CSE 165: 3D User Interaction

Lecture #7:
Input Devices Part 2

Announcements

- Homework Assignment #2
  - Due tomorrow at 2pm
  - Sony Move check out
- Homework discussion
  - Monday at 6pm

Input Devices

Application-Specific Devices

- Virtual hang-gliding over Rio de Janeiro (L. Soares at. al.)
- Virtual canoe, Siggraph 2005
  - Real-time water simulator with pre-computed 3D fluid dynamics
  - Creates realistic wakes and force feedback of water resistance

Cave Painting

- Physical props (brush, color palette, bucket) allow intuitive painting
- System created by Daniel Keefe at Brown University (now Prof. at Univ. of Minnesota)

Cave Painting Video

- http://www.youtube.com/watch?v=WQv-LnHrmwU

3D Input Devices for Games

Nintendo Wiimote

PlayStation Move

Microsoft Kinect

Leap Motion

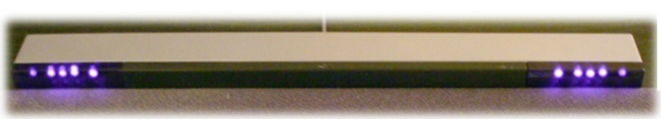
Razer Hydra

The Wiimote

- Uses Bluetooth for communication
- Senses acceleration along 3 axes
  - Used for sports games (tennis, bowling, etc.)
- 128x96 pixel monochrome camera with built-in image processing, requires sensor bar
  - Enables 2D on-screen pointer
- Standard buttons and trigger
- Provides audio and rumble feedback
- Up to 4 Wiimotes can be active simultaneously
- Connector for attachments
  - Nunchuck
  - Wii Zapper
  - Wii Wheel

Wii Wheel

Wii Zapper



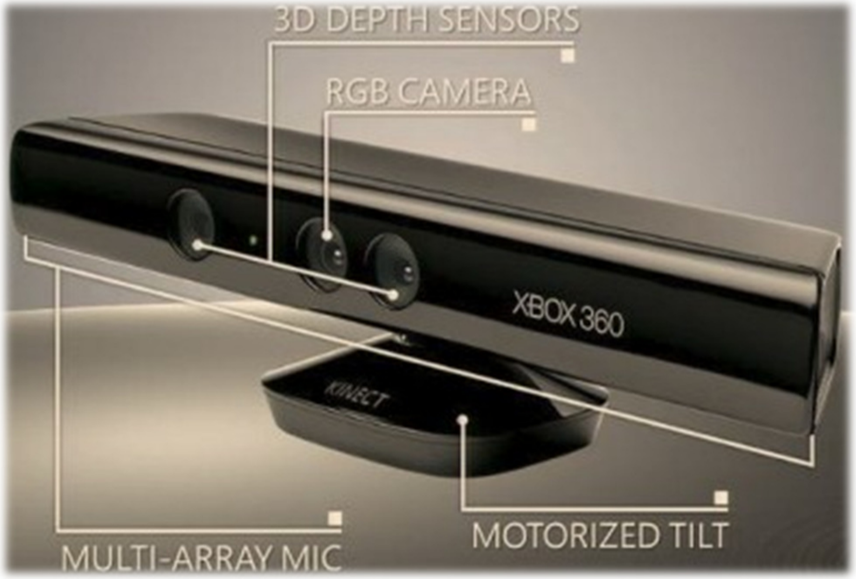
Sensor Bar

The Wii Motion Plus

- Initially (June 2009) optional add-on, later built-in
- Uses 3-axis gyroscope
- Captures relative 3D orientation
- Improves pose and motion estimation
- Information captured by gyroscope can be used to distinguish true linear motion from accelerometer readings

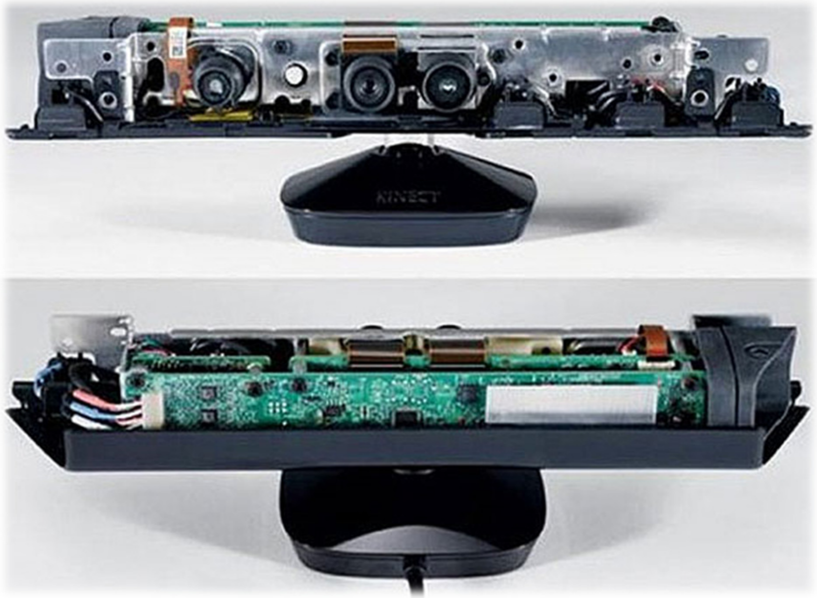
Microsoft Kinect

- Microsoft sold 8 million units in first 60 days on market
  - Guinness World Record for "fastest selling consumer electronics device"
- Kinect features
  - RGB camera
  - Depth sensor
  - Microphone array
  - Motorized tilt
  - Connects via USB
- Enables controller-less user interface
- Full body tracking possible
- 2 versions:
  - Xbox (~$100)
  - Windows PC (~$200)



