CSE 190: 3D User Interaction

Lecture #8: Wayfinding

Jürgen P. Schulze, Ph.D.

Announcements

- Homework assignment #2 due Friday, February 8th at 1pm in Sequoia lab 142
  - This time grading starts at 12 noon
  - Calit2 tour starts at 1pm
- Reminder: paper presentations
  - Next lecture:
    - Vivek
    - Joey
    - Matteo: A discussion of cybersickness in virtual environments

Rotational Mappings

- Most covered interaction techniques deal only with selection and translation
- Many do not work well for rotations
- Rotation options:
  - Direct mapping of object rotation to rotation of device
    - Can cause clutching: repeated grabbing and releasing of object to rotate further than wrist allows
    - Tracking jitter can make small rotations difficult
  - Rotation amplification or slow-down

Rotation Calculations

- Simplest way to calculate rotations: Euler angles
- Euler angles define rotation by 3 rotations about coordinate axes
- Typical problem with Euler angles: Gimbal Lock, occurs in certain object orientations
  - Video (play until 1:12)
    - http://www.youtube.com/watch?v=zc8b2Jo7mno
- Better than Euler angles: 4x4 rotation matrices
  - Problem: 16 numbers required to specify rotation
- Quaternions: greatly improve rotation calculations

Quaternions

- OSG defines mathematical operators for quaternions to add, subtract, multiply, etc.
- In OSG, quaternions can be specified by rotation angle and axis:
  - `osg::Quat(value_type angle, const Vec3d &axis)`
- Or mathematically:
  - `osg::Quat(value_type x, value_type y, value_type z, value_type w)`

Quaternion Definition

- [w, x, y, z]
  - w = cos(a/2)
  - x = sin(a/2) * nx
  - y = sin(a/2) * ny
  - z = sin(a/2) * nz
- a: angle of rotation
- {nx,ny,nz}: normalized axis of rotation

Useful Quaternions

w	**x**	**y**	**z**	**Description**
1	0	0	0	Identity quaternion, no rotation
0	1	0	0	180° turn around X axis
0	0	1	0	180° turn around Y axis
0	0	0	1	180° turn around Z axis
sqrt(0.5)	sqrt(0.5)	0	0	90° rotation around X axis
sqrt(0.5)	0	sqrt(0.5)	0	90° rotation around Y axis
sqrt(0.5)	0	0	sqrt(0.5)	90° rotation around Z axis
sqrt(0.5)	-sqrt(0.5)	0	0	-90° rotation around X axis
sqrt(0.5)	0	-sqrt(0.5)	0	-90° rotation around Y axis
sqrt(0.5)	0	0	-sqrt(0.5)	-90° rotation around Z axis

Quaternions: Further Reading

- Quaternions in Ogre3D:
  - http://www.ogre3d.org/tikiwiki/Quaternion+and+Rotation+Primer
- Quaternions in OSG:
  - http://www.openscenegraph.org/projects/osg/wiki/Support/Maths/QuaternionMaths

Navigation

Wayfinding – 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 (not when we are lost)

