Strategic Elements of Route Choice for Next Generation Digital Navigation Systems

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Context of Research: Personal, Digital Navigation Systems

- Vehicle or PDA/Smartphone based
- Take into account
  - User’s position (GPS)
  - Construction, traffic, and other obstacles
- Automatic generation of routes that prioritize or consider:
  - Shortest distance
  - Least Time
  - Avoiding Freeways
  - Avoiding Tolls
  - Intermediate waypoints
- Generally offer a single best route
  - And that’s often OK, but...
Subtle differences in preferences can lead to very different routes.

Consider a route from the bus loop at UCSB to the Fairview Shopping Center (OSH, Vons)

Los Carneros / Calle Real

Highway 217 / Fairview

- Both routes are 3.9 mi / 9 mins
- Many other reasonable routes
Overall Problem

• Current navigation systems oversimplify the criteria of route selection so that they can provide a single best route based on expressed user preferences.

• Better solution
  – Stated and revealed preferences
  – Find nearly equivalent routes and present these to the user. Use responses to further calibrate user strategic travel profile
Why bother?

- If existing methods generate least cost paths (in terms of time or distance) why would we modify that?
- Response
  - Purely “economic” concerns don’t capture the range of criteria
  - These other criteria are important for overall utility
Elements of Strategic Thinking

• **Strategy**
  – Generally, the method or plan to achieve a goal
  – Must involve *choice*

• **Strategic Thinking** (more/less not either/or)
  – General / Schematic (not details)
  – Conscious (not latent)
  – Conditional (if/then)
  – Number and depth of variable interactions considered

• **Strategic Disposition**
  – Affinity, frequency, and quality of strategic thinking

• **Example: Board Games**
Preferences and Heuristics as Strategies

• Preferences
  – Shortest distance
  – Least time
  – Fewest turns
  – Straightest path
  – Avoid freeways
  – Aesthetic appeal
  – Avoid left turns
  – Safety
  – Least complex

• Heuristics
  – Choose initially long straight segments (ISS) (Bailenson et. al, 2000/2002)
  – Choose path with least angular deviation from target (Hochmair and Frank, 2000)
  – Move to regions containing target as soon as possible (Wiener and Mallot, 2003)
Other types of wayfinding strategies

• Style
  – Route (Landmark) vs. Orientation (Survey) (Lawton, 1994)

• Explicit Techniques
  – Look-back strategy, edge following (Cornell, Heth & Rowat, 1992)

• Reliance on external aids
  – Maps or knowledge (Hutchins, 1995; Ishikawa et al., 2008)
    – Digital vs. analog

• Task-related
  – Search vs. Access (Passini, 1992)
Understanding Strategy in Wayfinding

• Instrumental rationality
  – Analysis of methods in the context of goals
• Conditional thinking vs. preferential thinking
• Ability
  – Ability mediates availability and effectiveness of strategy
• Uncertainty
  – Reducing variability vs. improving mean result
Research Program Goals

1. Investigate the role of vision in strategy formulation on search task
2. Create questionnaire to identify strategic disposition and affinity for risk taking
3. Identify points of similarity between pedestrian and driving strategies
4. Investigate the role of scale on search strategy
5. Explain wayfinding behavior (search and access) in terms of environmental spatial ability, strategic disposition, and affinity for risk.
Individual search strategies

- Idea from a series of articles
  - Tellevik, 1992
  - Hill et al., 1993
  - Gaunet & Thinus-Blanc, 1996

- Blindfolded or blind subjects search for objects in a small room

- Search Strategies
  - Perimeter
  - Gridline (aka Parallel)

- Memorization Strategies
  - Object-to-wall
  - Object-to-home
  - Object-to-object

(Hill et al., 1993)
Indoor Search
“Finding the Invisible Animals”

- **Design**
  - Audio cues of animal sounds
  - Laser detection of position
  - Two Trials
  - \( n = 42 \)
- **One of three conditions**
  - Sighted
  - Searched blindfolded
  - Always blindfolded
- **Variables**
  - Time, distance, serial distance
  - Pointing & model accuracy
  - Sex, trial, condition
  - Strategy selection
- **Post-task interview**
Indoor Search: Example

- Perimeter Search
- Localization
- Concentric Circle?
- Gridline

Sample animation for indoor search study.
Indoor Search: Strategy & Learning

- Overall performance commensurate with blindfoldedness
- Gridline searches much more common in second trial
  - 10% versus 38%
- Gridline strategy
  - Modest learning benefit
- Object-to-Object Visits
  - Improvement on model accuracy
  - Ambiguous pointing benefit
Indoor Search: Strategy & Performance

• Care must be taken in analyzing connections between strategy and performance.
  – Total distance is reduced for gridline searchers.
  – But search distance is generally longer.
  – Trade-off between search strategy and memorization strategy.

