viewpoint: $p_v = (x_v, y_v, z_v)$ where
    - $x_v = (x - x_o)/s$
    - $z_v = (z - z_o)/s$
    - y_v = *desired height at* (x_v, y_v)
  - Move vector: $m = (x_v\text{-}x_{curr}, y_v\text{-}y_{curr}, z_v\text{-}z_{curr}) * (velocity/distance)$
  - Each frame for *(distance/velocity)* frames: translate viewpoint by *m*

Selection-Based Travel Metaphors

Route-Planning Travel Techniques

- Drawing a path
- Marking points along a path

Manipulation-Based Travel Metaphors

- Manipulate either the viewpoint or world
- Should be used when both travel and object manipulation tasks are frequent
- Ideally the same metaphor can be used for both travel and object manipulation

Manipulation-Based Travel Metaphors

Viewpoint Manipulation Techniques

- Camera manipulation
- Avatar manipulation
- Fixed-object manipulation

Manipulation-Based Travel Metaphors

World Manipulation Techniques

- Single-point world manipulation
- Dual-point world manipulation

Grabbing The Air Implementation (one-handed)

- On pinch:
  - Obtain initial hand position in world CS: (x_h, y_h, z_h)
- Each frame until release:
  - Obtain current hand position in world CS: (x'_h, y'_h, z'_h)
  - Hand motion vector: $m = ((x'_h, y'_h, z'_h) - (x_h, y_h, z_h))$
  - Translate world by m (or viewpoint by $-m$)
  - $(x_h, y_h, z_h) = (x'_h, y'_h, z'_h)$
- Cannot simply attach objects to hand – do not want to match hand rotations

Other Aspects of Travel Techniques

Viewpoint Orientation

- Head tracking
- Orbital viewing
- Nonisomorphic rotation
- Virtual sphere techniques

Other Aspects of Travel Techniques

Velocity Specification

- Discrete changes
- Continuous control
- Direct input
- Automated velocity

Other Aspects of Travel Techniques

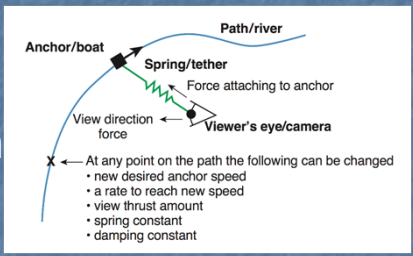
Vertical Travel

- Many techniques restrict travel to horizon
- Some techniques afford vertical travel
  - 3D steering
  - Virtual ladders
  - Virtual stairs

Other Aspects of Travel Techniques

Semiautomated Travel

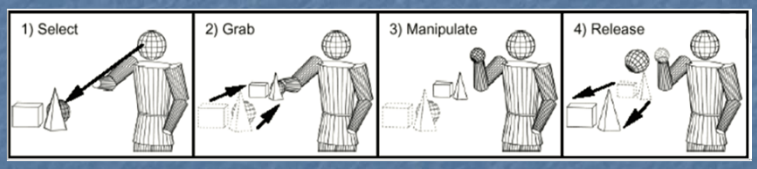
- The system provides general constraints
- The user moves within those constraints



Other Aspects of Travel Techniques

Scaling the World

- Active scaling
- Automated scaling



Other Aspects of Travel Techniques

Travel Modes

- Most techniques use a single mode for travel
- Some techniques require additional modes to transition among different travel methods
- Modes should be:
  - Well integrated to allow easy transitions
  - Clearly distinguished to avoid unintentional travel

Other Aspects of Travel Techniques

Multiple Cameras

- Most techniques use a single camera for travel
- Some techniques incorporate different perspectives of multiple cameras
- Examples:
  - Through-the-lens
  - Transitioning to remote camera feeds
  - Snapshots of augmented scenes

Other Aspects of Travel Techniques

Nonphysical Input

- Not all travel techniques require physical input
- Brain-computer interfaces (BCIs) allow for travel by thinking about moving
- These interfaces require a great deal of time to train
- Else generically trained algorithms can be unresponsive and induce false positives

Wayfinding in 3D Environments

- Cognitive aspect of navigation
- Effectiveness depends on the number and quality of the wayfinding cues or aids provided
- Two types of wayfinding aids:
  - User-centered: make use of human perception
  - Environment-centered: depend on virtual world

Wayfinding in 3DUIs

- Difficult problem
- Differences between wayfinding in real world and virtual world
  - unconstrained movement
  - absence of physical constraints
  - lack of realistic motion cues
- 3DUIs can provide a wealth of information

Wayfinding in 3D Environments

User-Centered Wayfinding Cues

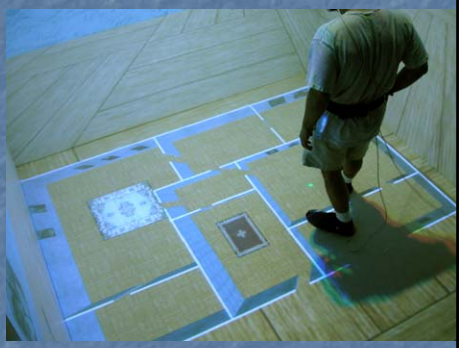
- Field of view
- Motion cues
- Multisensory output
- Presence
- Search strategies

Wayfinding in 3D Environments

Environment-Centered Wayfinding Cues

- Environment legibility
- Landmarks
- Maps
- Compasses
- Signs
- Trails
- Reference objects

Maps



Compasses

Signs

Design Guidelines

- Match the travel technique to the application.
- Consider both natural and magic techniques.
- Use an appropriate combination of travel technique, display devices, and input devices.
- Choose travel techniques that can be easily integrated with other interaction techniques in the application.

Design Guidelines

- Provide multiple travel techniques to support different travel tasks in the same application.
- Make simple travel tasks easier by using target-based techniques for goal-oriented travel and steering techniques for exploration and search.
- Use a physical locomotion technique if user exertion or naturalism is required.

Design Guidelines

- The most common travel tasks should require a minimum amount of effort from the user.
- Use high-speed transitional motions, not instant teleportation, if overall environment context is important.
- Train users in sophisticated strategies to help them acquire survey knowledge.
- If a map is used, provide a you-are-here marker.

Case Studies

VR Gaming Case Study

- Rotating bookshelf allows the user to walk between rooms
- Virtual elevators allow for vertical travel
- Key concepts:
  - Natural physical movements for navigation can enhance the sense of presence.
  - Even with a limited tracking area, consider ways to allow and encourage the use of a physical walking metaphor.
  - If the application allows, use story elements to help users make sense of travel techniques.

Case Studies

Mobile AR Case Study

- Uses a multi-camera navigation system
- Interface shows camera viewpoints with regularly updated thumbnails of their video footage
- Variable perspective visualization blends first-person and remote viewpoints together
- Key concepts:
  - Creating a good mental map of the observed environment is crucial to adequately making use of the augmented information within.
  - The use of multi-camera systems can help by providing an overview and resolving occlusions.

Conclusion

- 3D travel is another foundational task
- Physical and virtual travel approach have various tradeoffs
- Wayfinding affects navigation in 3D UIs
- Design your virtual world to provide sufficient environment-based wayfinding cues

Next Class

- System Control
- Readings
  - 3DUI Book – Chapter 8