Information for the Wayfinding Task

- Landmarks
- Signs
- Maps
- Directional information

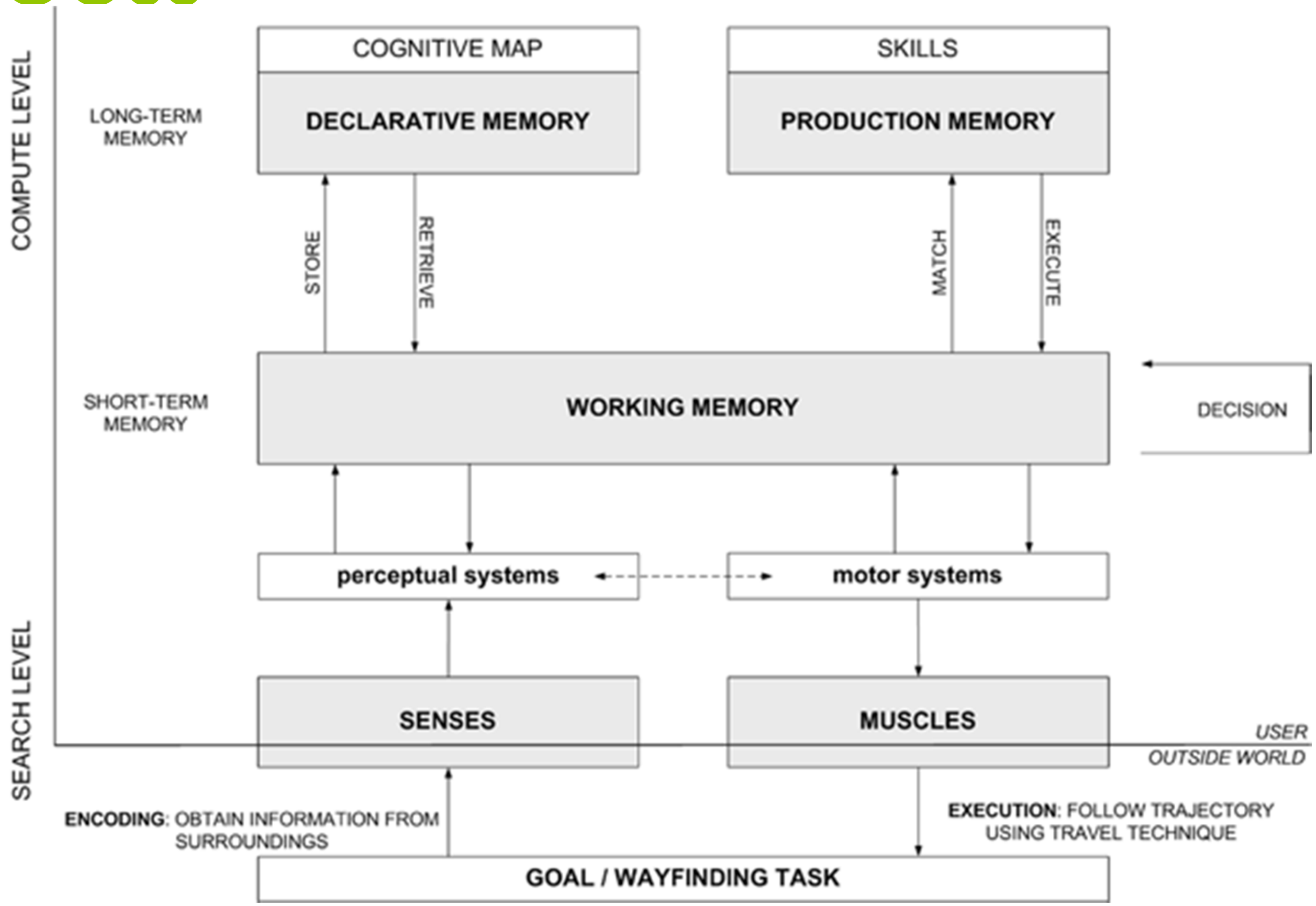
Transferring Spatial Knowledge

- 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 as Decision Making Process



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

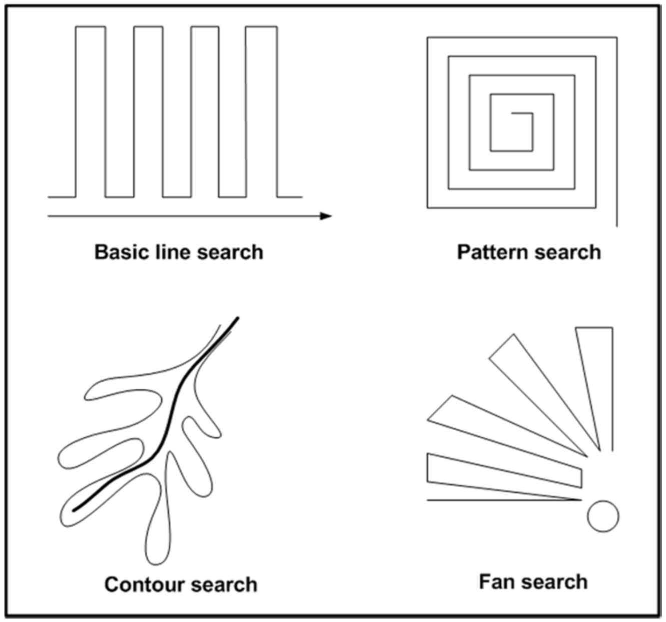
- Egomotion – feeling we are the center of space
- Egocentric – first person
  - relative to human body
- Exocentric – third person
  - relative to world
- Build up exocentric representation of world
  - survey knowledge
- Use egocentric when exploring for first time
  - landmark/procedural knowledge