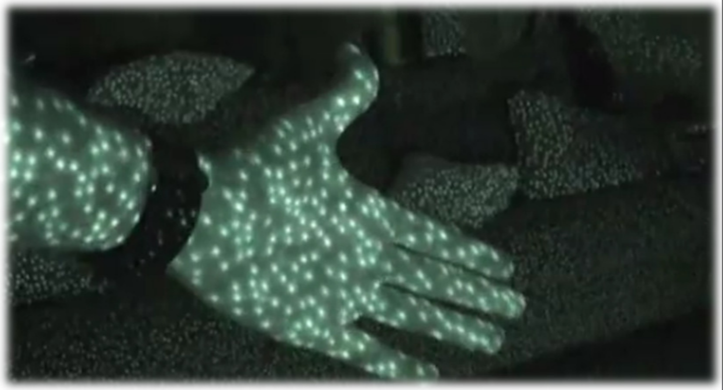
Kinect – Hardware Details

- RGB Camera
  - 640 x 480 RGB pixels at 30Hz
- Depth Sensor
  - 640 x 480 monochrome pixels with 11-bit depth CMOS sensor at 30 Hz
  - Field of view: 57 ° horizontally, 43° vertically
  - Infrared laser projector
  - 4-11 feet range, down to 16 inches in near mode (Windows version only)
- Multi-array mic
  - Four microphones
  - Multi-channel echo cancellation
  - Sound position tracking
- Motorized tilt
  - 27° up or down



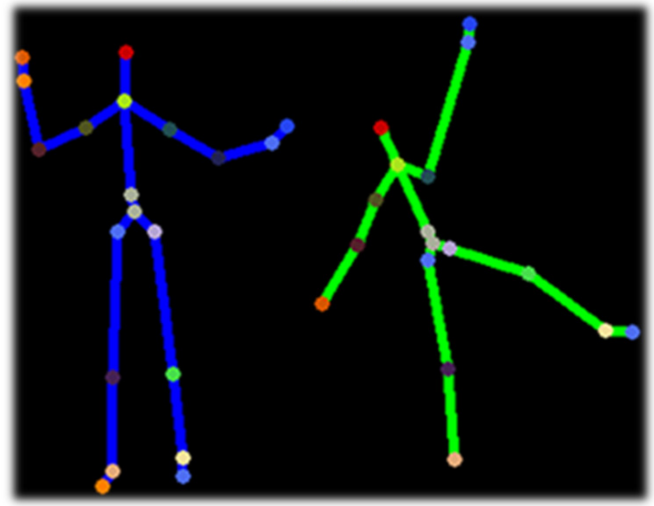
www.hardwaresphere.com

Kinect – Extracting 3D Depth



- Infrared laser projector emits known dot pattern
- CMOS sensor reads depth of all pixels
- Finds location of dots
- Computes depth information using stereo triangulation
  - Normally needs two cameras
  - Laser projector acts as second camera
- Depth image generation

Kinect – Skeleton Tracking



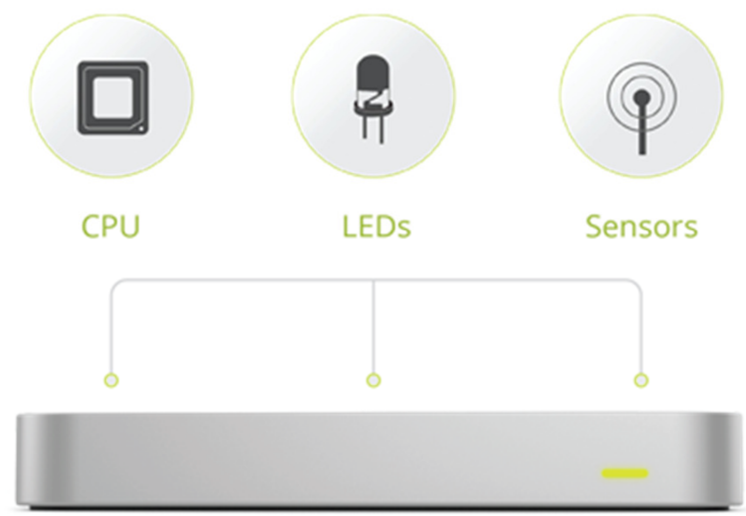
- Combines depth information with human body kinematics
  - 20 joint positions
- Object recognition approach
  - per pixel classification
  - decision forests (GPU)
  - millions of training samples

Leap Motion

- http://www.youtube.com/watch?v=_d6KuiuteIA

Leap Motion Overview

- Released July 2013
- Small form factor (3 x 1.2 x 0.5 inches)
- Short range finger tracking
  - No access to depth map
- Two IR cameras + optimized image processing
- Inexpensive (~$70)
- Drivers for Windows and Mac OS
- Well documented SDK

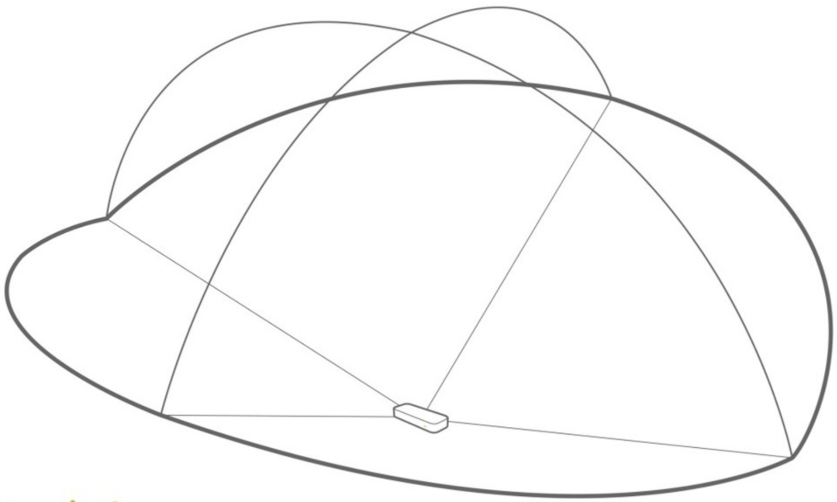


Leap Technology

- 8 cubic feet of interactive space
- 2 cameras
- 3 IR LEDs
- 850 nm wavelength (invisible for the eye)

