3D User Interface Travel Techniques

Lecture #9: Navigation I – Travel
Spring 2009
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Universal 3D Interaction Tasks

- Navigation
  - Travel – motor component
  - Wayfinding – cognitive component
- Selection
- Manipulation
- System control
- Symbolic input
Travel

- The motor component of navigation
- Movement between 2 locations, setting the position (and orientation) of the user's viewpoint
- The most basic and common VE interaction technique, used in almost any large-scale VE

Travel Tasks

- Exploration
  - travel which has no specific target
  - build knowledge of environment
- Search
  - naive: travel to find a target whose position is not known
  - primed: travel to a target whose position is known
  - build layout knowledge; move to task location
- Maneuvering
  - travel to position viewpoint for task
  - short, precise movements
Travel Characteristics

- Travel distance
- Amount of curvature/number of turns in path
- Target visibility
- DOF required
- Accuracy required
- Other tasks during travel
- Active vs. passive
- Physical vs. virtual

A Technique Classification – Component Decomposition

- Travel
  - Direction/Target Selection
  - Velocity/Acceleration Selection
  - Conditions of Input

- Conditions of Input:
  - gaze-directed
  - pointing
  - choose target from list
- gesture
  - slow in, slow out
  - physical props
- start/stop buttons
  - automatic start/stop
  - constant movement
Alternate Technique Classification
- User Control Level

Travel Techniques
- Physical locomotion ("natural" metaphors)
- Steering techniques
- Route planning
- Target-based techniques
- Manual manipulation
- Viewpoint orientation techniques
Physical Locomotion Techniques

- **Walking techniques**
  - large-scale tracking
  - Walking in place (GAITER)
- **Treadmills**
  - single-direction with steering
  - omni-directional
- **Bicycles**
- **Other physical motion techniques**
  - VMC / Magic carpet
  - Disney’s river raft ride

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Physical Locomotion Devices (I)

- Omni-Directional Treadmill
- GaitMaster II
- Large Scale Tracking
Physical Locomotion Devices (II)

String Walker

Steering Techniques

- continuous specification of direction of motion
  - gaze-directed
  - pointing
  - torso-directed
  - camera-in-hand
  - semi-automated
  - physical device (steering wheel, flight stick)
Steering – Gaze-Directed

- Move viewpoint in direction of “gaze”
- Gaze direction determined from head tracker
- Cognitively simple
- Doesn’t allow user to look to the side while traveling

Steering – Gaze-Directed Implementation

- Each frame while moving:
  - Get head tracker information
  - Transform vector \([0, 0, -1]\) in head CS to \(v = (x, y, z)\) in world CS
  - Normalize \(v\): \(\hat{v} = \frac{v}{\|v\|}\)
  - Translate viewpoint by \((\hat{v}_x, \hat{v}_y, \hat{v}_z) \times \text{current\_velocity}\)
Pointing Technique

- Also a steering technique
- Use hand tracker instead of head tracker
- Slightly more complex, cognitively
- Allows travel and gaze in different directions – good for relative motion

Pointing Implementation

- Each frame while moving:
  - Get hand tracker information
  - Transform vector \([0,0,-1]\) in hand CS to \(v=[x,y,z]\) in world CS
  - Normalize \(v\): \(\hat{v} = \frac{v}{\|v\|}\)
  - Translate viewpoint by \((\hat{v}_x, \hat{v}_y, \hat{v}_z) \times \text{current\_velocity}\)
Semi-Automated Travel

- Example - Galyean’s river analogy (1995)

![Diagram of river analogy with anchor/boat, spring/tether, force attaching to anchor, viewer's eye/camera, and path/river.]

- at any point on the path the following can be changed:
  - new desired anchor speed
  - rate to reach new speed
  - view thrust amount
  - spring constant
  - damping constant

Route-Planning

- one-time specification of path
  - draw path
  - points along path
  - manipulating user representation

![Route-Planning interface with path and user interface elements.]

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Target-Based Techniques

- discrete specification of goal
  - point at object
  - choose from list
  - enter coordinates
- Map/WIM-based target specification

Map-Based Travel Technique

- User represented by icon on 2D map
- Drag icon with stylus to new location on map
- When released, viewpoint animated smoothly to new location
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
    - $x_v = (x - x_o)/s$
    - $z_v = (z - z_o)/s$
    - $y_v = \text{desired height at } (x_v, y_v)$
  - Move vector: $m = (x_v-x_{curr}, y_v-y_{curr}, z_v-z_{curr}) \times (\text{velocity/distance})$
  - Each frame for $(\text{distance/velocity})$ frames: translate viewpoint by $m$
Manual Manipulation – Grabbing the Air Technique

- Use hand gestures to move yourself through the world
- Metaphor of pulling a rope
- Often a 2-handed technique
- May be implemented using Pinch Gloves™

Grabbing The Air Implementation (one-handed)

- On pinch:
  - Obtain initial hand position in world CS: \((x_p, y_p, z_p)\)
- Each frame until release:
  - Obtain current hand position in world CS: \((x'_h, y'_h, z'_h)\)
  - Hand motion vector: \(m = ((x'_h, y'_h, z'_h) - (x_p, y_p, z_p))\)
  - 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
Viewpoint Orientation Techniques

- Head tracking
- Orbital viewing
- Non-isomorphic rotation
- Virtual sphere

Next Class

- Navigation – Wayfinding
- Readings
  - 3DUI Book – Chapter 6