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 dead reckoning (backtracking of user's own movement)
  - cue conflicts can hinder cognitive map development
- Multisensory Output
  - audio
  - Tactile maps

User-Centered Wayfinding Support (2)

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



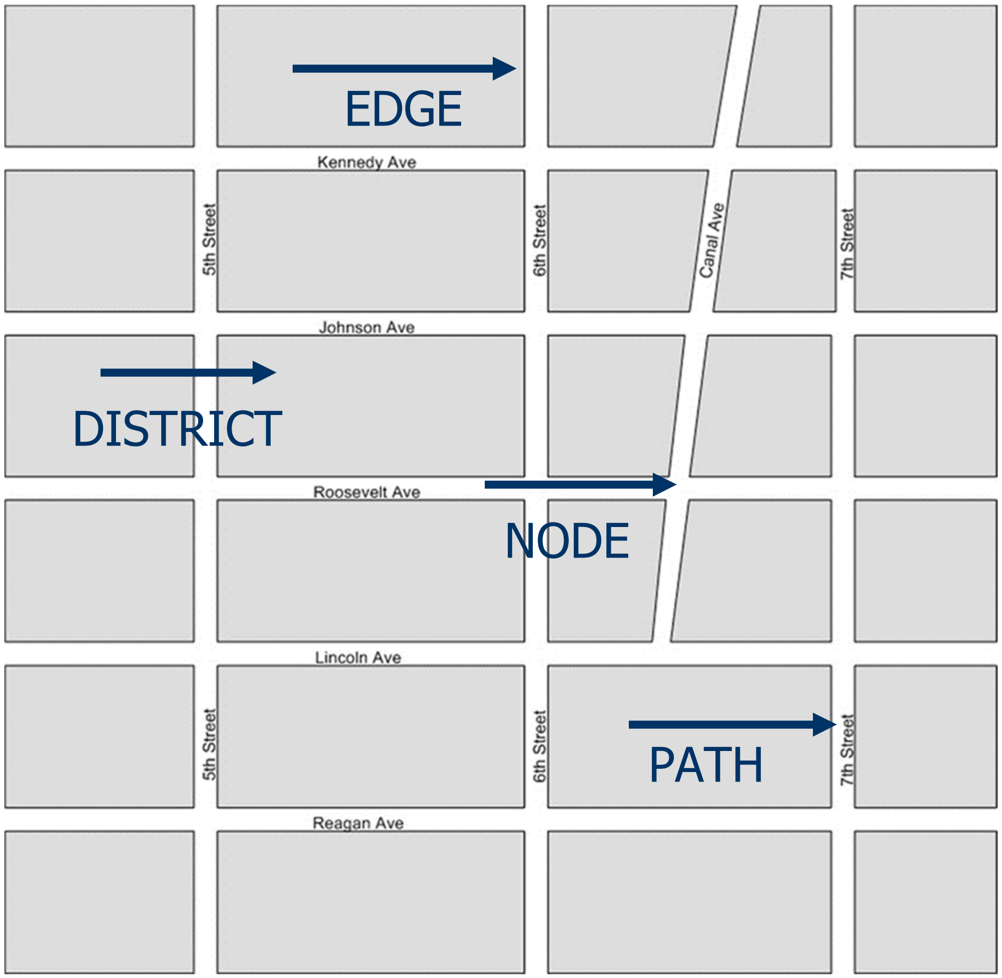
Environment-Centered Wayfinding Support

- 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)



