# CSE 165: 3D User Interaction

Lecture #10: Navigation

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# Announcements

- Homework Assignment #3
  - Due February 13th at 1:00pm
  - Update on Move driver issues
  - Device swapping opportunity
- Next week:
  - Lecture on Tuesday held by TA Dylan
  - Instructor's office hour moves to Thursday after class (3:30-4:30pm)

# Move Buttons

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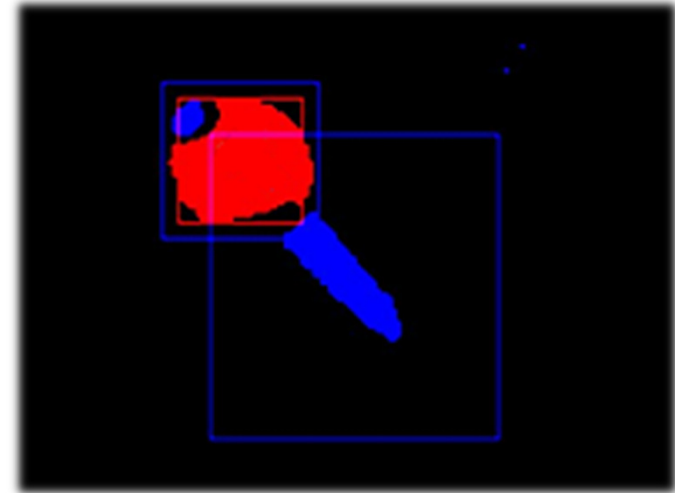
# Navigation