Leap Tracking

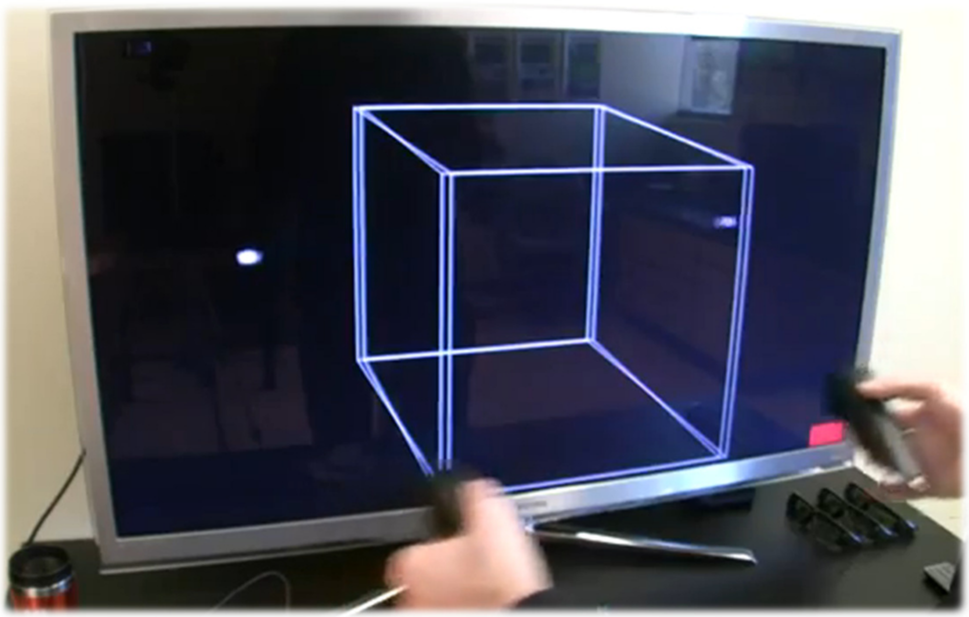
- USB controller reads sensor data into own local memory and performs resolution adjustments
- This data is streamed via USB to Leap Motion tracking software
- Images appear in grayscale
  - Intense sources or reflector of infrared light can make hands and fingers hard to distinguish and track



Interaction Area
2 feet above the controller, by 2 feet wide on each side (150° angle), by 2 feet deep on each side (120° angle)

Razer Hydra Video

- Razer Hydra for low-cost 3D displays
  - By Oliver Kreylos, UCD
  - http://www.youtube.com/watch?v=H5bSzVByLjM



Razer Hydra

- Developed by Sixense Entertainment
- Released June 16, 2011
- Tracks absolute position and orientation (6 DOF)
  - Precision: 1mm and 1 degree
- Uses a weak electro-magnetic field
- Two wired input devices

STEM

- Wireless motion tracking
- Five tracking points
- Allows tracking of all four limbs plus the head – or any other configuration
- Optimized performance from the desktop to the living room, with an 8-foot radius (16-foot diameter) range from the Base
- Backward compatibility via the Sixense SDK: uses an updated version of the Sixense SDK that also supports games and applications developed for the Razer Hydra.

STEM Distortion Correction

- Electro-magnetic fields get distorted by metal in the environment
- This can be counteracted by calibration and software
  - https://www.youtube.com/watch?v=y8e2LPfMGvI

Myo

- Gesture control armband
- Expandable circumference
- Weight: 93 grams
- Thickness: 0.45 inches
- Bluetooth 4.0
- EMG muscle sensors
- Motion sensor
- Haptic feedback (vibration)
- $199

Playstation Move

- http://www.youtube.com/watch?v=hTKpgSpq-8o

PlayStation Move

- Consists of
  - PlayStation Eye camera
  - up to 4 motion controllers
  - Cost for Eye + 1 controller: ~$50
- Features
  - Combines camera tracking with motion sensing
  - 6 DOF tracking (position and orientation)
  - Several buttons on front of device
  - Analog button on back of device
  - Vibration feedback
  - Wireless and USB connectivity

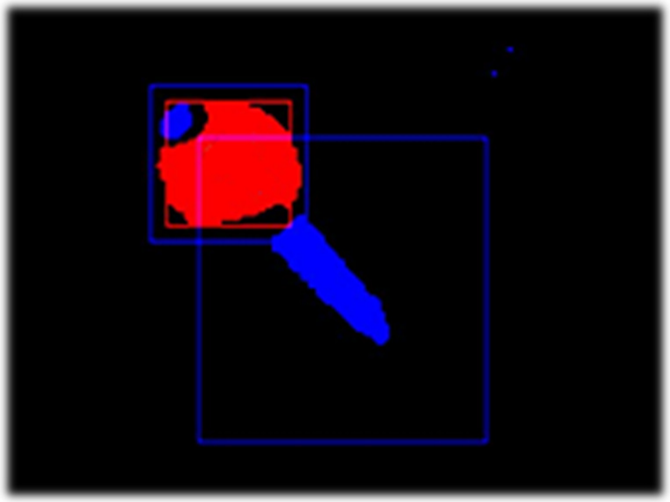
PlayStation Move – Hardware

- PlayStation Eye
  - 640 x 480 (60Hz)
  - 320 x 240 (120Hz)
  - Microphone array (4 mics)
- Move Controller
  - 3-axis accelerometer
  - 3-axis gyroscope
  - Magnetometer: helps to calibrate and correct for drift
  - 44mm diameter sphere with RGB LEDs
    - Used for position tracking
    - Invariant to rotation
    - Provides own light source
    - Color ensures visual uniqueness

www.hardwaresphere.com

PlayStation Move – 6 DOF Tracking

- Image Analysis
  - Find sphere in image with segmentation algorithm
  - Given known focal length and measured size of sphere in image, calculate 3D position
- Sensor Fusion
  - Combines results from image analysis with inertial sensors
    - Accelerometer
      - Gives pitch and roll angles when controller is stationary
      - Gives controller acceleration when orientation is known
    - Gyroscope
      - Measures angular velocity and acceleration



Move Buttons

- Four buttons (Square, Triangle, Cross, Circle) on front
- Two buttons (Select on left, Start on right) on sides
- Big Move button front center
- Small PS button on front with PlayStation Logo
  - Used as power button to switch on the controller
  - Holding it for about 10 seconds will turn off the controller
    - cannot be overwritten by software
- Trigger button on back, can be used as
  - a digital button
  - an analog button with an 8-bit value

Move – Controller

- Accelerometer (16 bit)
  - Kionix KXSC4 10227 2410 (3-axis)
- Gyroscope (16 bit)
  - 2 chips: one for x and y (STM LPR425AL), one for z axis (Y5250H 2029 K8QEZ)
- Magnetometer (12 bit)
  - AKM AK8974 magnetic compass
  - helps to calibrate and correct for drift
- Temperature sensor
- Microcontroller (STM32F103VBT6)
- Bluetooth module (Cambridge Silicon Radio BC4RE), sending 60 updates/sec
- Mini USB connector
- 44mm diameter sphere with RGB LEDs
  - Used for position tracking
  - Invariant to rotation
  - Provides own light source
  - Color ensures visual uniqueness

www.hardwaresphere.com

Move - Camera

- PlayStation Eye
  - 640 x 480 (60Hz)
  - 320 x 240 (120Hz)
  - Microphone array (4 mics)
  - Manual exposure control