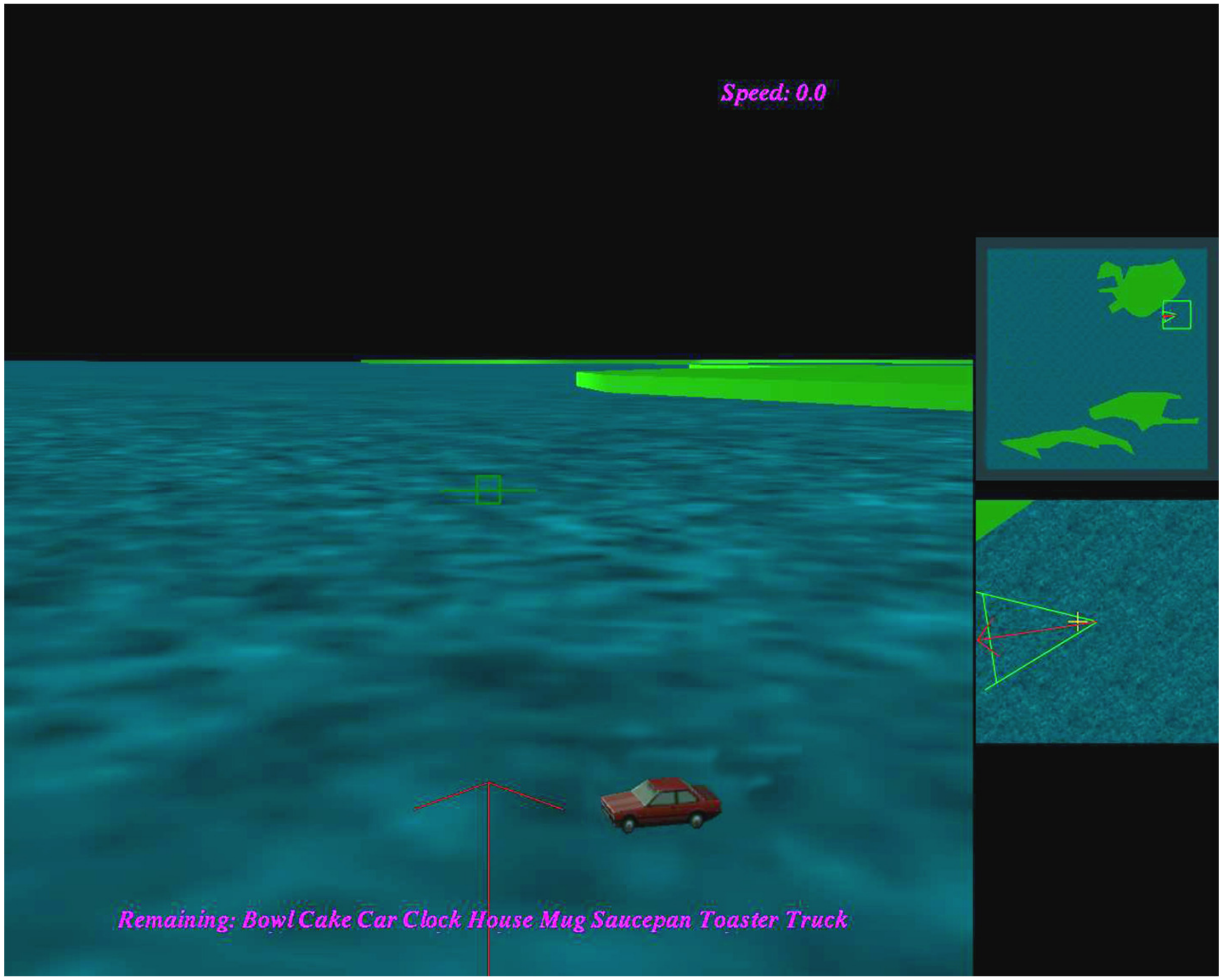
Environmental Design (3)