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



**Basic line search**

**Pattern search**

**Contour search**

**Fan search**
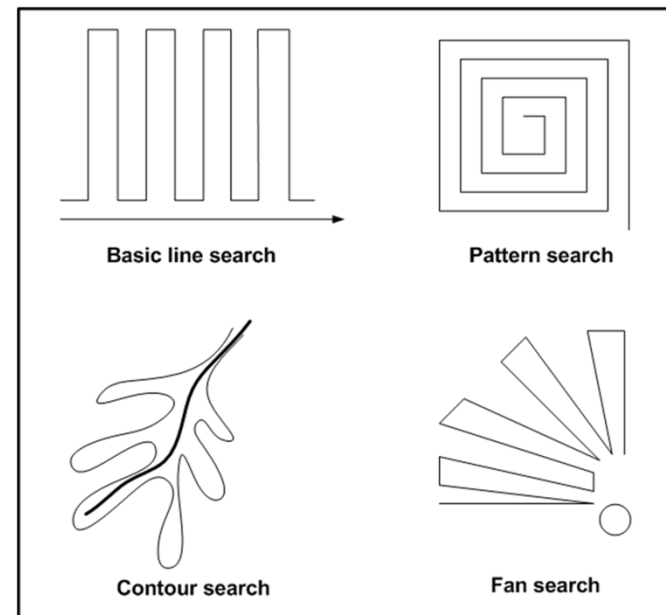
# 3D UI With the Leap

- 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
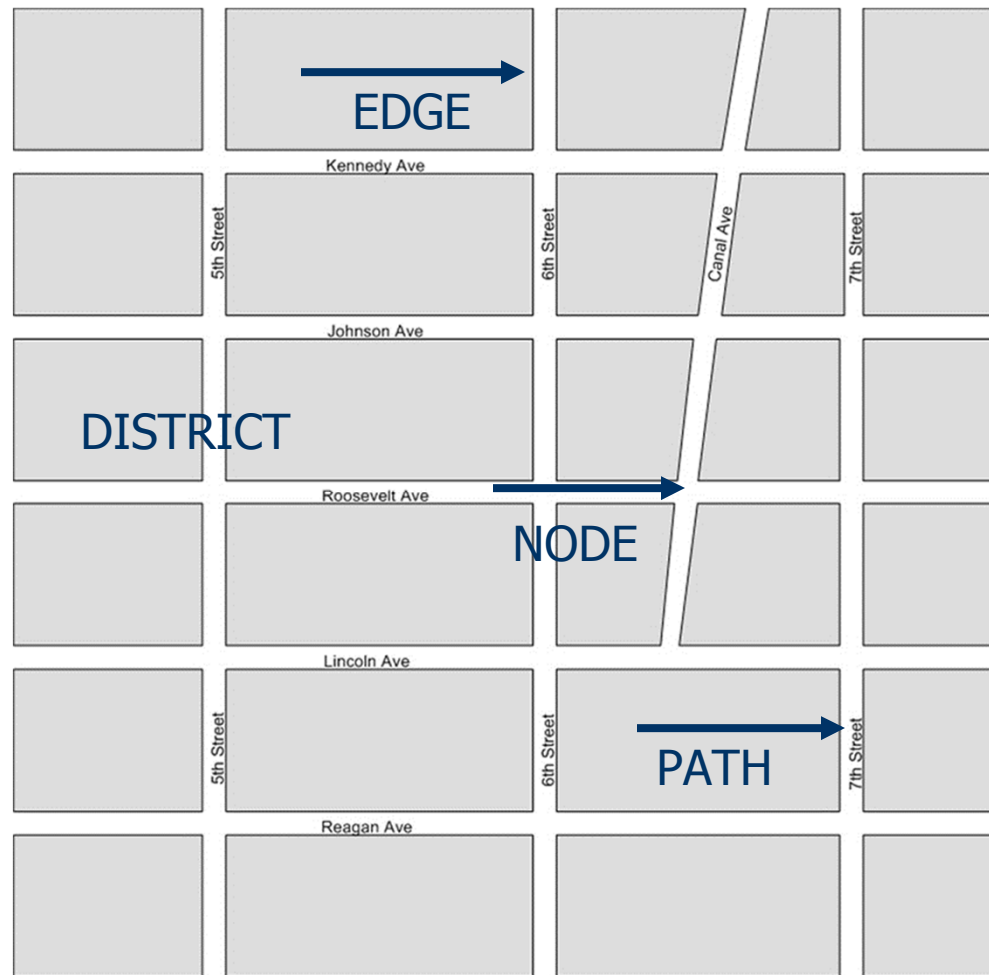
# Environment-Centered Wayfinding Support

- 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
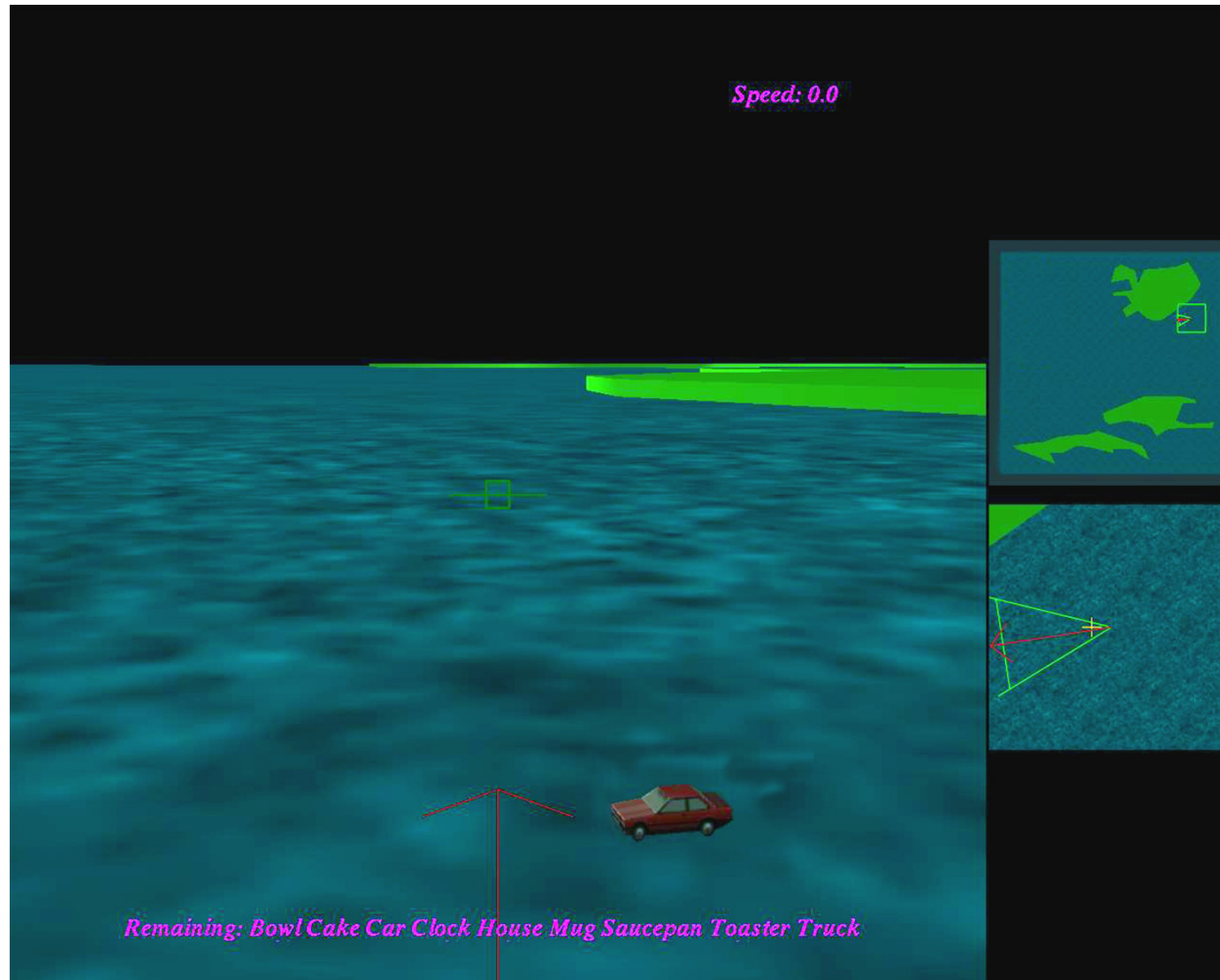
# Environmental Design (2)