Move – 6 DOF Tracking

- Image Analysis
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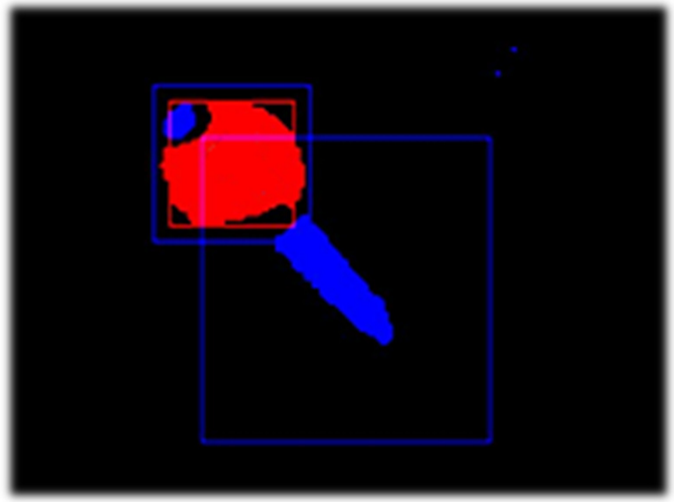


Navigation

Wayfinding – Cognitive Component

Travel – Motor Component

Wayfinding

- Cognitive process of defining a path through an environment
  - use and acquire spatial knowledge
  - aided by natural and artificial cues
- Common activity in our daily lives
- Often unconscious activity (except when we are lost)

Information for the Wayfinding Task

- Landmarks
- Signs
- Maps
- Directional information

Transferring Spatial Knowledge

- Want to transfer knowledge to the real world
  - training
  - planning
- Navigation through complex environments to support other tasks

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 and Travel

- Exploration
  - browsing environment
  - useful in building cognitive map
- Search
  - spatial knowledge acquired and used
  - naïve search – not enough info in cognitive map
  - primed search – use of cognitive map defines success
- Maneuvering
  - uses very little of cognitive map

Wayfinding and Spatial Knowledge

- Landmark knowledge
  - visual characteristics of environment
  - shape, size, and texture
- Procedural knowledge
  - sequence of actions required to follow a path
  - requires sparse visual information
- Survey knowledge
  - topographical knowledge
  - object location/distance/orientation

Egocentric and Exocentric Reference Frames

- Egomotion – feeling we are the center of space
- Egocentric – first person
  - relative to human body
- Exocentric – third person
  - relative to world
- Build up exocentric representation of world
  - survey knowledge
- Use egocentric when exploring for first time
  - landmark/procedural knowledge

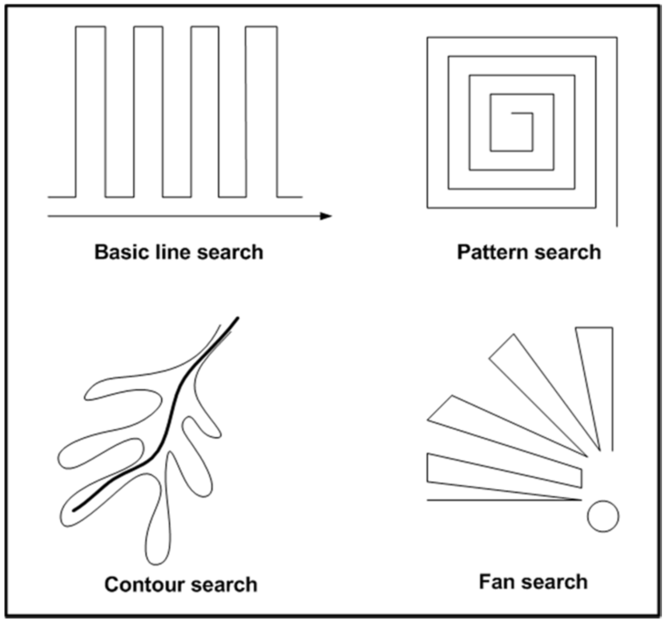
User-Centered Wayfinding Support (1)

- Field of view
  - small FOV can inhibit wayfinding
    - user requires repetitive head movements
    - lack of optical flow in periphery
- Motion cues
  - enable judgment of depth and direction
  - supports backtracking of user's own movement
  - cue conflicts can hinder cognitive map development
- Multisensory Output
  - audio
  - Tactile maps

Tactile Map

User-Centered Wayfinding Support (2)

- Presence (feeling of "being there")
  - assumed to have impact on spatial knowledge
  - closer to real world
- Search strategies



3D UI With the Leap

- Selection
  - Hover w/timeout
  - Trigger with non-dominant hand gesture
  - Two finger near-pinch
- Manipulation
  - Hand orientation
  - 3-finger orientation
  - 2-finger orientation (2 DOF)

Menus

- Hover over buttons
- Leap API-Supported gestures:
  - Rotate
  - Swipe

General Tips

- Finger pinches hard to detect
- More than 3 fingers hard to distinguish
- Fingers hard to distinguish when hand not close to horizontal
- Hand detection (left/right): need to bring hands into FOV from back edge
- Options for camera motion: rotate around circle, set with non-dominant hand, map orientation of non-dominant hand