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

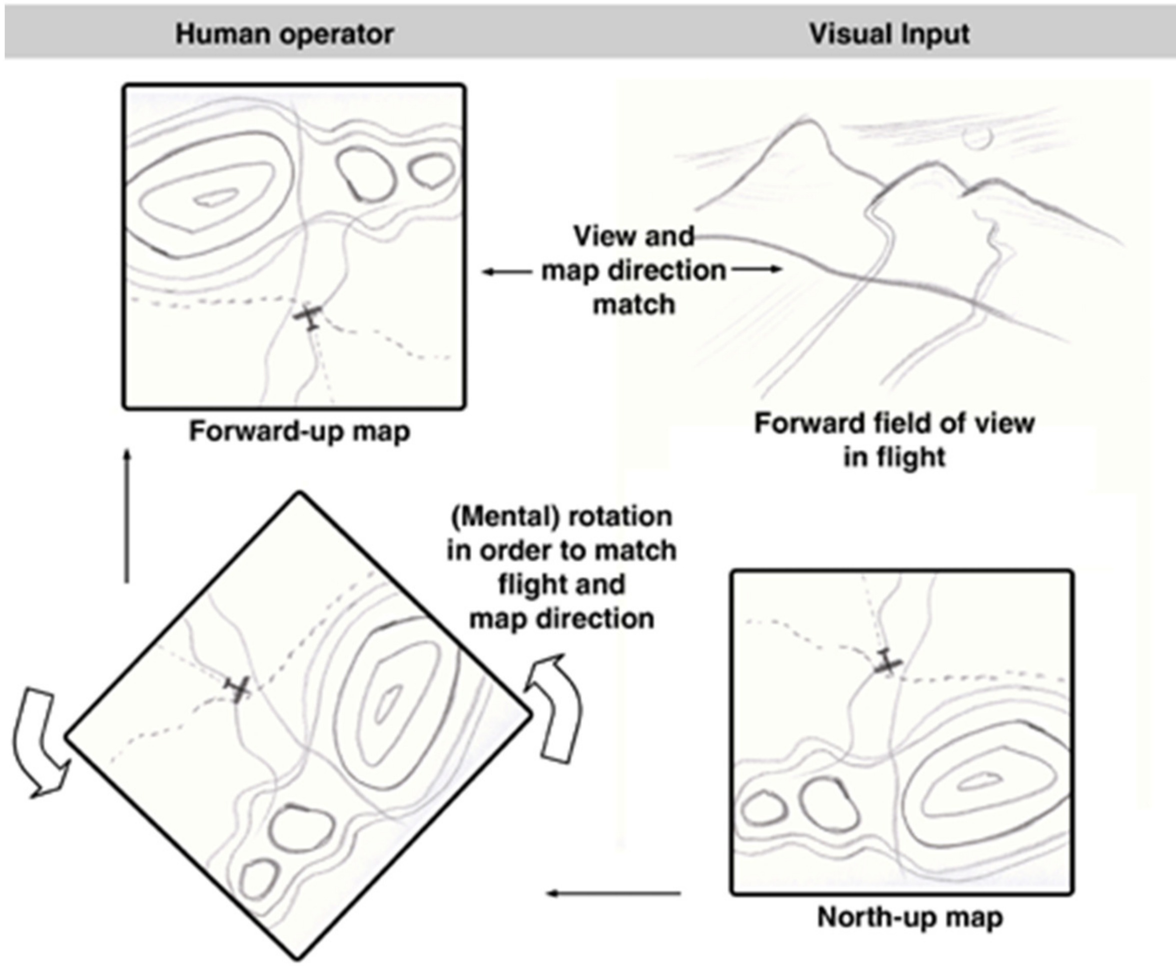
Artificial Cues

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

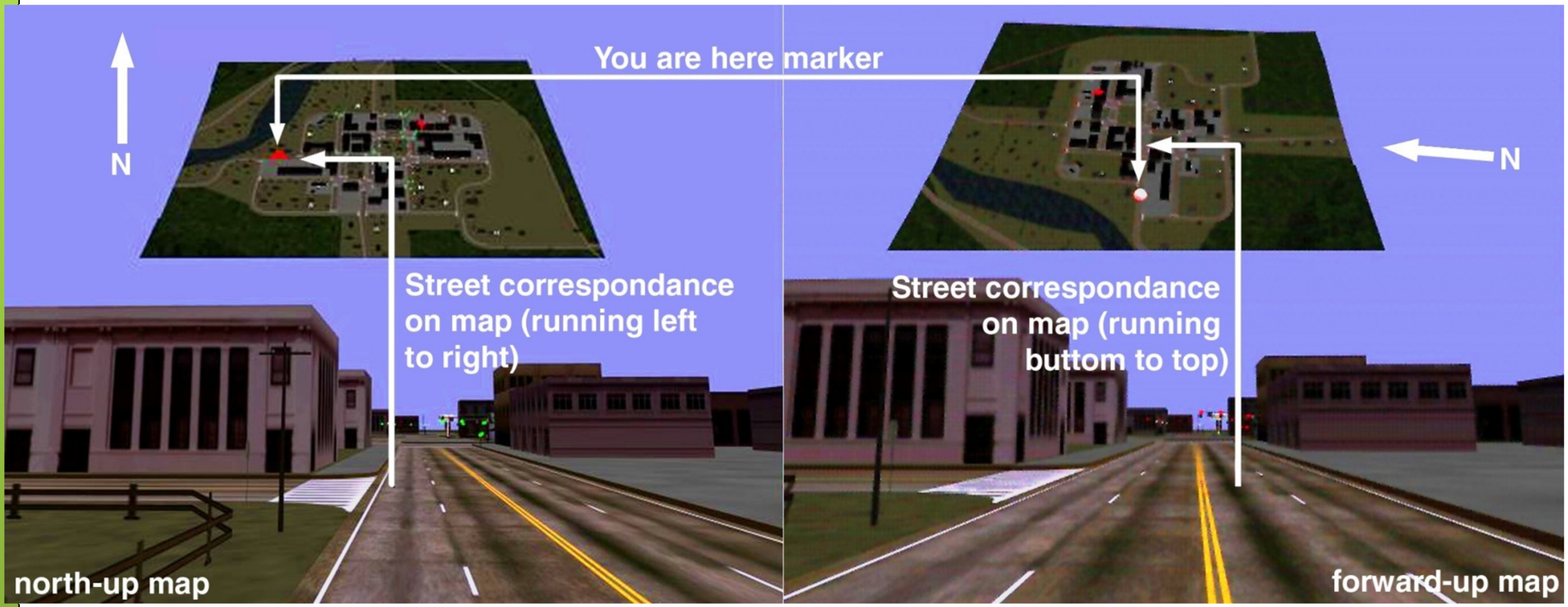
Maps (1)


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