EDGE

Kennedy Ave

5th Street

6th Street

Canal Ave

7th Street

Johnson Ave

DISTRICT

Roosevelt Ave

NODE

Lincoln Ave

5th Street

6th Street

PATH

7th Street

Reagan Ave

# Environmental Design (3)

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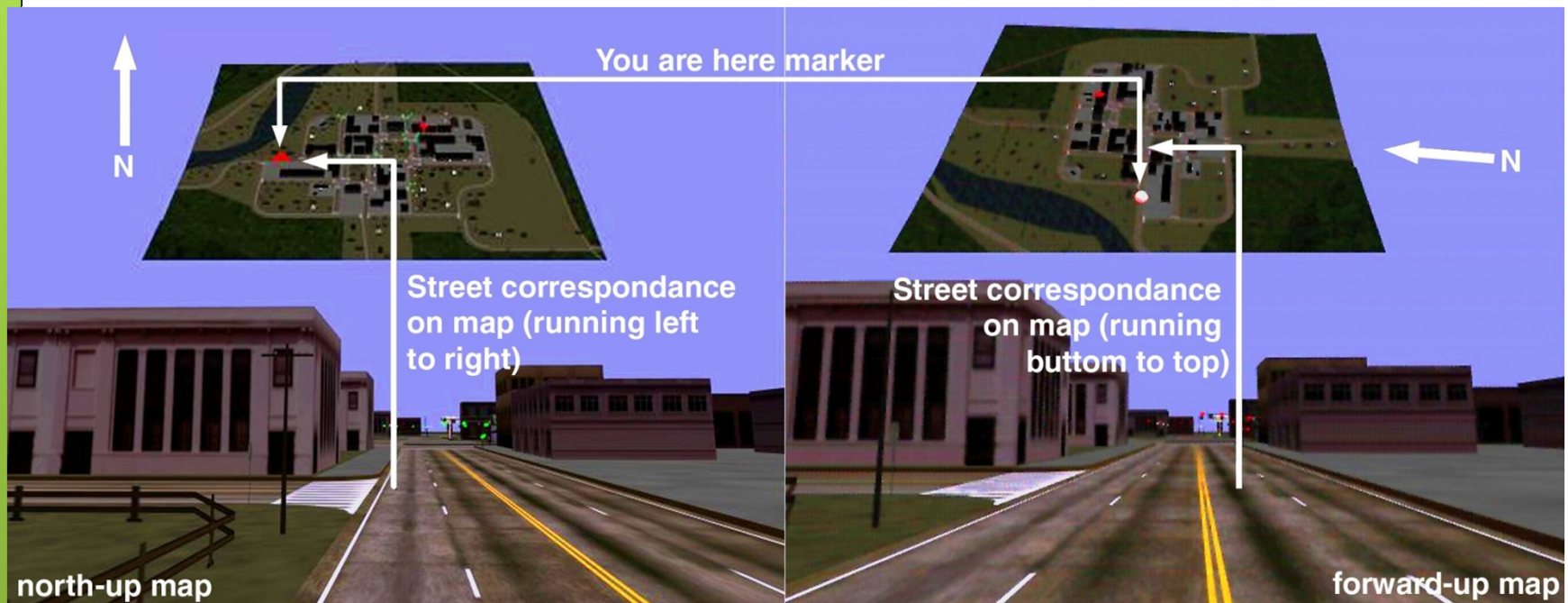  - lighting
  - closed and open spaces
- Color and texture