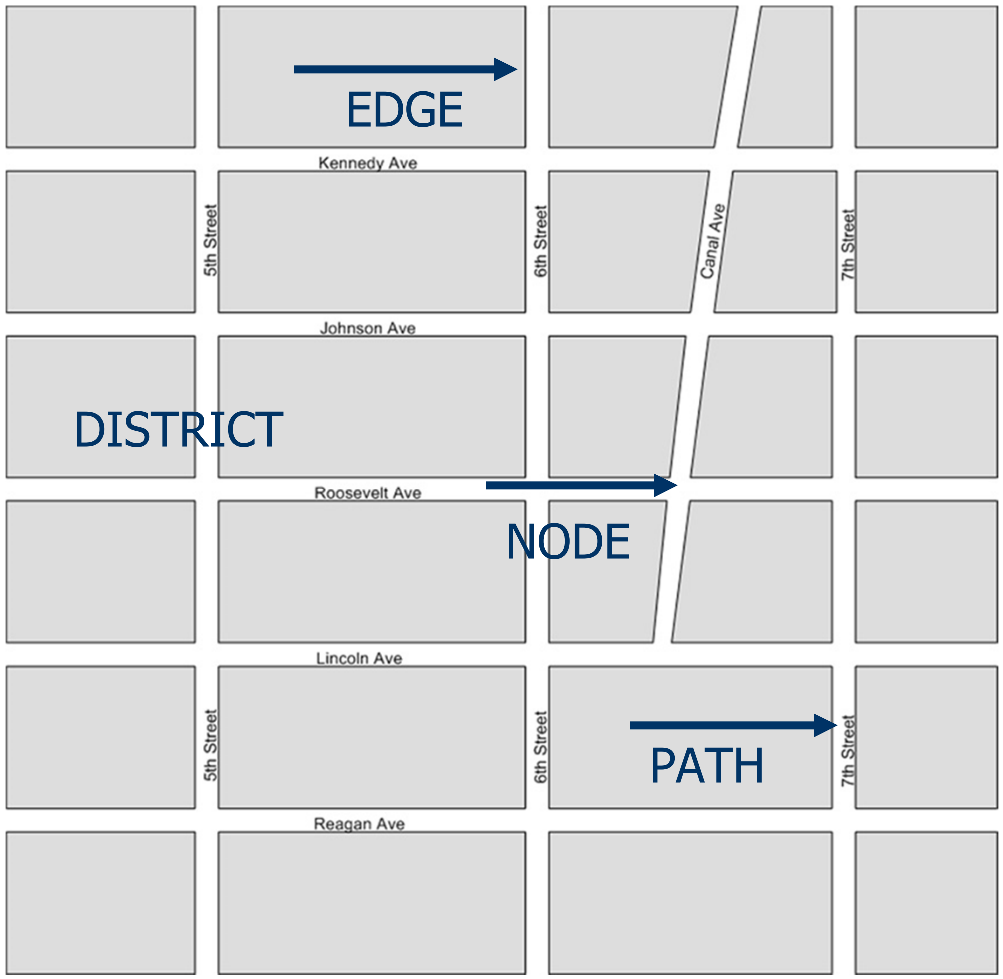
Environment-Centered Wayfinding Support

- Environmental design
- Artificial aids

Environmental Design (1)

- World’s structure and format can aid in wayfinding
- Legibility techniques
  - divide large scale environment into parts with distinct character
  - create simple spatial organization
  - include directional cues to support egocentric/exocentric reference frames
  - often repetitive

Environmental Design (2)



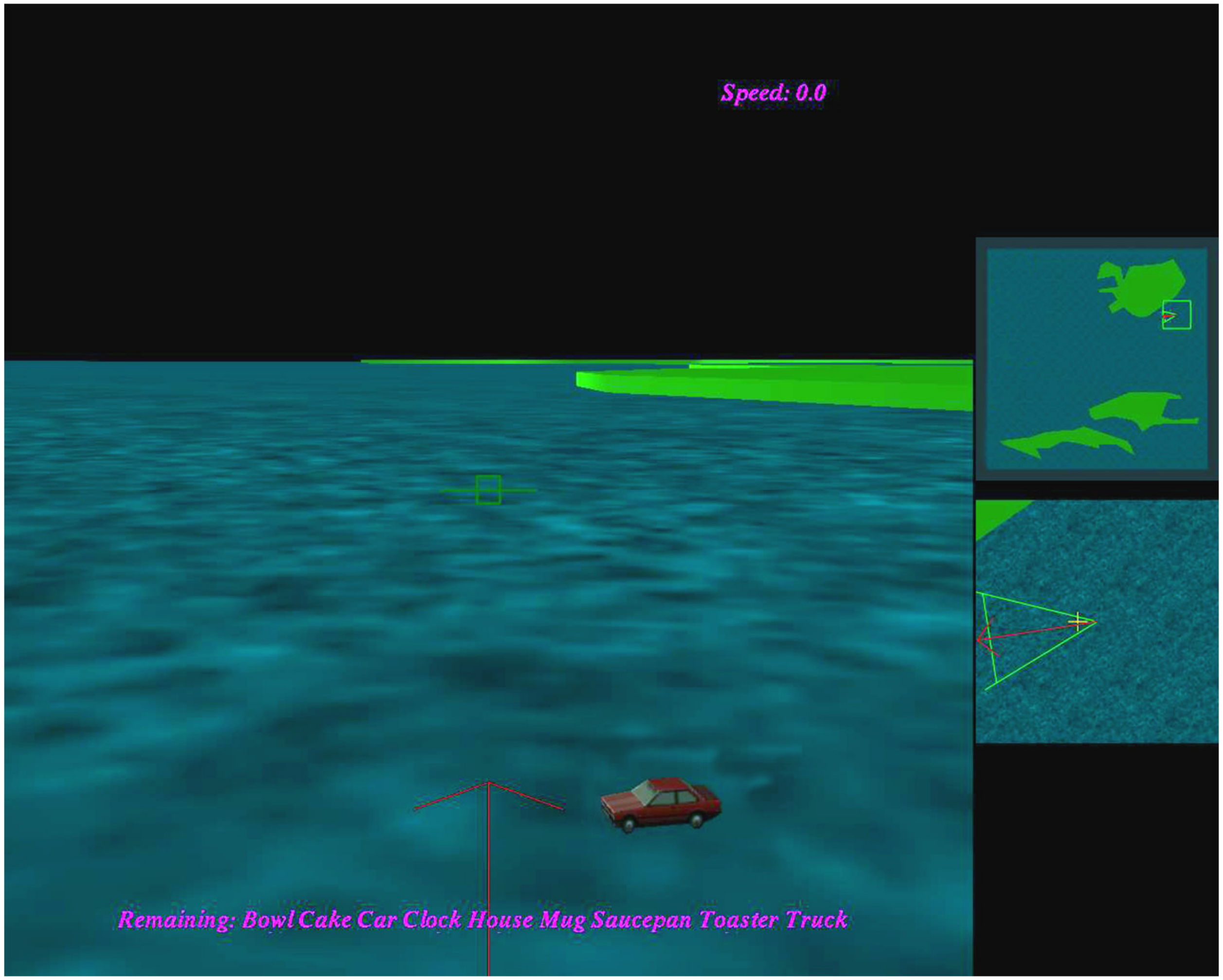
Environmental Design (3)

- Natural environment
  - horizon, atmospheric color, fog, etc…
- Architectural design
  - lighting
  - closed and open spaces
- Color and texture