Maps (2)

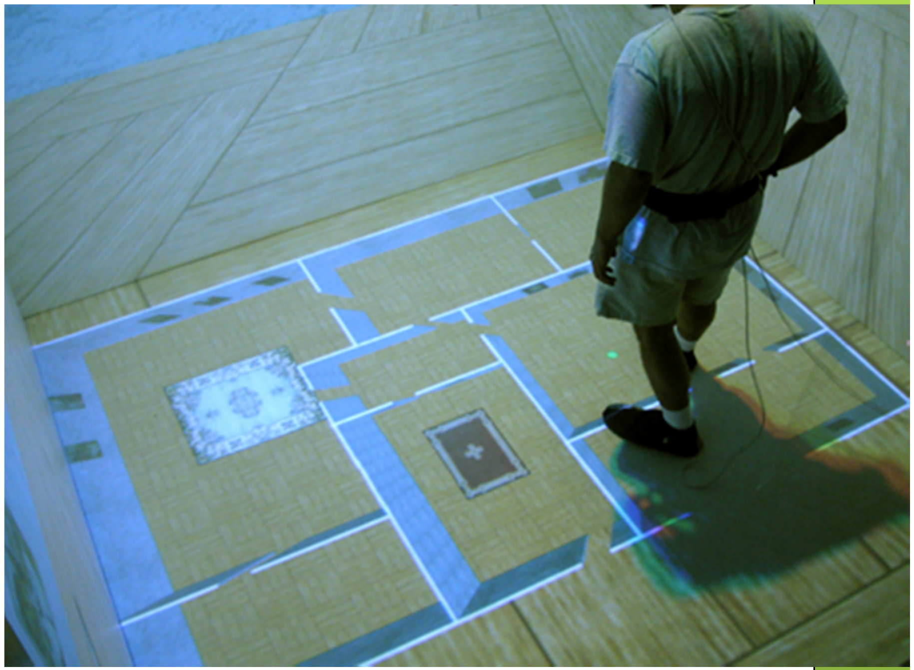

Human operator
Visual Input
View and
map direction
match
Forward-up map
Forward field of view
in flight
(Mental) rotation
in order to match
flight and
map direction
North-up map