# Artificial Cues

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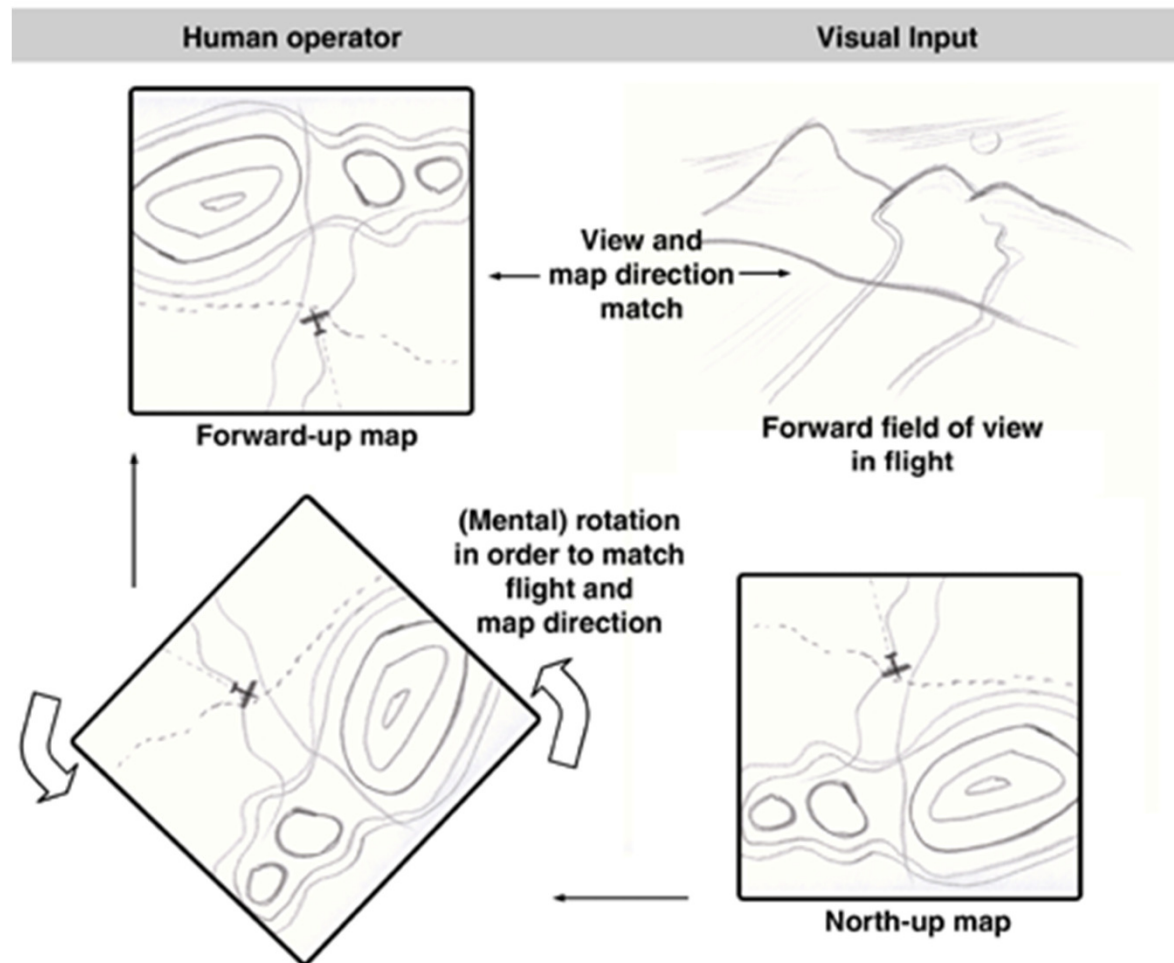- Artificial landmarks
- Trails