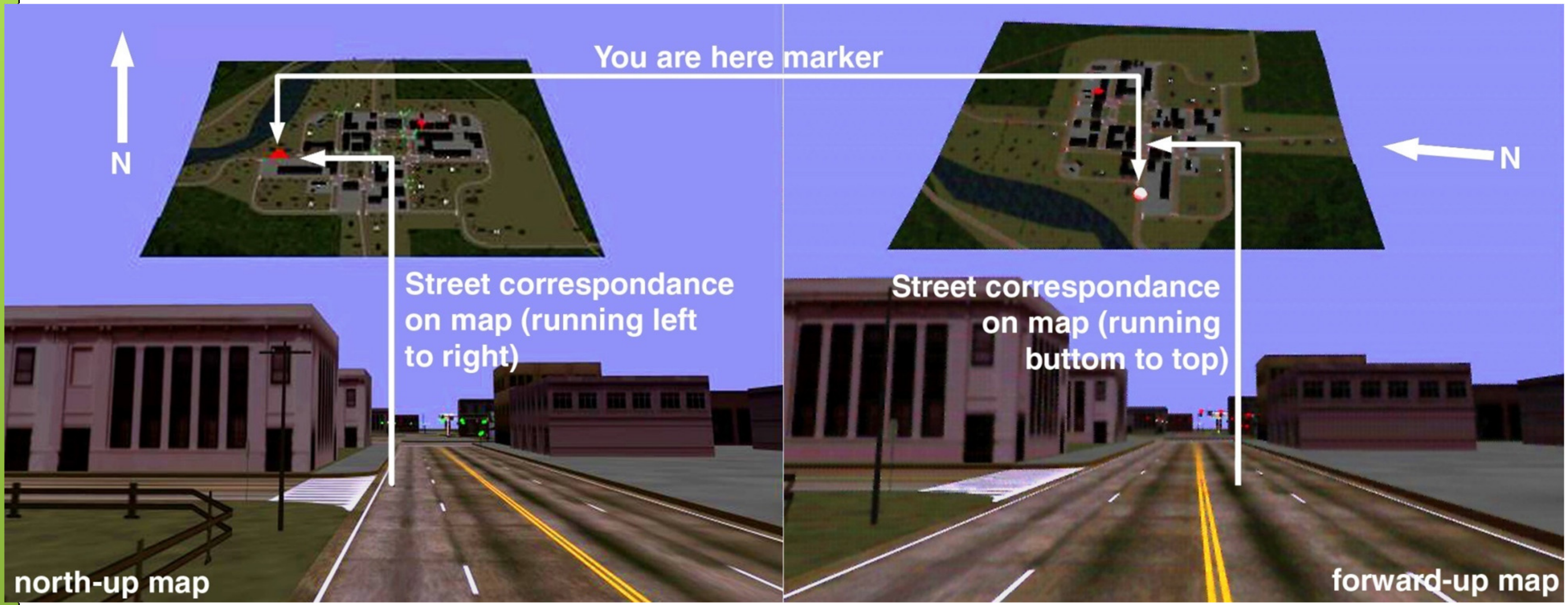
Artificial Cues

- Maps
- Compasses
- Signs
- Reference objects
- Artificial landmarks
- Trails

Maps (1)

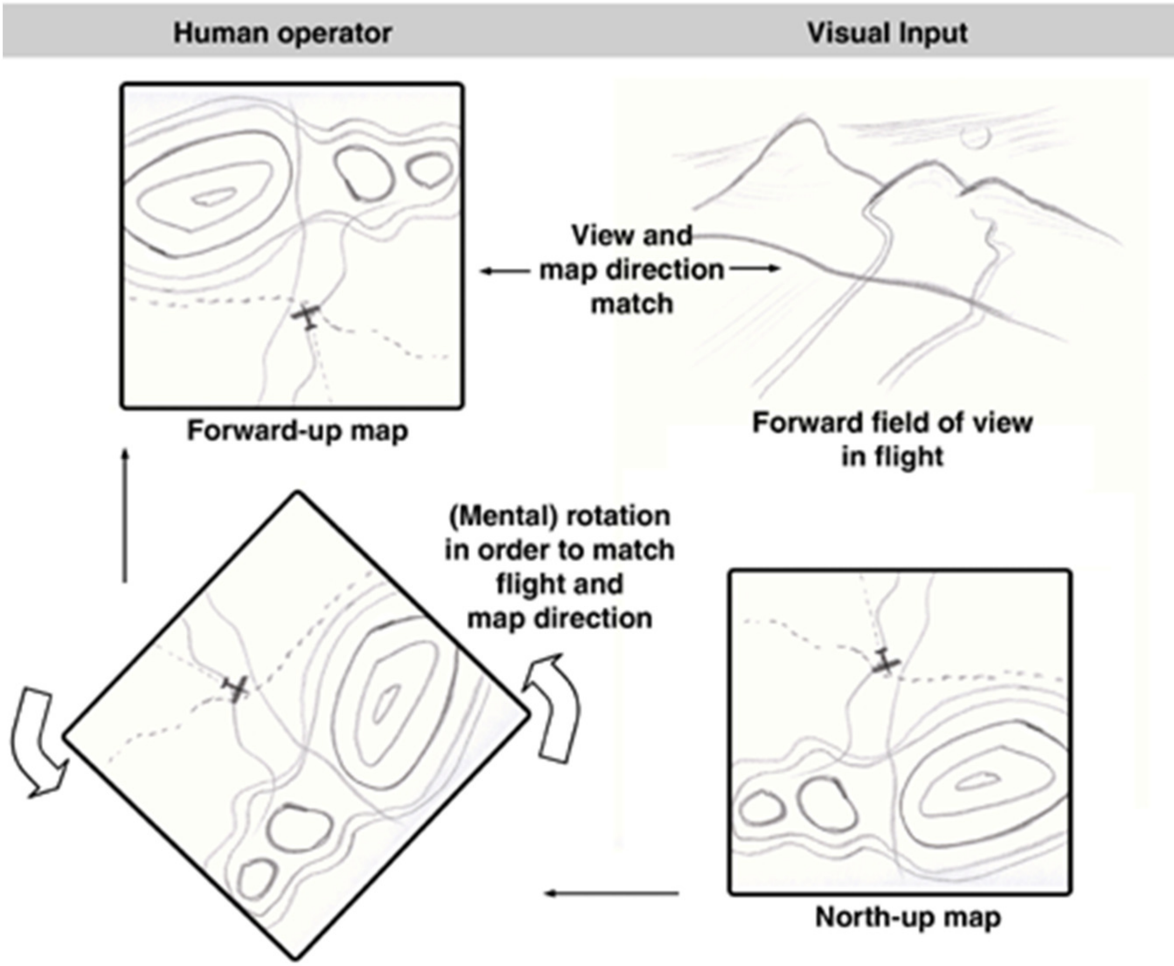

Speed: 0.0
Remaining: Bowl Cake Car Clock House Mug Saucepan Toaster Truck

Maps (3)