Maps (3)

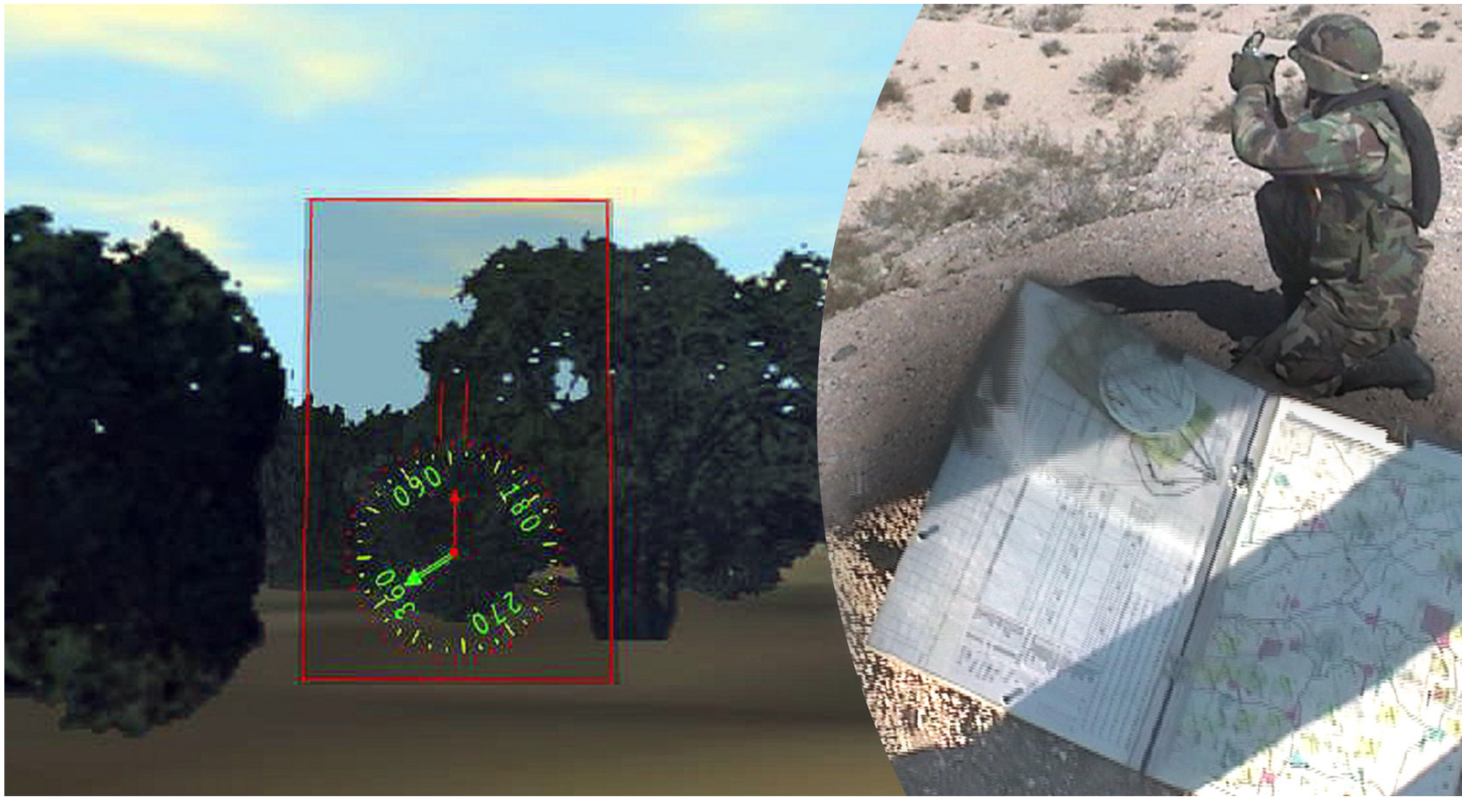


You are here marker
N
Street correspondance on map (running left to right)
north-up map
N
Street correspondance on map (running buttom to top)
forward-up map