• Search strategy is more important for controlling variability than for reducing the median search cost.
Questionnaire Development

• n = 101
• Environmental Spatial Ability (SBSOD)
  – 15-item (Hegarty et al., 2002)
• Strategists & Risk-takers
  – 40-item
  – Factor analysis for reduced set
    • 10 item strategic disposition
    • 5 item risk-taker
• Mode-specific attitudes about risk
• Mode-specific criteria ranking
  – walking
  – driving
Adapting Prospect Theory to Wayfinding

Choose between
- A sure $20
- A 50-50 chance at $40 or nothing

Choose between
- A sure million dollars
- A 50-50 chance at 2 million dollars or nothing

Choose between
- A sure route taking 15 minutes
- An alternative with 50-50 chance of taking 10 or 20 minutes

Variables
- Mode – Walking, Driving, Parking
- Mean – Low, High
- Variability – Probability, Payoff ratio
Means and Variances when Walking and Driving

• Modality matters
  – Mean important when walking
  – Scaled variance important when driving

• Similar outlook within individuals
  – $r(99) = .46$
Route Selection Criteria

• Ranked Criteria
  – Separate ranking by mode
  – Fast, safe, attractive, simple, easy
• Mode Matters
  – Simple (not complex) more important for driving routes.
  – Related to risk-taker, r(99) = .34
Outdoor Search – Scale in Strategy Formulation

- Hypotheses
  - Scale influences strategy
  - Strategy, risk-taking, SBSOD influence strategy/performance
  - Condition & sex similar to indoor study
- Three conditions
  - Medium (19 x 14 meters)
    - Sighted
    - Blindfolded
  - Large (43 x 23 meters)
    - Sighted
- n = 50
Emphasis on exploratory strategies
Explaining Gridline Search

- Risk-averse individuals more likely to conduct gridline search
  - Gridline searchers had higher mean search times, lower variability
- No significant effect for
  - Environmental spatial ability (SBSOD)
  - Strategic disposition
- No relationship to object-to-object visits (OTOVs)
Impact of Scale

- Increased use of systematic searches
- Decreased use of memorization efforts
- Costs usually increase at a decreasing rate with distance (Tobler, 1993).
Route Asymmetry

Rationale
• People often take a different route from A to B than from B to A.
• Same criteria applied to the same environment
• Perception of the environment is key
  – These different routes appear “better” depending on one’s perspective.
• Golledge (1995) and Bailenson et al. (1998; 2000)

Questions
• How much of the difference is attributable to general variability?
• Is the return trip actually better?
• What features in the environment tend to result in asymmetry?
• Are some individuals more prone to asymmetry than others? If so, why?
Route Asymmetry Study Design

- Seven legs between four waypoints
  - Trailer 942
  - Corner store at Buchanan,
  - Flagpole near Cheadle
  - Psychology Building Archway
- Random order according to several criteria
  - Flagpole / Psychology excluded
  - Five unique connections (Routes)
- Position tracked with GPS
- Only immediate destination known
  - Subjects radioed for the next destination
- Each walk took about 25 minutes
- $n = 65$
There was a significant amount of variability.

• Little evidence to support increased distance efficiency.

• Environmental spatial ability correlated to distance efficiency
  • $r(63) = .32$, $p = .009$

• But not strategy or risk-taking

• Sex differences largely attributable to SBSOD
Measuring Asymmetry

- Binary (Same / Different)
- Gate Coding
  - Major pathways & obstacles
  - Common sequence length
    - CHLQ, AFKP, etc.
- Some gates (and Routes) showed more asymmetry than others
  - “High-friction” areas
Obstacles and Asymmetry

- Risk-takers move through high-friction sites.
  - Fast potentially relevant
  - But not “simple”
- Symmetry connected to
  - SBSOD
  - Strategist
  - Lawton’s Orientation Strategy
- But not
  - Risk-taking
  - Fast / Simple preferences
Summary

• Strategic thinking is
  – broad in scope
  – conditional in nature
  – conscious in the mind

• Selection of strategy influenced by
  – Ability
  – Scale
  – Strategic disposition & attitudes about risk

• Mode matters, but
  – Similar criteria, weighted differently
  – Attitudes about risk transcend, but manifest differently

• Evaluate in terms of effect on
  – Central tendency
  – Variability

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