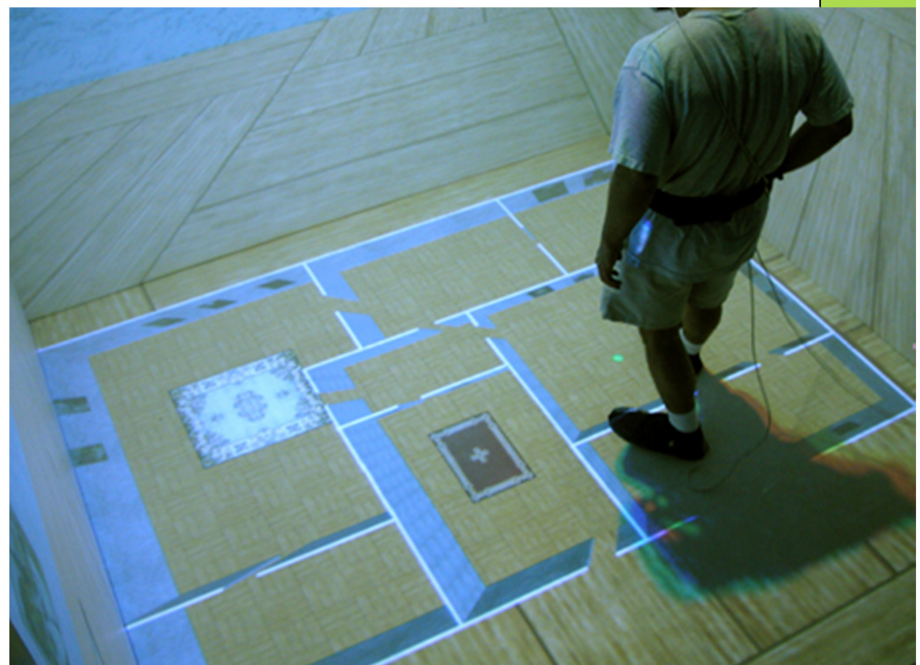


You are here marker
N
N
Street correspondance
on map (running left
to right)
Street correspondance
on map (running
buttom to top)
north-up map
forward-up map

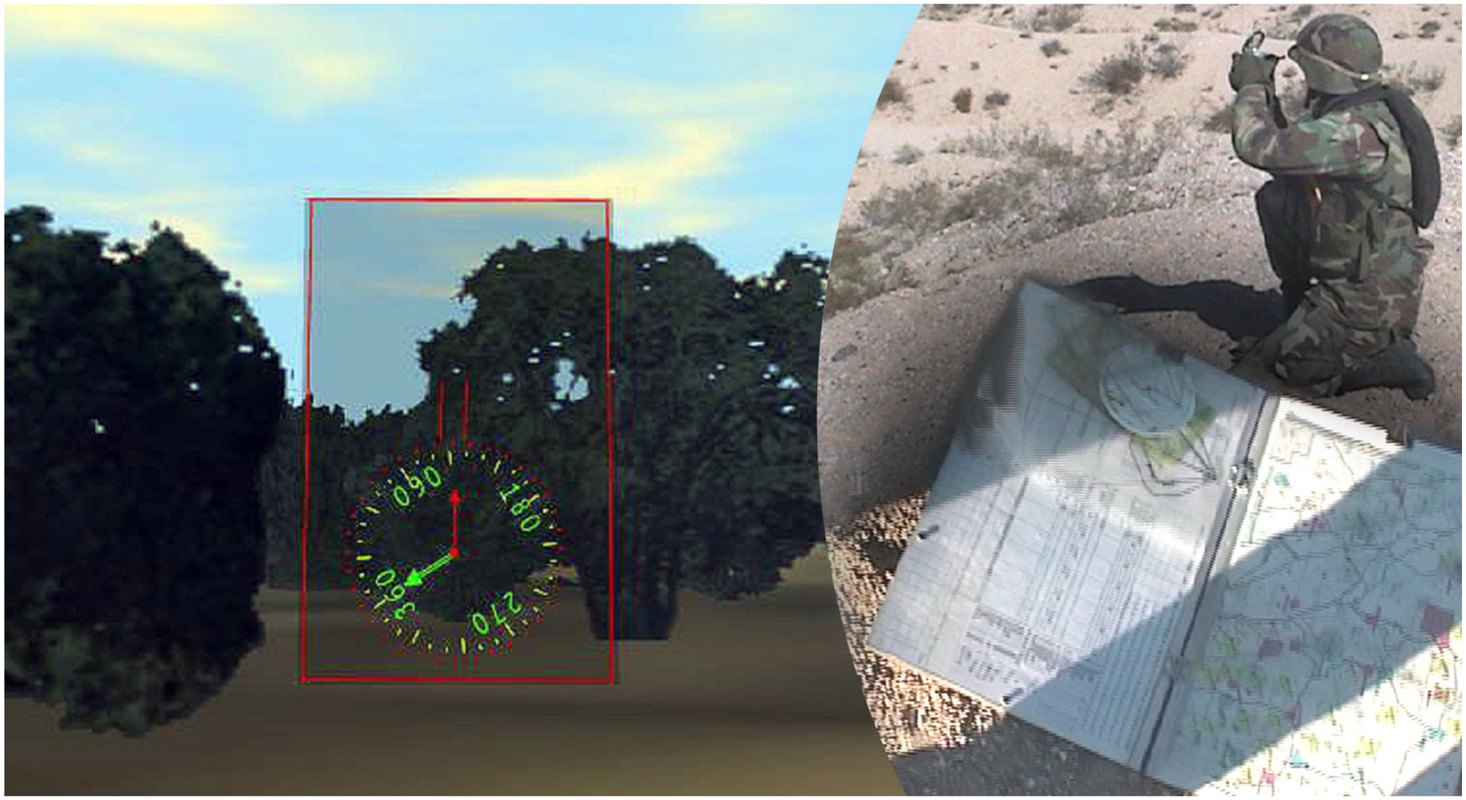
Maps (2)