# Maps (1)



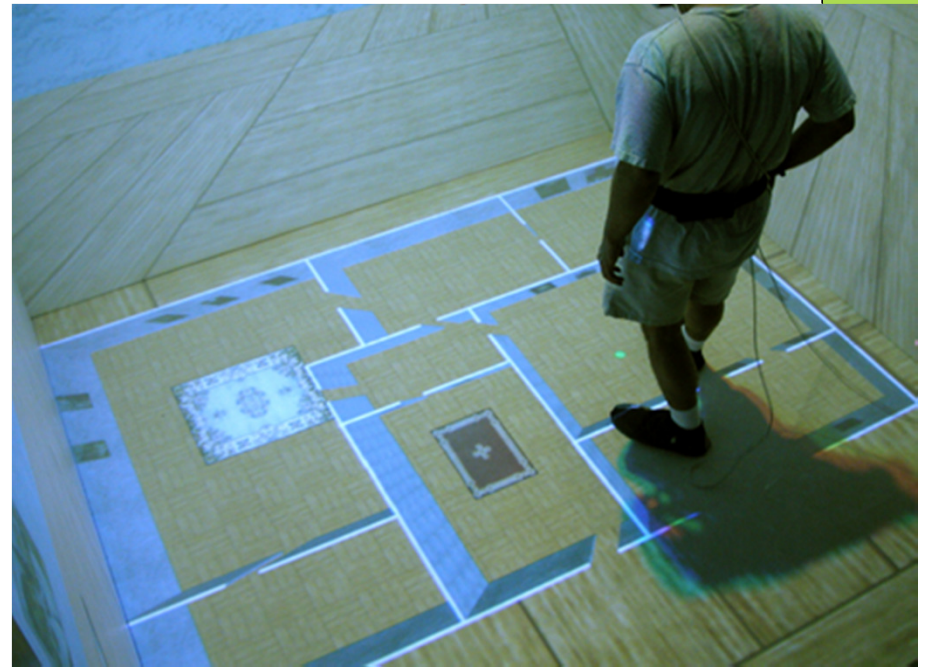Speed: 0.0

Remaining: Bowl Cake Car Clock House Mug Saucepan Toaster Truck

# Maps (3)



You are here marker

Street correspondance on map (running left to right)

north-up map

Street correspondance on map (running buttom to top)

