User-Centered Wayfinding
Presence

- Sense of “being there”
  - Measured by
    - Behavior: E.g., duck to avoid being hit, physiological responses
    - Questionnaire responses
- Aids effectiveness of real-world wayfinding cues
- Promoted by
  - Improved emulation of real-world effects
    - E.g., lower latency, higher FOV
  - Virtual body
    - E.g., Looking down and seeing your feet

Meehan, Insko, Whitton, and Brooks, SIGGRAPH '02
User-Centered Wayfinding
Search Strategies

- Learn approach to aid effective wayfinding (e.g., based on expert knowledge)
  - Search patterns/paths
  - Switching between egocentric and exocentric views (e.g., immersive vs. world-in-miniature)

Environment-Centered Wayfinding
Environment Design

- Design environment for effective wayfinding
  - Legibility techniques
  - Real-world principles
Environment-Centered Wayfinding
Environment Design: Legibility

- **Legibility**
  - “the ease with which [a city’s] parts may be recognised and can be organised into a coherent pattern” — K. Lynch, *The Image of the City*, 1960

- **Legibility Techniques (K. Lynch)**
  - Divide environment into distinct parts
  - Organize spatially to clarify relationships among parts
  - Use directional cues to support matching egocentric and exocentric reference frames (e.g., to help equate “Left” with “South”)

Lynch was an urban planner who coined the term “wayfinding”

Environment-Centered Wayfinding
Environment Design: Legibility

- **Building blocks of cognitive maps (K. Lynch)**
  - **Landmarks**: Static, recognizable objects
  - **Districts**: Sections of environment with distinct character providing coherence
    - Style (architectural), color, lighting, use,…
  - **Paths**: Major avenues of travel
    - Roads, sidewalks, footpaths,…
  - **Nodes**: Points of interest on paths
    - Intersections, town squares,…
  - **Edges**: Borders to districts or obstacles
    - Waterfront, walls, “wrong side of the tracks”,…
    - May also serve as paths

Environment-Centered Wayfinding

Environment Design: Legibility

- Creation/reinforcement of legibility building blocks
- Repetitive structure
  - Use of right angles promotes survey knowledge vs. route knowledge
    - E.g., midtown NYC vs. downtown NYC
- Can be applied to virtual environments, including abstract ones
  - R. Ingram and S. Benford, Automated application of legibility techniques to information spaces, 1997

Environment-Centered Wayfinding

Environment Design: Real World Principles

- Natural environment
  - E.g., sun, stars, horizon, aerial perspective
- Built environment (architecture)
  - Illumination for recognizability/emphasis
  - Openings to guide users
- Use of color/texture to group and emphasize in both natural and built environments

http://www.flickr.com/photos/stevegrosbois/
http://www.flickr.com/photos/listenmissy/
Environment-Centered Wayfinding

Environment Design: Real World Principles

- Appeal to additional senses
  - Audio
  - Olfactory
  - Haptics

H. Dinh et al., Evaluating the importance of multi-sensory input on memory and the sense of presence in virtual environments, IEEE VR 99

Memory of locations of objects in office virtual environment improved by addition of appropriate nonvisual cues

- Auditory
  - Flushing toilet near bathroom
- Olfactory
  - Coffee near kitchen
- Tactile
  - Breeze from a fan

M. Heilig, 1957, www.mortonheilig.com
http://www.youtube.com/watch?v=vSINEBZNCks
Environment-Centered Wayfinding
Artificial Cues

- Maps
- Compasses
- Signage
- Reference objects
- Trails
- Grids
- Audio/olfactory/haptic cues

Environment-Centered Wayfinding
Artificial Cues: Maps

- Graphic representation of an area, drawn to (smaller) scale
- “You-are-here” map
  - Includes location marker
- Orientation
  - North up: Better for exocentric tasks
  - E.g., finding a target not marked on map
  - Forward up: Better for egocentric tasks
  - E.g., finding a target marked on map
- Position/size
  - Fixed vs. movable
  - User-controlled vs. system-controlled
  - Same display vs. separate display
    - E.g., placing a map on an appropriate handheld display could provide higher-resolution, easy control of display pose, and touch input

R. Darken & B. Petersen 2002
http://citeseer.ist.psu.edu/viewdoc/summary?doi=10.1.1.12.4619 (use cached copy)
Environment-Centered Wayfinding
Artificial Cues: Maps

B. Bell, T. Höllerer, and S. Feiner, UIST 2002

- Situation awareness aid controlled by head orientation:
  - yaw → yaw
  - pitch → pitch, position, scale, annotation

- Annotations move between real world and aid
Environment-Centered Wayfinding
Artificial Cues: Maps

B. Bell, T. Höllerer, and S. Feiner, UIST 2002
Environment-Centered Wayfinding
Artificial Cues: Maps

- How to support collaboration?
  - What information should be shared?
  - How should information be visualized?