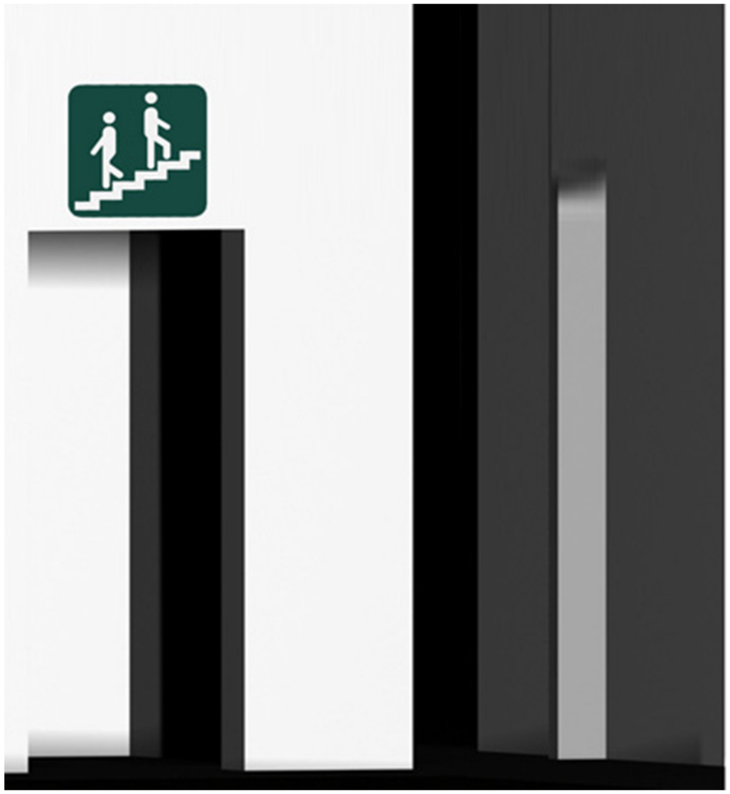
Maps (4)



Compasses



Signs

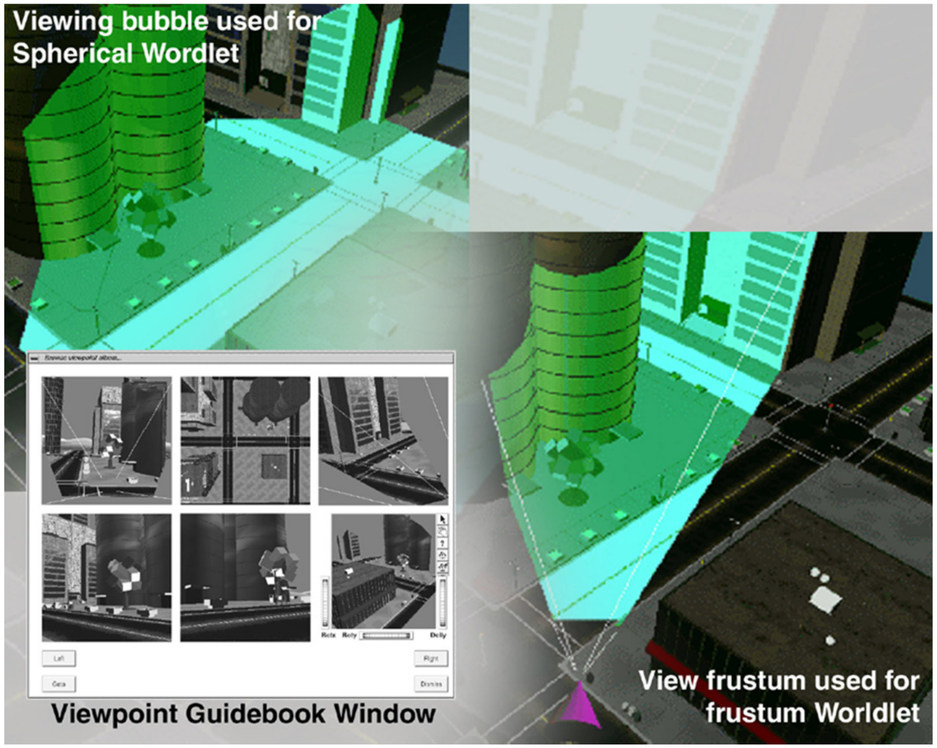


Reference Objects

- 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