forward-up map

# Maps (2)



**Human operator**

**Visual Input**

Forward-up map

View and map direction match

Forward field of view in flight

(Mental) rotation in order to match flight and map direction
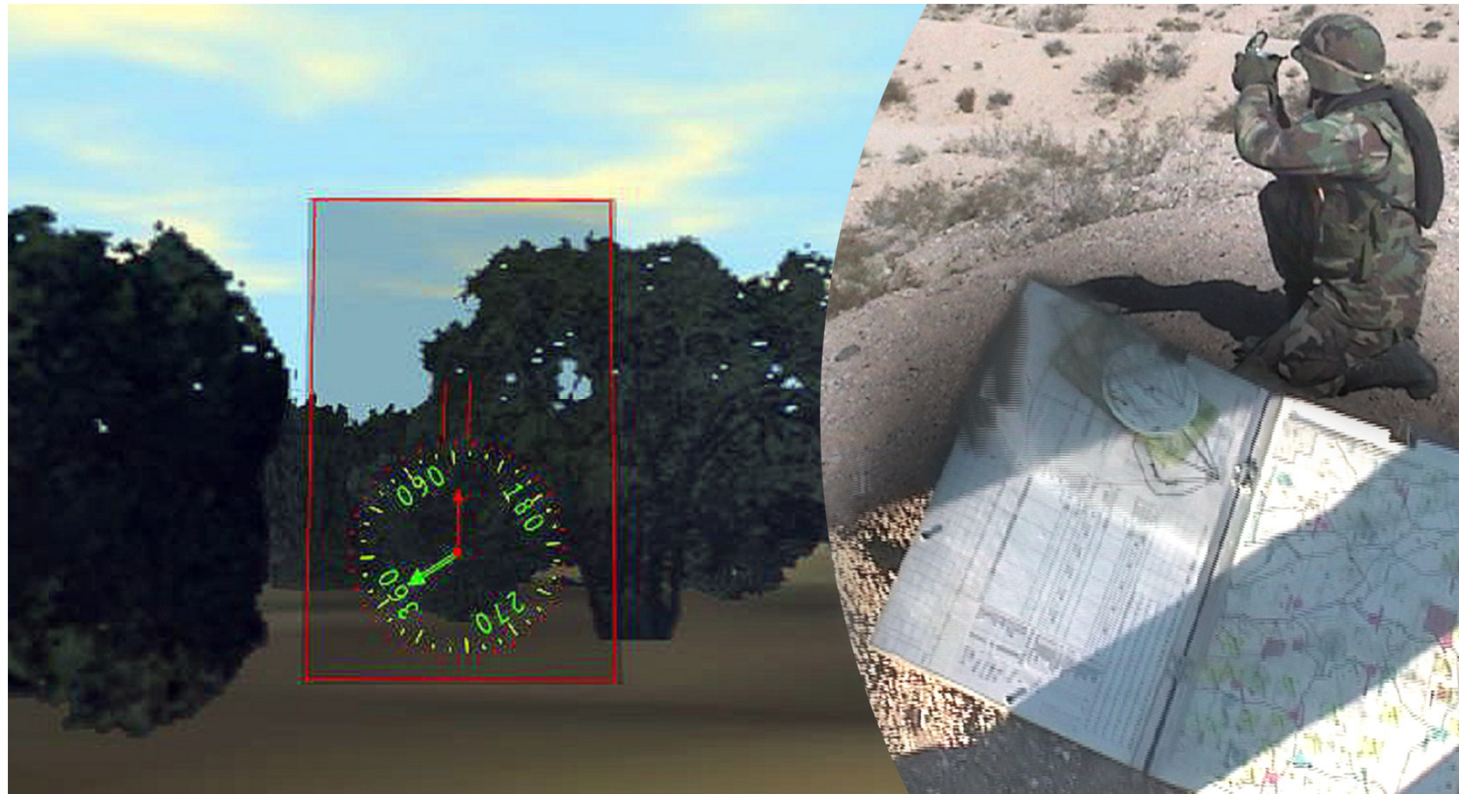
North-up map