Example: Monitoring Other Users’ Views

- Strawman rule
  - Brightness of object based on number of users viewing it
  - Could also accumulate viewing history or differentiate users’ gaze by color

Testbed using rule-based architecture
B. Bell and S. Feiner, CVRV 2003
Example: Monitoring Other Users’ Views

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Environment-Centered Wayfinding
Artificial Cues: Maps

- Step WIM
  - WIM on the floor
  - Invoked by toe tap
  - User walks around WIM
  - Toe tap
    - Dismisses WIM if user looking up
    - Goes to current location if user looking down

Note use of head orientation to modify meaning of an action
Environment-Centered Wayfinding
Artificial Cues: Maps

- Step WIM
  - WIM scale mode invoked by heel click
  - User walks relative to original position at click, to scale WIM up/down
  - User clicks heels again to exit scale mode


Environment-Centered Wayfinding
Artificial Cues: Compasses

- Pointer to north or other designated object
  - Typically always visible
  - E.g., Floating compass arrow points north, rotating in ground plane
  - Provides only directional information

R. Darken & B. Petersen 2002
http://citeseer.ist.psu.edu/viewdoc/summary?doi=10.1.1.12.4019 (use cached copy)

http://www.layar.com/layers/compassnavigation
Environment-Centered Wayfinding
Artificial Cues: Compasses

- Pointer to north or other designated object
  - Typically always visible
  - E.g., Currently selected object pointer, rotating in image plane
  - Provides only directional information

Note: Pointer turns red and stays horizontal when selected object is in half-space behind user

Columbia Mobile Augmented Reality System
www.cs.columbia.edu/graphics/projects/mars/marsUIs.html

Environment-Centered Wayfinding
Artificial Cues: Other Directional

- Virtual “sun”
  - Infinitely distant
  - Visible in only one direction
  - Provides only directional information

R. Darken & S. Petersen 2002
http://citeseer.ist.psu.edu/viewdoc/summary?doi=10.1.1.12.4619
(use cached copy)
Environment-Centered Wayfinding
Artificial Cues: Signage

- Displays identifying objects or places
  - E.g., labels

Environment-Centered Wayfinding
Artificial Cues: Reference Objects

- Objects of known scale
  - Facilitate measurement of size and distance
  - E.g., people


Environment-Centered Wayfinding
Artificial Cues: Artificial Landmarks

- Objects added specifically for wayfinding
  - Distinguishable
  - Positioned for recognizability
  - Virtual “sun” was for direction only

R. Darken & B. Petersen 2002
http://citeseer.ist.psu.edu/viewdoc/summary?doi=10.1.1.12.4619 (use cached copy)

Environment-Centered Wayfinding
Artificial Cues: Trails

- Objects added to show user’s path
  - E.g., lines, breadcrumbs, footprints (show direction)
  - Could have functionality to assist following
  - Cause clutter if left indiscriminately

R. Darken & B. Petersen 2002
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Environment-Centered Wayfinding

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Environment-Centered Wayfinding

Artificial Cues: Grids

- Regular ruled overlays
  - Partition environment
  - Allow users to determine current partition, organize search
    - radial grids (can elicit exploration of pie slices)
    - rectangular grids (can elicit “back and forth” exploration of grid)
Wayfinding Evaluation

- Measure
  - Time to target
  - Path
    - Length
      - Unnecessary turns
      - Repetition
  - Ability to answer questions
  - Ability to draw layout sketches
    - Number of (in)correct objects
    - Relative/absolute characteristics of objects in sketch
      - Size
      - Orientation
      - Position (to evaluate absolute position, distance, direction)

Paths in targeted map searches
(with target on map):
(A) Forward-up
(B) North-up