Human operator
Visual Input
View and
map direction
match
Forward-up map
Forward field of view
in flight
(Mental) rotation
in order to match
flight and
map direction
North-up map

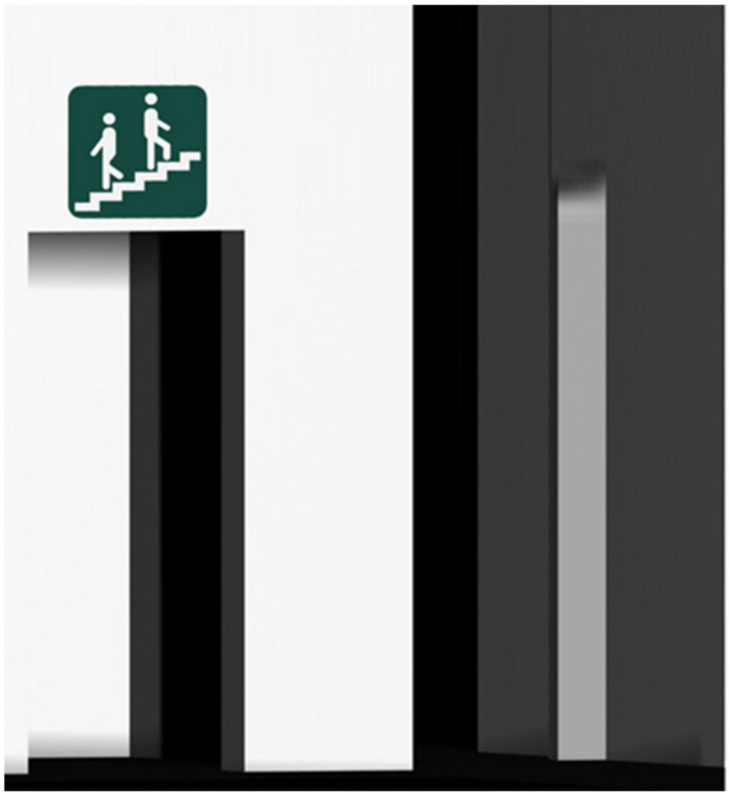
Maps (4)



Compasses



Signs



Reference Objects

- Objects that have well known size
  - chair, human figure, etc…
- Useful to estimate distances

Artificial Landmarks

- Local – help users in decision making processes
- Global – seen from any location

Trails

- Help user retrace steps
- Show what parts have been visited

Navigation

Wayfinding – Cognitive Component

Travel – Motor Component

Travel

- The motor component of navigation
  - Good travel techniques integrate aids to wayfinding
- Movement between two 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
  - naïve: 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

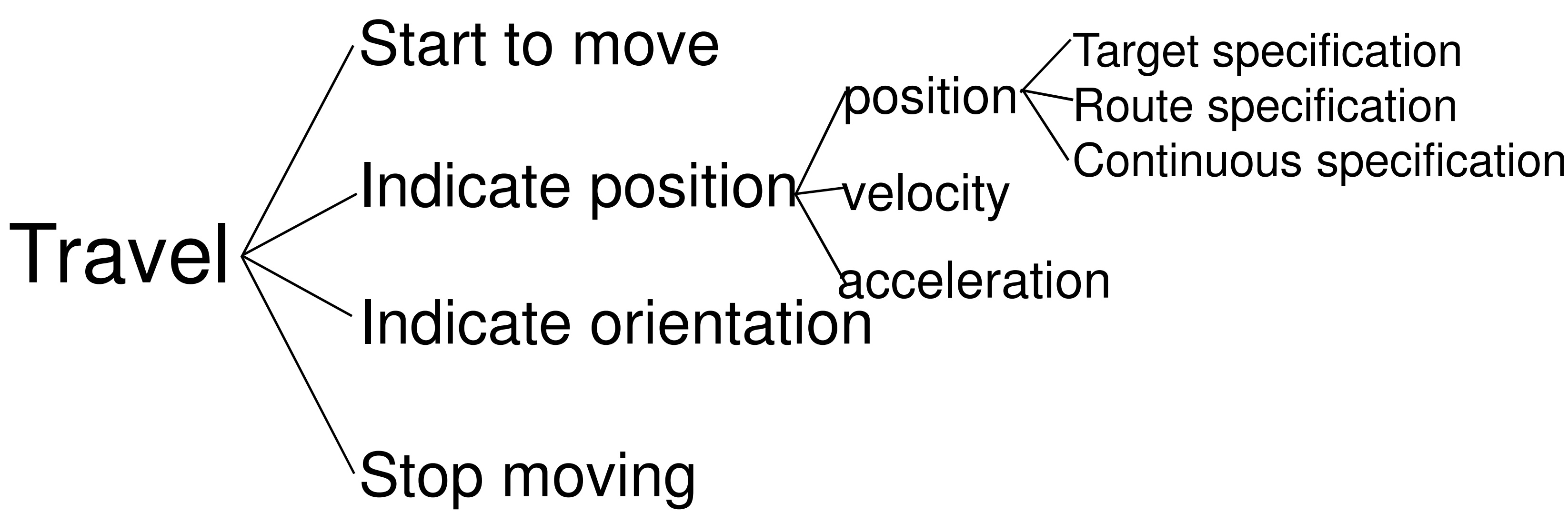
- Travel distance
- Amount of curvature/number of turns in path
- Target visibility
- DOF required
- Accuracy required
- Other tasks during travel
- Active vs. passive
- Physical vs. virtual

A Technique Classification – Component Decomposition

- Travel
  - Direction/Target Selection
    - gaze-directed
    - pointing
    - choose target from list
  - Velocity/Acceleration Selection
    - gesture
    - slow in, slow out (fast in-between)
    - physical props
  - Conditions of Input
    - start/stop buttons
    - automatic start/stop
    - constant movement

From: Bowman, Koller, and Hodges, Travel in Immersive Virtual Environments. IEEE VRAIS '97

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
- Treadmills
  - single-direction with steering (Gait Master)
  - omni-directional
- Bicycles
- Other physical motion techniques
  - Magic carpet
  - Disney's river raft ride

Large Scale Tracking

Omni-Directional Treadmill

- Video:
  - http://www.youtube.com/watch?v=BQw1tsgrJOs

Omni

- https://www.kickstarter.com/projects/1944625487/omni-move-naturally-in-your-favorite-game