# 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
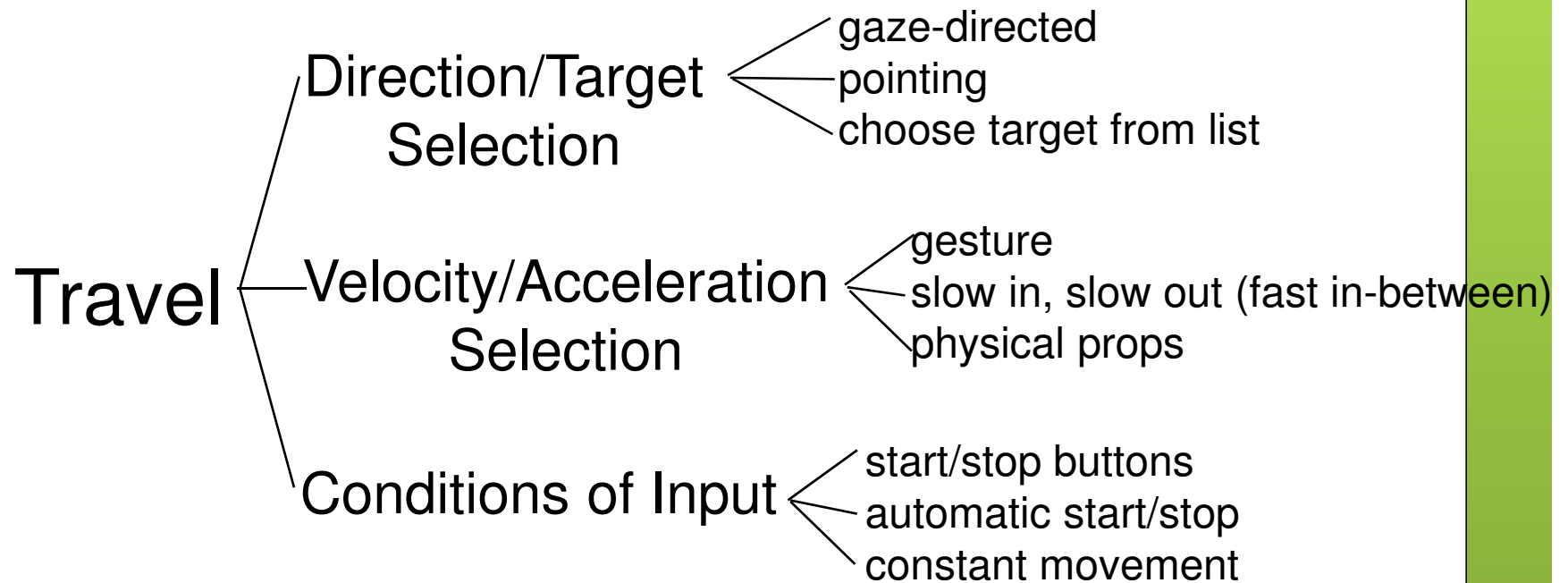
# Travel Tasks

- 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
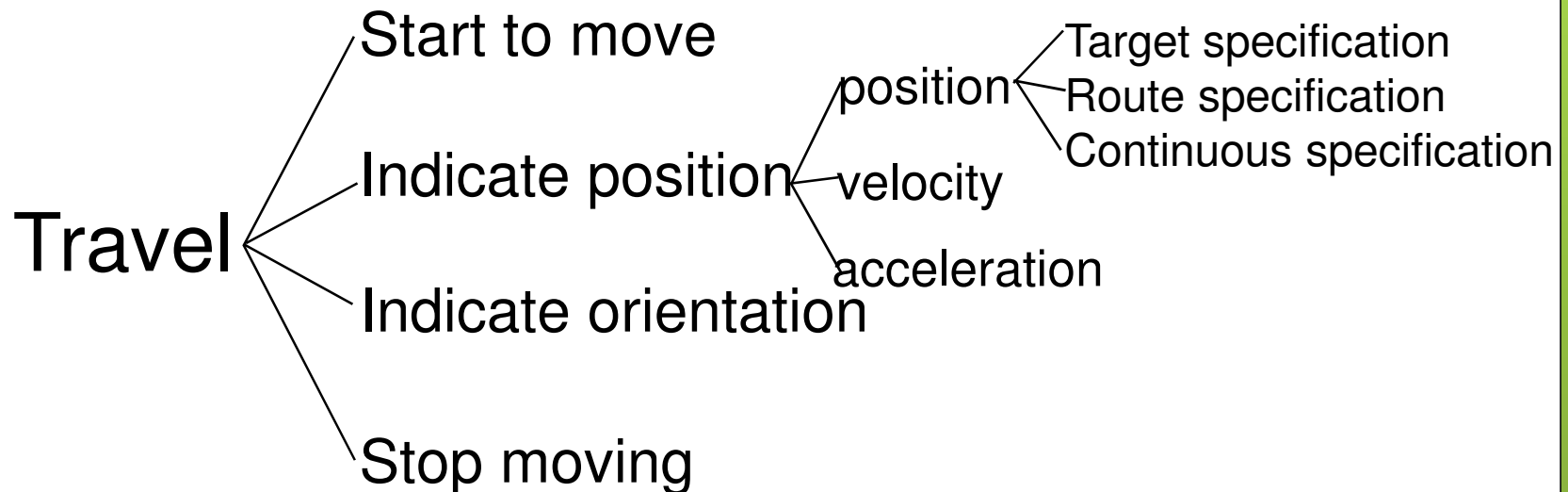  - short, precise movements

# 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
- Start to move
- Indicate position
  - position
    - Target specification
    - Route specification
    - Continuous specification
  - velocity
  - acceleration
- Indicate orientation
- Stop moving

# 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=BQw1t sgrJOs

# Omni

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